

***Conceptual modeling for the design
of intelligent and emergent information systems***

Amjad Fayoumi

Computing and Technology, Nottingham Trent University
Nottingham, England, NG7 2RD, UK
amjad.fayoumi@ntu.ac.uk

Pericles Loucopoulos

Manchester Business School, University of Manchester
Manchester, England, M15 6PB, UK
pericles.loucopoulos@mbs.ac.uk

Corresponding author: Amjad Fayoumi, Amjad.Fayoumi@ntu.ac.uk

Cite this paper: Fayoumi, A. and Loucopoulos, P., 2016. Conceptual modeling for the design of intelligent and emergent information systems. *Expert Systems with Applications*, 59, pp.174-194.

Abstract—A key requirement to today's fast changing economic environment is the ability of organizations to adapt dynamically in an effective and efficient manner. Information and Communication Technologies play a crucially important role in addressing such adaptation requirements. The notion of 'intelligent software' has emerged as a means by which enterprises can respond to changes in a reactive manner but also to explore, in a pro-active manner, possibilities for new business models. The development of such software systems demands analysis, design and implementation paradigms that recognize the need for 'co-development' of these systems with enterprise goals, processes and capabilities. The work presented in this paper is motivated by this need and to this end it proposes a paradigm that recognizes co-development as a knowledge-based activity. The proposed solution is based on a multi-perspective modeling approach that involves (i) modeling key aspects of the enterprise, (ii) reasoning about design choices and (iii) supporting strategic decision-making through simulations. The utility of the approach is demonstrated through a case study in the field of marketing for a start-up company.

Keywords— conceptual modeling; business architecture; business best practices; enterprise architecture; design rationale; system dynamics

1. INTRODUCTION

The on-going digitization and the ubiquity of software applications meet an ever-increasing pool of users. Their requirements on reliability, usability and affordability are drivers for the development and evolution of software systems that are regarded as the most significant disrupting factor in most industries (Andreessen, 2011) and a key driver in the economic growth of nations (Digital-Europe, 2009). One increasingly important consideration is how the design and evolution of the software system can comply with the design and evolution of the enterprise.

The notion of 'intelligence in software' that can adapt itself dynamically to support the ever-changing requirements of markets and enterprises, so that enterprises making use of their Information Systems (IS) to develop new business models even if such business models were not anticipated previously, is a key requirement in today's disruptive environments (ISTAG, 2012). Software technologies have been extremely successful at delivering software products of high caliber functionality and at low prices when dealing with systems whose elements are controlled by a single organization (Sommerville, et al., 2012). Increasingly however, enterprises (commercial as well as public administrations) collaborate in a variety of ways thus dealing with systems whose elements are operationally and managerially independent. In such cases, the behavior of the components is not known a priori and their requirements are in a state of continuous evolution. Since contemporary applications are dynamic, sooner or later business processes and, thus, their supporting technologies, such as web services, workflow scripts (e.g., BPEL, BPMN), data schemas (e.g., XML, XSL) will need to be changed. In general, this is a problem of both evolution and adaptability of applications.

Fusing traditional business practices with newly developed IS creates new challenges for enterprises to balance between business agility and control. Thus, it is difficult to determine the impact of key decisions, deploy cross-functional initiatives, optimize key resources and funding, and streamline communication between business and IS without a clear strategy that identifies the relation between business change and IS implementation. This has highlighted the need for more powerful concepts, techniques and tools for improving the construction of an IS and for aligning the system to the enterprise business goals and processes.

A key challenge that is addressed by the approach presented in this paper is "How can system developers be guided and supported by appropriate tools to apply *co-evolutionary* design methods where both enterprise capabilities and system functionalities need to evolve to remain relevant?". To address this challenge, it has been argued that a paradigm shift is required, one that considers the development and operation of an IS as a continuous *knowledge-based activity* (Yu, 2009) utilizing conceptual modeling (G. Guizzardi, Wagner, Falbo, Guizzardi, & Almeida, 2013) as a way to bring together an understanding of complex enterprise phenomena and an attempt to design IS solutions that support agility and dynamic change. This paradigm shift is based on three principles: (a) Systems thinking that considers independent components that form a unified whole (Kawalek, 2004; Wilby, Macaulay, & Theodoulidis, 2011); (b) Abstract thinking implying that one moves away from the physical manifestation of processes (Hans-Georg Fill, 2014); and (c) Operational thinking that considers the dynamics of a business process and in particular its behavior over time (Sterman, 2000). In terms of processes involved there are essentially two activities: (a) *model building and critiquing* and (b) *simulation and group deliberation*. Models are mainly built by analysts with input from domain experts and are subsequently critiqued and revised by these experts. Analysts also

facilitate simulation sessions where model parameters are instantiated by stakeholders. Consensus building stakeholder workshops develop scenarios that facilitate deliberation of alternative future realizations. The new challenges faced by system developers may be summarized as follows.

First, the *design requirements* problem succinctly pointed out in (Brooks, 2010) can now be stated as follows: *What is the emergent behavior and dynamics of the software artifact and its environment in their evolutionary trajectory?* Now users, designers and other stakeholders need to ask: will the system continue to satisfy our emergent goals, and what those goals could be expected to be during the artifact's lifetime; in contrast to the older problem: what are the (fixed) goals of the system and what is it expected to do?

Second, the *specification* problem can be stated as follows: *How can designers anticipate and represent the emergent behaviors of the system and its components and how does the resulting system behavior conform and relate to emerging environments and the notations used to represent and predict it?* Accordingly, designers need to ask how they can represent, communicate and analyze increasingly complex and dynamic systems and their emergent requirements, and how this is possibly conditioned by the nature of presentations brought to bear in the design context in contrast to the older problem: how to faithfully represent the system components, their relationships and behaviors in ways that guarantee that these meet functional and non-functional requirements?

Third, the *predictability* problem of designs can be stated as follows: *How does the artifact and its behavior change the environment as to make our predictions of system behaviors faithful?* In other words, now designers need to attend more closely to the continuous dynamic composition of the system and its environment, and how do they together differ from the environment in separation. Designers need to predict faithfully the impact of the system on the environment, and vice versa. This is a different problem from those faced earlier where the system was assumed to not affect the environment, or the environment the system, with rare exceptions.

These three perspectives are addressed in this paper based on the notion of a multi-perspective approach for knowledge-intensive systems that involve the intertwining of business practices, human activities and IS systems (Fayoumi, Loucopoulos, & Fayyumi, 2013). This approach is applicable for intelligent emergent software applications where the focus needs to be shifted from engineering of individual systems and components towards the generation, adaptation and maintenance of software-intensive ecosystems consisting of software, hardware, human and organizational agents, business processes and more. We use conceptual modeling for (i) modeling key aspects of the enterprise, (ii) reasoning about design choices and (iii) supporting strategic decision-making through simulations. The resultant benefit from this multi-perspective approach is a systematic way of analyzing and designing robust intelligent IS that can respond in an efficient and effective manner in changes to the business model of an enterprise as a response to either internal or external factors. We demonstrate the approach through a case study focusing on the design of a marketing strategy.

The paper is organized as follows. Section 2 briefly discusses standards and best business practices that are relevant to both business and IS. This section deals with the state-of-the-art of enterprise architecture, enterprise modeling and related modeling standards. Section 3 introduces the way in which our approach is designed to fuse business practices into a formal set of conceptual

models to assist with the reasoning, simulation, and development of IS components. Section 4 illustrates the approach with a case study and then presents an evaluation of the results. Section 5 concludes the paper with a review of the approach, theoretical and practical insights and finally a reflective discussion on potential future directions for research.

2. BACKGROUND AND RELATED WORK

2.1 Standards and best practices in Business and IT Management

As part of the continuous development of business practices, several frameworks, standards, and models have been proposed for improving and benchmarking industrial activities. These were developed with a focus on various business levels (strategic, tactical, and operational). For example, balanced scorecard (BSC) provides an integrated framework in which to implement, control, and measure strategy from the different perspectives of an organization's performance. This assists with high-level managerial decision-making by linking different aspects of the organization together. This framework has been widely adopted by organizations and industry. As presented in Kaplan and Norton (2004), the BSC is used to align four aspects of business strategy—customer, finance, internal business processes, and learning and growth—in order to measure an enterprise's performance. The four aspects of the BSC provide a balance between short-term and long-term objectives, between desired outcomes and the performance drivers of those outcomes, and between soft and hard objective measures. Its main limitation is that it takes time to plan and implement a mature BSC strategy, which prevents organizations from adapting quickly in a dynamic environment.

Total quality management (TQM) is another well-known standard and was one of the earliest to be developed. TQM is based on a strategic approach that focuses on maintaining existing quality standards while making incremental improvements. Some practitioners see TQM as a cultural change initiative, as the focus is on establishing a culture of collaboration among the various functional departments within an organization so as to improve overall levels of quality (Hellsten & Klefsjö, 2000). However, the issues of flexibility, cumulative shared thinking, and enhanced communication were subsequently addressed in the Hoshin Kanri approach of lean strategic development (Jackson, 2006). TQM is often associated with the development, deployment, and maintenance of organizational systems that are required for various business processes (Black & Porter, 1996; Hellsten & Klefsjö, 2000). Other standards, for example, the six sigma approach, have a stronger operational focus. Primarily, six sigma is a problem-solving process that helps to ensure that processes are fully effective. It is an intensive, data-driven approach that focuses on how to eliminate the defects from any process and covers all services, from manufacturing to transactional. The difference between TQM and six sigma is that TQM tries to improve quality by ensuring conformance to internal requirements, whereas six sigma does so by reducing the number of defects within the process. Six sigma relies on intensive quantitative measurement and analysis. Businesses that want to maintain sustainable growth by using the six sigma approach focus on the following four process areas (Hellsten & Klefsjö, 2000).

- The strategic portfolio renewal process: defining and developing the product and technology portfolio.
- The strategic R&D process: basic research and development of technologies.
- The tactical design engineering process: product commercialization.
- Operational production and support engineering: port launch support services.

Other standards focus on value creation and delivery, such as the value reference model (VRM). The VRM provides the main processes of each individual unit in the value chain with a reference for the key issues to consider. These issues support planning, governance, and execution by setting objectives to increase the performance of supply network. The key elements of the standard VRM include inputs/outputs, metrics, and best practices. The VRM uses a process-based, common language syntax and semantics to build the foundation for successfully implementing a service-oriented architecture (VCG, 2012). It includes best practices and quality processes in value/supply-chain activities. There are six business functions of the value chain: (1) research and development; (2) the design of products, service or processes; (3) production; (4) marketing and sales; (5) distribution; and (6) customer service. The VRM helps to identify and quantify opportunities to add value within a process of change in each of the six business functions. However, it is limited in addressing issues around the realization of complex, dynamic, and extended enterprises, where value is embedded in a long, complex chain of triple-effect influences (VCG, 2012). In Rummler's performance management and measurement framework (Rummler, 2007) the author argues that most information technology (IT) problems stem from a lack of understanding of the business environment. He proposed a framework based on the concept of a "value creation hierarchy", which is made up of five levels: (1) the super system; (2) value-creation systems; (3) primary processing systems; (4) the process level; and (5) sub-process/task/sub-task. The Rummler framework, along with its nine performance variables model, has a proven industry record of improving performance. It resulted in the development of the wider artifacts framework, which considers the organization as an open system.

Some other open standards help in benchmarking the processes of re-engineering business activities. One of these methods is the American Productivity and Quality Center's (APQC's) process classification framework (PCF) (APQC, 2009), which is used to identify and improve a wide spectrum of business processes and workflows; for example, product design, manufacturing, shipping, customer service, and support. The PCF was first developed in 1992; since that time it has continued to evolve and improve to meet organizations' expectations and requirements and is still frequently updated to reflect new enterprise categories, processes, definitions, and key performance indicators. The PCF categorizes more than 1,500 operating and management processes and associated activities into 13 enterprise levels (APQC, 2009). Likewise, the business process maturity model (BPMM) is a benchmarking specification (BPMM OMG, 2008). The BPMM is based on five levels, similar to the capability maturity model integration (CMMI) model (Godfrey, 2008). However, the BPMM is business-focused, while the CMMI is information-system focused. The BPMM provides detailed practices for maturity levels, BPMM design, process areas, process area threads, process area goals, process area practices and sub-practices, guidance for practice topics, and process area templates. While CMMI focuses on the maturity and capabilities of the organization from IT point of view. CMMI assume that the maturity level is highly depending on the control processes that use IT systems.

There are further standards relevant to IT quality and services. The information technology infrastructure library (ITIL) is a set of concepts and practices for information technology services management (ITSM), development, and operations (Steinberg, Rudd, Lacy, & Hanna, 2011). The ITIL provides a foundation for quality IT service management by using documented, well-established processes that cover the whole service life cycle (Steinberg, et al., 2011). Similarly, the control objectives for information and related technology (COBIT) specification provides maturity models for controlling IT processes (Goldman & Ahuja, 2011). These allow management personnel to identify where an organization stands currently and map this to where it aims to be in relation to the best in

class in its industry and to international standards. COBIT's management guidelines are generic and action-oriented. They are concerned with justifying costs and benefits, identifying critical success factors, creating performance indicators, and planning for and mitigating risk. In addition, all of this can benefit from the practices of benchmarking how other companies implement their control and governance and how they measure and compare what should be implemented as strategies, operations and IT (Hardy, 2006). [Table 1](#) provides a summary of the reviewed business best practice models.

Formatted
Script Font

TABLE 1: BUSINESS IMPROVEMENT INDUSTRY STANDARDS

Specification	Reference	Description
BSC	(Humphreys & Trotman, 2011) and (Goldman & Ahuja, 2011)	Framework for financial and non-financial measures (customer, internal business processes, and learning and growth) aligned to strategic goals.
VRM	(VCG, 2012)	Value focus processes within six business functions of the value chain: (1) research and development; (2) design of products, services, or processes; (3) production; (4) marketing and sales; (5) distribution; and (6) customer service. VRM has been evaluated to fit more enterprise architecture projects than other supply-chain reference models such as SCOR.
Rummler	(Rummler, 2007)	Framework to measure performance within three dimensions (goals, design, and management) within five levels for each (super-system, value creation, organization, process, and performer).
APQC	(APQC, 2009)	Process classification frameworks (PCFs) act as a business process taxonomy. The APQC outlines all of the processes practiced by most organizations, categorizes them, and aligns them according to a hierarchical numbering system within thirteen categories.
TQM	(Hellsten & Klefsjö, 2000) and (Black & Porter, 1996)	Total quality management (TQM) is a management approach to long-term success through customer satisfaction. It covers most of the management aspects and engages all the stakeholders in improvement processes.
Six Sigma	(Devane, 2004) and (George & George, 2003)	Focuses on process improvement and aims to reduce defects and variation in processes. Focuses on measuring operational processes quantitatively.
BPMM	(BPMM OMG, 2008)	Five levels of maturity based on business process management, total quality management, and organizational change.
CMMI	(Godfrey, 2008)	Process-improvement approach with five levels. Considers different organizational aspects (technology, people, processes, structure, strategy, and management).
ITIL	(Steinberg, et al., 2011)	ITIL is a set of practices/processes for IT service management (ITSM) that focuses on aligning IT services with the needs of the business.
COBIT	(Goldman & Ahuja, 2011)	Framework focusing on IT management and IT governance practices. Aims to close the gaps among control requirements, technical issues, and business risks.

The traditional best practice specifications described above can help by offering a tested ground for solving particular business problems quickly and successfully. Therefore, all these standards can be used alongside our proposed modeling approach. We can classify the practices into the following areas of concern.

- Strategic development
- Value and supply chain activities
- Business processes
- Quality improvement and performance measurement
- IT service quality and delivery

Among these specifications it is difficult to find a comprehensive view of business architecture within a single standard. Each standard sets out practices and processes to be implemented (what), a framework to be used (what), or a methodology to be followed (how); however, one standard rarely covers all of these aspects and none of the standards asks why we need these processes or elements. At the same time, none of the standards considers the alignment between business and IS development. A comprehensive approach to generating, validating, and

applying enterprise-design artifacts is desperately needed. Incorporating cognitive, social, and business methods into the consideration of IS development is the only way to overcome such a challenge; such an approach will provide business stakeholders with the ability to make business decisions, while allowing IT personnel to make technical decisions that are aligned to business goals. In this paper we develop an approach that focuses on bridging the gap between traditional best practices and IS development by building a business architecture. The business architecture will take advantage of conceptual modeling techniques in order to reduce complexity, support decision-making, and enhance expressiveness.

2.2 Enterprise architecture modeling

Enterprise architecture is a field of research and practice that is interested in developing a blueprint of an enterprise's (business and IT) aspects, views, concepts, and supporting tools and methodologies to give business owners a holistic view of the structure and behavior of their organization. Typically, enterprise architecture is divided into strategic, tactical, operational, informational, and technical layers. However, different enterprise architecture frameworks have different methods of viewing and classifying the enterprise concepts (ontology and taxonomy). Enterprise architecture is considered as a powerful approach to providing a holistic view of enterprises, yet the main challenges lie in the cost and time of EA imitative implementation, and its usefulness in supporting decision-making. In the last two decades, many enterprise architectural methodologies have emerged: some of these methodologies are well adopted and widely used, while others have been confined to the theoretical or academic frame.

Some of the most well-known frameworks are TOGAF (TOGAF, 2009), Zachman (Zachman, 2004), and Archimate (ArchiMate, 2012). Others, such as BMM (BMM OMG, 2010), EBMM (Malik, 2011) and the Business Model Canvas (Osterwalder, Pigneur, Smith, & al., 2010) have more of a business focus. Some are designed for more complex systems architecture, such as DoDAF/MoDAF (Martin, 2006). Previous research has divided enterprise architecture into three subcategories: (1) business architecture; (2) information architecture; and (3) technology architecture. A recent development in the area was also presented in (Kang, Lee, Choi, & Kim, 2010) using SBVR based ontology to operationalize and align the components of enterprise architecture focusing on strategies of business, IT and human resource. The intertwining of business architecture with the enterprise's environment plays a crucial role in business landscape dynamics. In practice, to build a business architecture one needs to use enterprise modeling tools, have a business ontology, and have an architectural blueprint.

Enterprise modeling (EM) techniques represent enterprise artifacts, typically with a reference to an EA framework. It has been argued that EM helps enterprises to solve problems and make timely better decisions (Stirna & Zdravkovic, 2015). One of the very important features that must be considered when using EM is how to contextualize EM and how the generated models can have an immediate impact on business. Another issue is that EM needs to focus on modeling the future and support business and organizational change. However, so far few enterprises managed to create a real value of their EM effort (Stirna & Zdravkovic, 2015).

A number of business modeling languages have been proposed to fulfill particular elements of business (e.g. rules, decisions, goals, processes, organization structure, value proposition...etc.) and they have been used successfully in industry and in academia. For instance, e3-value is a value-

oriented modeling language and tool that focuses on creating and delivering value within and among businesses and organizations (Gordijn, 2002). The *i** framework was proposed in the early 1990s for capturing and analyzing early requirements (Gordijn, Yu, & van der Raadt, 2006). However, since that time the framework has evolved significantly and has been applied to many areas of IS and business, including strategic and operational modeling (Samavi, Yu, & Topaloglou, 2009). In addition, the Business Rules Group specification of the semantics of business vocabulary and business rules (SBVR) (S. OMG, 2006) is a well-known standard. The SBVR aims to identify business concepts, business vocabulary, and related business facts, which can then be used to construct rules based on the domain concepts and facts and aligned with business objectives. The SBVR is a controlled natural language based approach; it has formal structure and semantic to allow mapping language to IS development. (Reynares, Caliusco, & Galli, 2015). Another recent business modeling specification is the Decision Model and Notation (DMN), which provides the constructs needed to model business decisions in the form of visual notation and an approach to automating decisions in ISs (D. OMG, 2014).

Besides the development of the enterprise architecture frameworks and modeling tools, there was a corresponding effort in academia to advance the enterprise modeling field. One of the recent and interesting approaches to EM presented by Frank (Frank, 2014a) called the Multi-Perspective Enterprise Modeling (MEMO). It is based on three levels of abstraction (meta-modeling) semantic and syntax languages specification. The levels were created to ensure interoperability, integrity and transformability of the models, it integrates several enterprise perspectives' concepts into one robust meta-model helps to develop domain-specific modeling languages (Frank, 2013). The MEMO approach suggests building new modeling languages (notations) as well as their meta-models (concept semantics) and underlying foundation (interoperability semantics). It is considered a powerful conceptual modeling technique for information systems development, it can be evaluated as a perfect candidate to build domain-specific modeling languages, with strong semantic and syntax capability. One important limitation we found is that the approach does not recommend any way for optimization and simulation, it doesn't show anyway how MEMO can simulate, quantify and predict different scenarios with different configurations. In later research, Frank (Frank, 2014b) suggested that cognitive modeling is important for design rationale and justification of decisions. In his proposal he suggested that the power-modeling should consider approaches that focus on three aspects 1- productivity and quality, 2- implementation and 3- user involvement.

In other recent developments in the area, (Bērziša, et al., 2015; Danesh, Loucopoulos, & Yu, 2015) propose a capability oriented enterprise modeling, focusing on how enterprises design, develop and deliver particular business capability. The work proposed meta-model and set of modeling tools to measure the value and impact through the enterprise development lifecycle. In (Maria-Eugenia Iacob, Dick Quartel, & Henk Jonkers, 2012) the authors propose an extension to ARCHIMATE meta-model with the notion of capabilities, resources and value to enable strategic alignment of technical projects. Building upon this work, Azevedo, et al. (2015) argue that the subjective nature and usage flexibility of the notion of capability, can result in multiple interpretations of the dependencies between capability-related concepts and other elements of the enterprise architecture and stress the need for a more rigorous conceptualization of capability. To this end, they discuss the semantics of the capability-related concepts proposed in (M.-E. Iacob, D. Quartel, & H. Jonkers, 2012) in terms of the Unified Foundation Ontology (UFO) (Giancarlo Guizzardi,

Wagner, Almeida, & Guizzardi, 2015) and reveal a number of additional relationships between capability and the structural and behavioral elements of the enterprise architecture.

Another important enterprise modeling foundational approach developed by Karagiannis and Kühn (2002) helped the development of what is called 'meta-modeling framework' as a core of the enterprise modeling approach. The meta-model approach consists of two main elements: 1) modeling technique, which has to identify a) modeling procedure and b) modeling language; and 2) modeling mechanisms which describe the underlying elements of how the model will be executed logically and mathematically. This approach has been used to develop interoperability framework for model-based enterprise engineering (Hinkelmann, et al., 2015).

3 TOWARDS THE DEVELOPMENT OF INTELLIGENT EMERGENT IS

3.1 The foundation: Conceptual modeling

Conceptual modeling can help to identify and visualize concepts, enabling us to gain an understanding of how some uncertain elements influence businesses (Mylopoulos, 2008; Robinson, 2010). Historical patterns can assist us to predict the future through a process of learning but, however, it cannot guarantee the accuracy in understanding either historical patterns or prediction of any future ones. An important goal of this effort is to try to reach the best possible level of wisdom when making decisions. Analysts describe their understanding of the world using a particular language that is driven by their perception of reality, and this is exactly what the conceptual model is about. Conceptual modeling can support cognitive argumentation; humans create the semantics for concepts in order to obtain a more realistic and formal view of reality. This conceptual model can be made robust and formal by using one of the semantically and syntactically mature modeling notations proposed in the last three decades (Gregory, 1993; Yucong & Cruz, 2011).

Implementing software systems or simulations is a matter of simplifying reality (Robinson, 2010); however, conceptual models can represent the reality of the 'current situation' or a vision of the 'desired situation'. It can also describe problems or solutions such as implementing software systems or simulations which considered as a matter of simplifying reality (Robinson, 2010). Conceptual modeling can be considered as the first phase of design rationale (Regli, Hu, Atwood, & Sun, 2000), as a simulation (Robinson, 2008), or as a way of capturing and organizing an information systems development knowledge in the development of software and systems (Mylopoulos, 2008; Rolland & Prakash, 2000).

Using conceptual modeling techniques allows the model artifacts to be mapped to other models (model transformation) without losing any of the necessary design characteristics (Karagiannis, Fill, Höfferer, & Nemetz, 2008). Since conceptual modeling is a form of simplification, the focus will be only on the aspects understood by the designer to be necessary for the design. As such methods require regular updates by domain modeling experts, the model will represent a robust view of the conceptualized business domain artifacts and their relations in order to aid the development of business architecture and IS. For the purpose of formal development, it is crucial to use formal notations to build detailed conceptual models. Additionally, in order to bridge the gap between business and IS we need to use formal modeling techniques that have robust structures, syntax, and semantics to allow code-generating and algorithm-building during the later stages.

3.2 The approach

Conceptual modeling is presented in our approach as a basis for the simulation process (as in Robinson (2008)), the software design and implementation process (as in Rolland and Prakash (2000)), and for reasoning based on Lamsweerde's (2009) and Louridas and Loucopoulos's (2000) work.

We focus on business architecture to build a mediation layer to bridge between business best-practices and information system development, business architecture is defined as "a formalized collection of practices, information and tools for business professionals to assess and implement business design, and business change" (Baudoin, Covnot, Kumar, LaCrosse, & Shields, 2010). It provides a holistic view of business objectives, policies, governance structure, capabilities and resources; it also describes elements of business processes, rules and extends into the wider market and supply network design (Versteeg & Bouwman, 2006). The successful business architecture is measured by the extent of business visibility, the ease of analysis, the identification of emerging behavior or elements, agility in response to change. Business agility is usually measured by an organization's ability to sustain and increase business advancement in a rapidly changing environment.

The enterprise engineers or designers will build mediated business architectures in order to give formal descriptions to business practices so that they can be transferred to IS specifications. A business architecture provides a critical input to IS planning and architecture, and helps deliver business solutions that are aligned to business strategy. There is also a feedback relationship between technology and business and between trends in technology and capabilities of IS. Both of these relations influence business-design choices in the realms of how best to automate business capabilities, value chains, processes, and channels. An organization's business model, goals, structure, and other artifacts need to be considered in terms of how business architecture can become a value-added, business-focused discipline within the organization.

The lack of business design is a result of the need for better and more mature insight. Enterprises need a blueprint for their own business in order to respond appropriately to business change; they also need to understand how their business relies on and is intertwined with IS architecture. Strategic and tactical requirements drive solutions that are reflected in the future 'to be' state of the business architecture. In turn, the 'to be' business architecture allows IS to more concisely articulate the future state of the IS architecture. Business and IS can then craft a collaborative approach to keeping business and IS synchronized through various business and IS transformations.

[Figure 1](#) ~~Figure-1~~ illustrates the suggested generic approach.

[Figure 1](#) ~~Figure-1~~ illustrates the high-level components that need to be considered. Appropriate business architecture, supported by reasoning, decision-making and methods to rectify any negative impacts that could be caused by making these strategic decisions, must be implemented by looking to different alternatives on the level of enterprise motivation. In addition, the decision-making related to business design is influenced by the capability of IS; balancing the control and monitoring of business activities between business people and IS staff is essential and should be based on the limit on the services that the IS architecture can provide. In business-driven IS there are clear lines of feedback

from the business environment, enterprise capabilities and motivation to business design decisions. There is another line of feedback from the IS architecture and monitoring to business environment which can be done by analyzing historical performance.

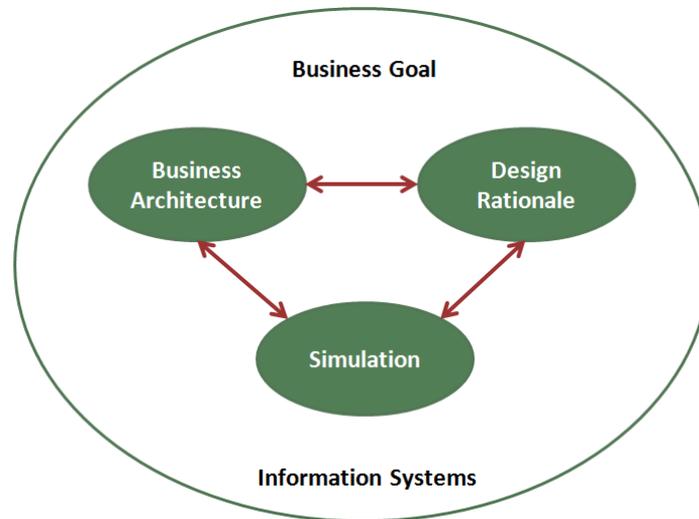


FIGURE 1: THE GENERIC COMPONENTS OF THE APPROACH

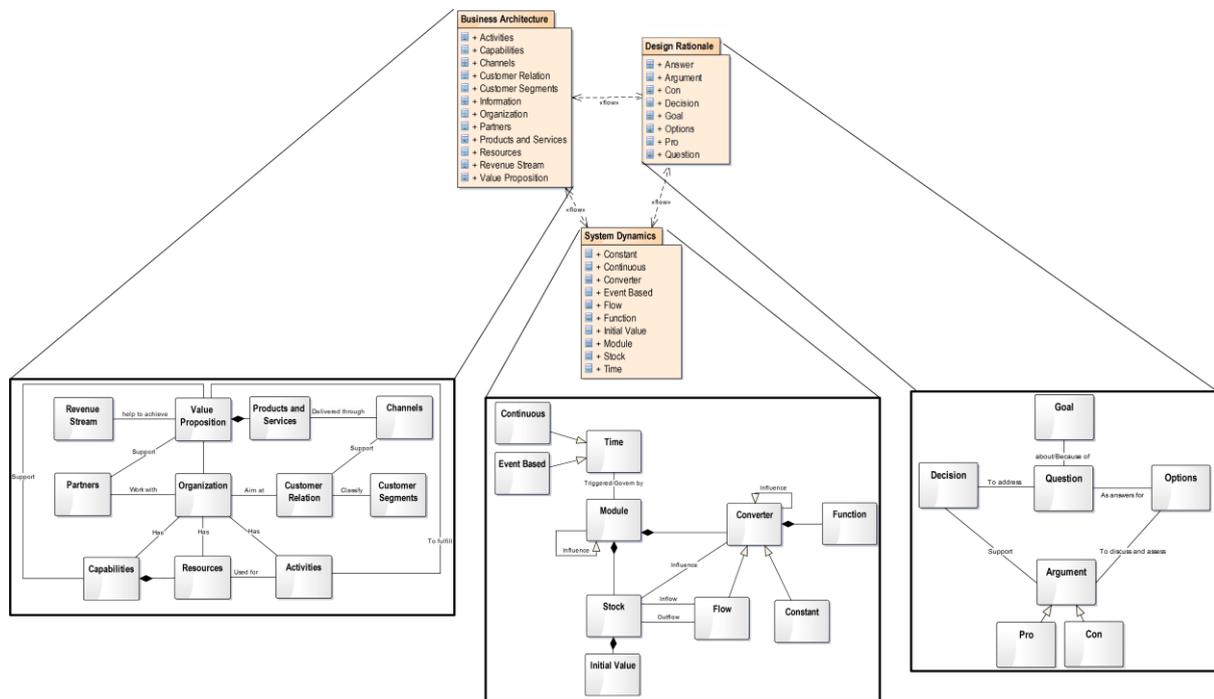


FIGURE 2: META-MODEL OF THE APPROACH

In order to implement the three components of the approach, we develop a modular meta-model, which means that the designer will take responsibility of understanding the enterprise context and decide what is the most suitable meta-model to use. For instance, in this paper we suggest using the business model canvas (Osterwalder, et al., 2010) for implementing business architecture and this can be replaced in different scenarios based on the designer preferences and the enterprise requirements. Similarly, in the second component we will use the system dynamics to fulfill the

simulation task, the system dynamics simulation can support simulation tasks for discrete and continuous time, also it can support importing historical data to enhance predictive analysis under a set of simulation constraints. The system dynamics modeling is based on a stock-and-flow diagram (Sterman, 2000). Finally, the design rationale for qualitative reasoning will use the enhanced Goal, Question, Options, Criteria (GQOC) to structure the reasoning argument, some other design rationale argument structures presented in (Regli, et al., 2000). [Figure 2](#) illustrates the interaction of the main approach's components (business architecture, design rationale and system dynamics simulation) and the meta-model of each one:

In business architecture, the use of conceptual modeling techniques aims to structure the approach to modeling and understanding holistic business knowledge and give business managers the insight they need to make better decisions. In addition, business architecture modeling allows a smooth transition from business to IS or enables enterprises to build 'business-driven ISs' by mapping the business artifacts to the appropriate IS artifacts. The key reasons to consider business architecture are that it enables businesses to:

- Align strategy, operation and IS implementation;
- Understand systemic implications and risks;
- Support decision-making;
- Manage business change by increasing agility and visibility;
- Optimize business and utilize resources;
- Provide a foundation for continuous improvement; and
- Define services accurately, in a way that represents business capabilities and fulfills activities in the business processes.

To simplify the way how the approach can be used, we propose using patterns that aid analysis and design and allow experts to construct simulation and implementation models. [Figure 3](#) shows a process of mining patterns; the process begins with recognizing patterns by analyzing real scenarios or taking advantage of best practices. Analyst experience plays a major role in the abstraction of patterns, where the patterns are used as a codified chunk of knowledge that can be detailed and then used for simulation and IS implementation tasks. [Figure 3](#) describes how the patterns can be used as part of the proposed approach.

Formatted
Script Font
States), C

Formatted
Script Font
States)

Formatted
Script Font
States)

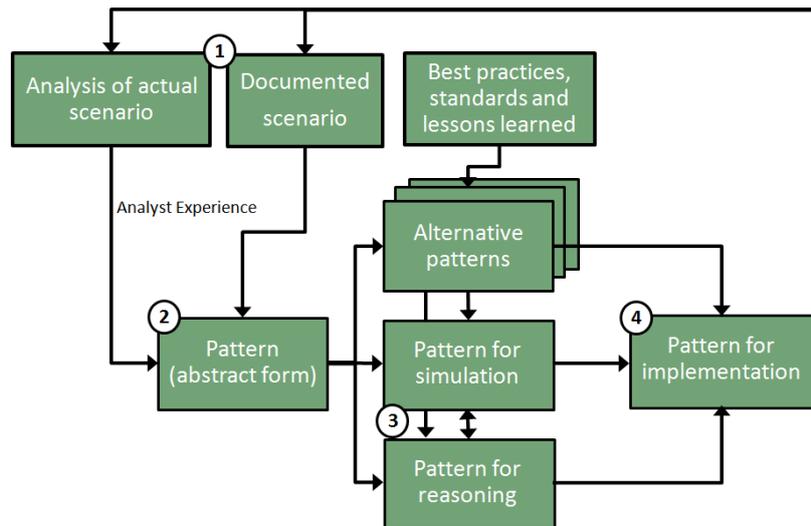


FIGURE 3: INTERLINKING PATTERNS IN BUSINESS AND IS

Our process to realizing our approach's concepts is detailed as follows and is represented in [Figure 4](#).

1. Define business goals: the goal model will offer a description of why the enterprise is doing something and provide refinement on how to do it. In this stage capturing and modeling business goals will be fulfilled using the modeling notation KAOS (A Lamsweerde, 2003).
2. Align business goals to business best practices: after identifying business goals, it is important to understand how these goals should be implemented with respect to some business best practices or standards, so the description of goals and related concepts will be informed by these best practices.
3. Build the domain conceptual model: the domain conceptual model describes the business domain aspect which must be taken into consideration when developing the business architecture for one organization. The unified modeling language (UML) has established grammar (syntax and semantics), the UML object diagram will be used to define the conceptual model. This conceptual model will act as a foundation for further thinking on business architecture design; it will use a design rationale for reasoning and a causal-loop diagram, with its main relation of 'cause and effect', as a formal model for simulation purposes.
4. Develop a reasoning model: to support a business design rationale aligned to the business goals. At this stage we use the design rationale to build argument and matrices (Basili, 1992; Regli, et al., 2000). We follow the GQOC structure, the models should come out with decisions or suggestions to help designers to make decisions on the enterprise design options.
5. Simulation modeling: this stage will provide simulation based on quantitative values to further support enterprise design decision-making. The approach suggests using the system dynamics to simulate business patterns to increase business visibility with reference to the principles of business best practices. After conducting several reasoning and simulation models, the stakeholders should decide and agree on a strategic and tactical business design.
6. Design business operation models: alternative business processes that respond to strategic and tactical aspects will be developed using BPMN modeling notations. This

allows the enterprise to understand the actual operation design and select the most suitable for their vision from one side and their capabilities from the other side.

7. Build rule models: the business behavior should be governed by a set of rules and constraints and decisions. At this stage, the modeling of rules and decision-tables will take place for the selected business process model.
8. Alignment of business processes to IS services: include building use-cases, the enterprise engineer with other stakeholders will decide the IS services that are needed for each business process activity and the way to deploy them. This top down approach will support deploying IS services that are required to support business. The IS services can be either developed in-house, commercial off-the-shelf (COTS) or cloud-based services.
9. Continually measure, evaluate, and assess the situation and any new requirements: after deploying the IS services, the enterprise need to continuously assess if the enterprise including the IS design are achieving the expected outcome. Every enterprise model design either for business and IS needs to be evaluated against pre-defined KPIs against some particular goal which can be either functional or non-functional. Rapid change in information systems design is required to meet changes in the business demand.

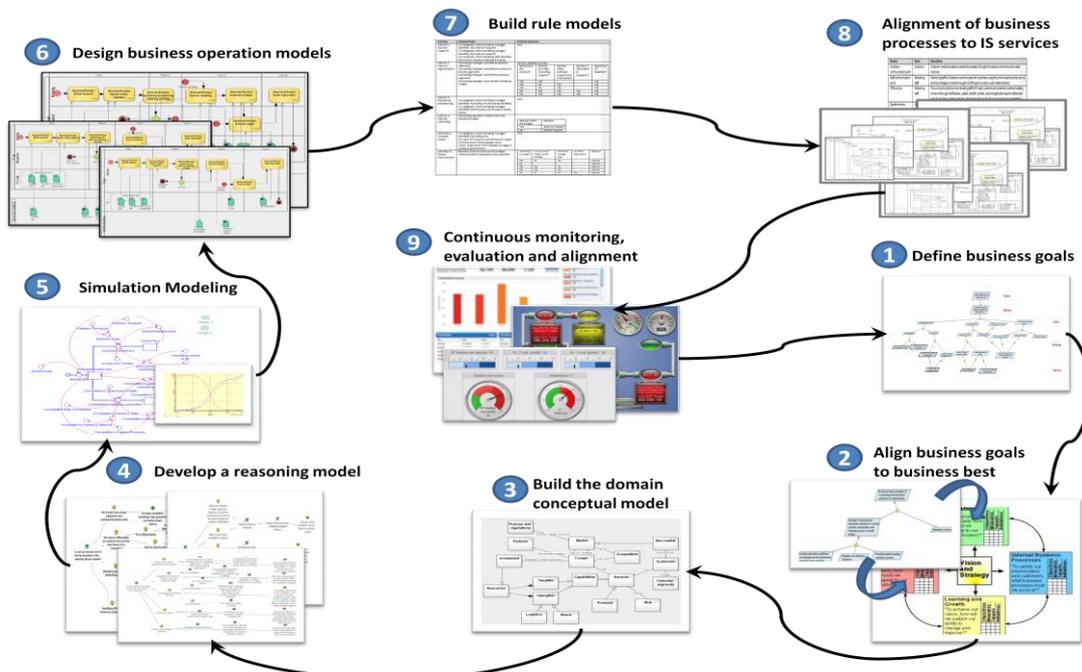


FIGURE 4: IMPLEMENTATION PROCESS

4 CASE STUDY

The case study which is used to demonstrate the approach discussed in preceding sections was carried out during the years 2012-2013, and is based on a real company that for reasons of anonymity will be referred to as 'Learndia'. Learndia is based in Saudi Arabia and specializes in e-learning services. It provides a wide range of services relating to the development of e-learning solutions, providing equipment for classes and labs, technical support, consultancy, and training. The targeted customers would be classified into three groups: 1) universities, 2) government and 3) corporate. Learndia is a small entrepreneurship with no e-learning solutions or products in-house: it relies mainly on vendors' technology. A network of partnerships needed to be established. Additionally, the company could offer to customize and localize vendors' systems for customers, which would require a technical team. The most important aspect of the services that Learndia was looking to provide is consulting and training, from which most of the revenue is expected to come.

Learndia was looking to develop a business architecture and align it with its underlying IS components.

4.1 Define business goals (Goal modeling)

Figure 5 represents Learndia's top-level goals. The goal model represents the shareholders' long-term value as a vision, and describes how to operationalize this through a number of productivities and growth strategies. The goal model feeds into the long-term BSC financial perspective.

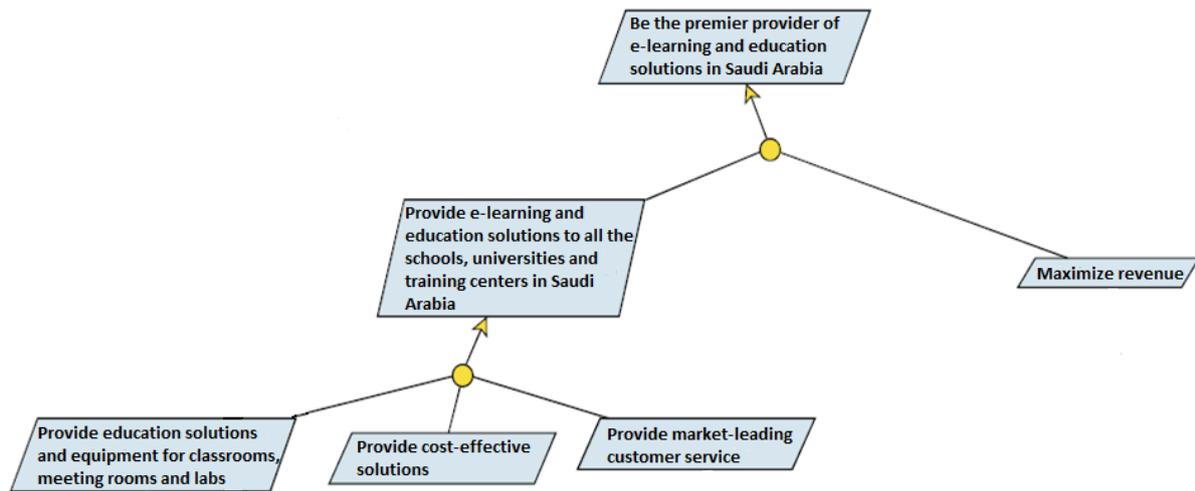


FIGURE 5: HIGH-LEVEL GOAL MODEL

4.2 Align business goals to business best practices

Here we align the goals to the customer-related BSC's principles. We indicated that some principles of the BSC standard are relevant to the customer and market perspectives can be fulfilled using the developed approach. These aspects will be captured from the highest level (strategic goals) to the lower-level operational (internal perspective) and information systems in what we call a vertical alignment. A number of concerns need to be taken into consideration, such as the market size and the targeted market segment. What do customers expect from Learndia's products and services in terms of quality, cost, time, and performance? How can Learndia maintain customer relations and ensure their satisfaction?

4.3 Build the domain conceptual model

Figure 6 presents the conceptual model of the domain concepts in the context of Learndia. It describes the market concepts and their relations and will provide more insight into the context of the business and the development of IS.

The first step in developing robust business model is by understanding the market, country and industry regulations, also identifying customer segments. Learndia needs to identify the investment needed to support their business activities for the short-term strategy. Such as investment will also help Learndia to build their capabilities by procuring the required tangible and intangible resources (human, financial, technical and other types of resources). These capabilities will allow Learndia to deliver the promised services and products to the targeted customers. Also, Learndia should identify their key business partners and the type and level of support expected from each one, business partners are also determined by market analysis and customers' segmentation.

4.4 Develop a reasoning model (Rationale modeling)

Figure 7 shows the model that describes the rationale for the main concerns relating to the customer's perspective. This reasoning process will provide an assessment and answers in response to the issues.

Formatted
Script Font
States)

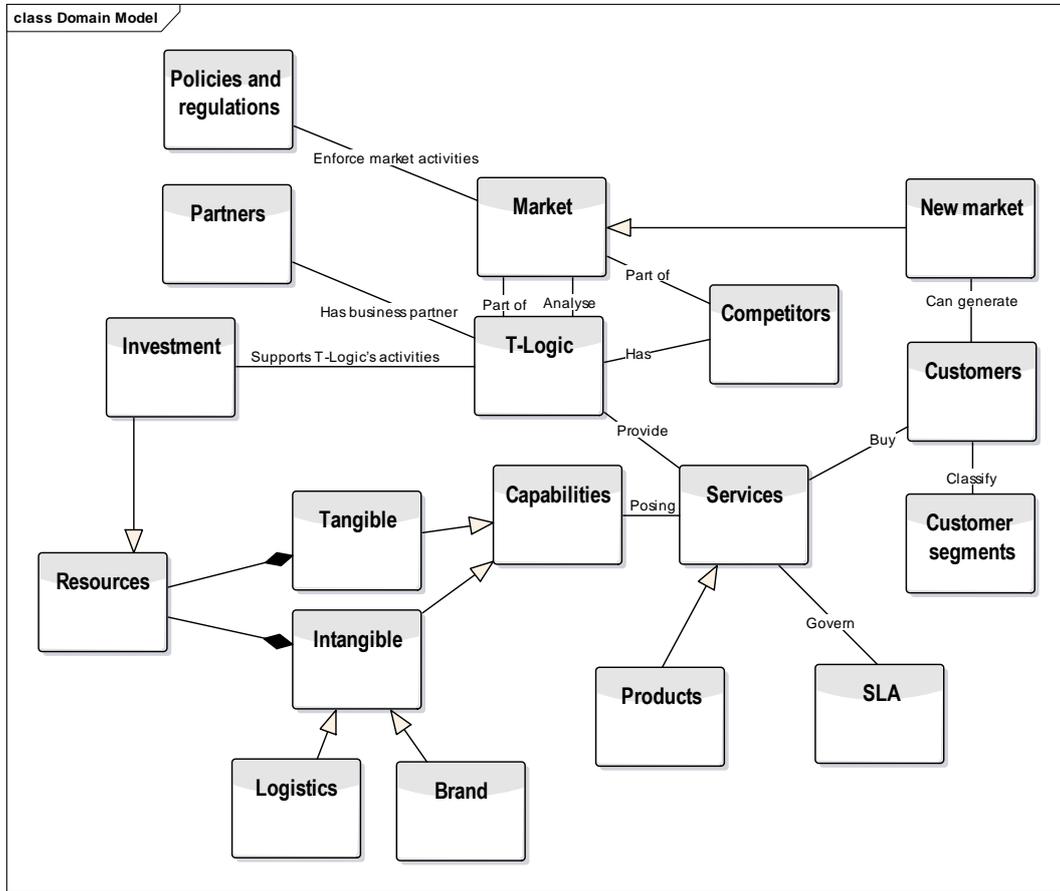


FIGURE 6: DOMAIN CONCEPTUAL MODEL

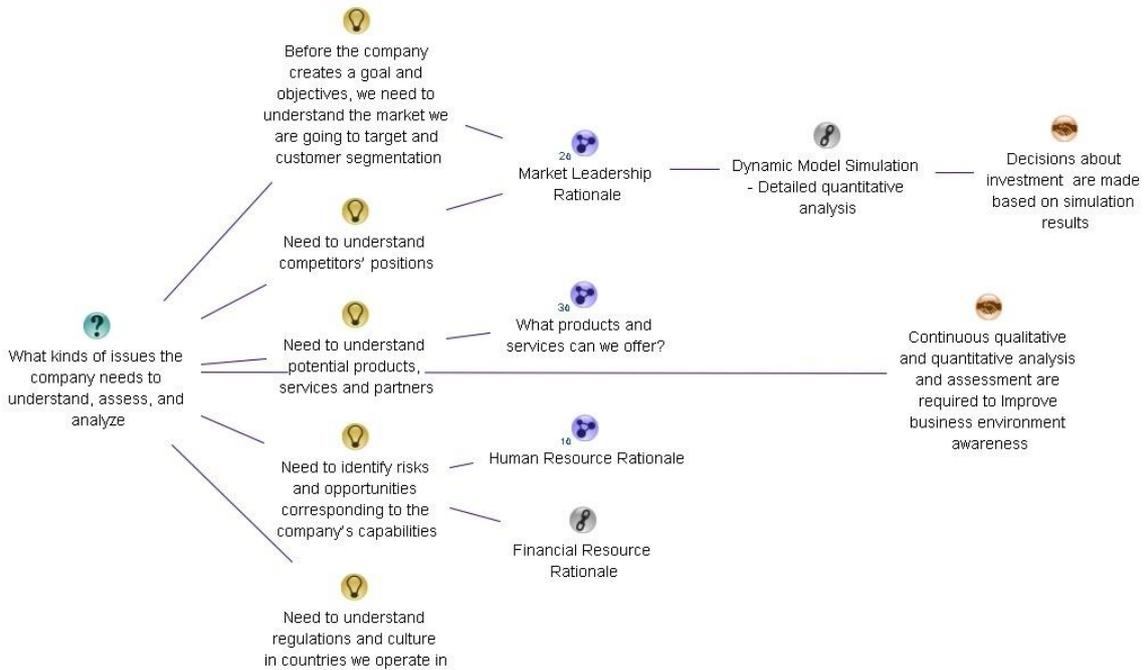


FIGURE 7: MARKET ANALYSIS RATIONALE

The model shown in [Figure 8](#) describes the rationale behind the market leadership objective, the requirements and related issues.

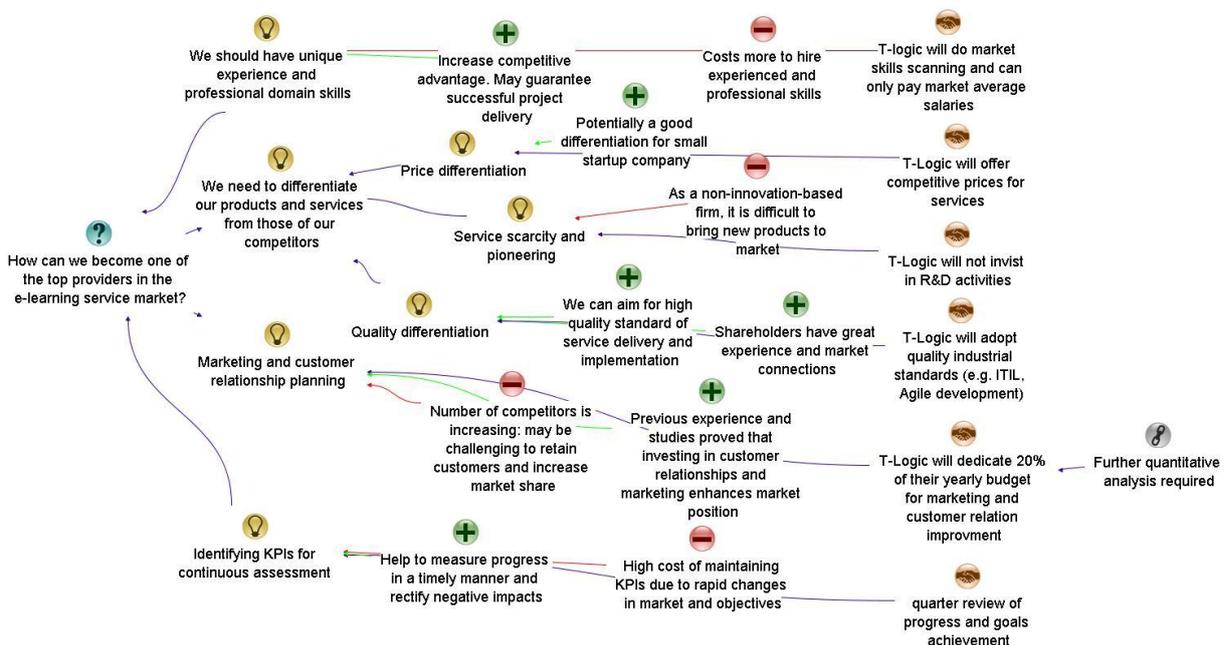


FIGURE 8: MARKET LEADERSHIP RATIONALE

The model in [Figure 9](#) describes the rationale behind the products and services that Learndia can offer.

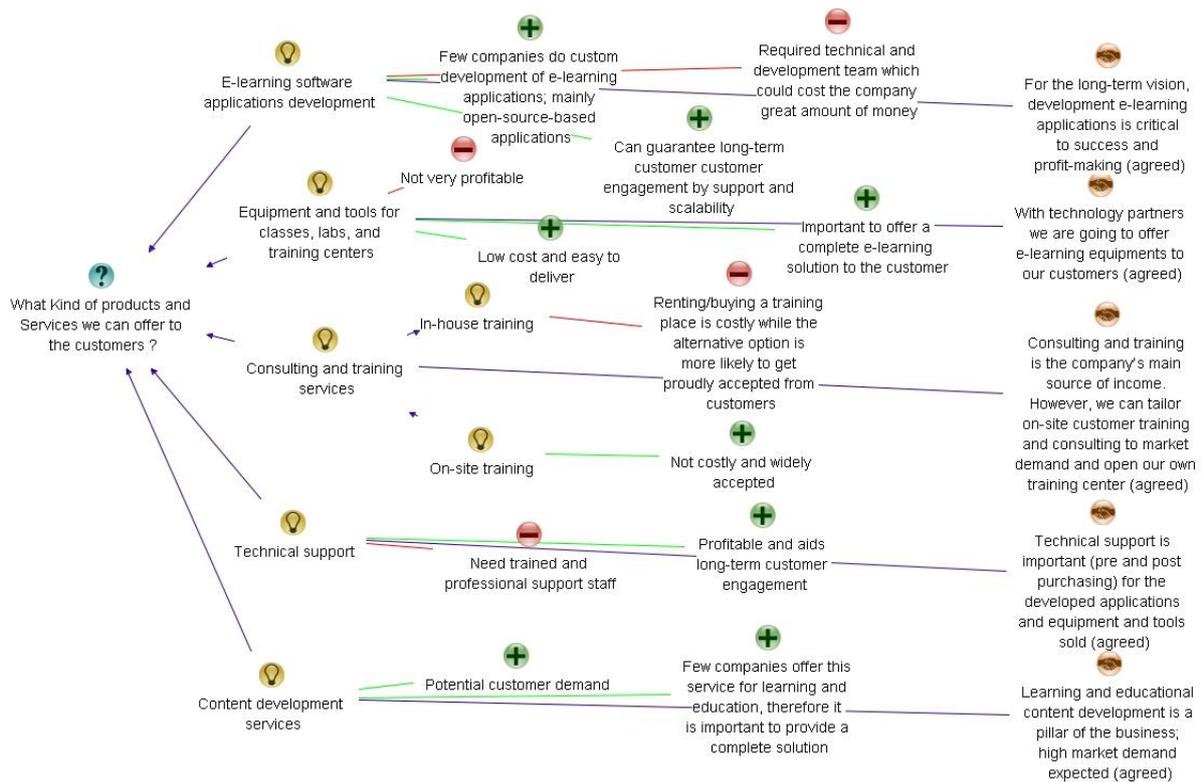


FIGURE 9: PRODUCTS AND SERVICES RATIONALE

4.5 Simulation modeling

Using system dynamics modeling for market analysis to provide a quantitative assessment that supports the decision-making required in the market analysis rationale, we built a dynamic simulation model. To run the dynamic simulation model, a set of influencing factors was identified with Learndia's stakeholders; these factors are shown in [Table 2-Table 2](#). The value of the impact of these factors may change; therefore, continuous evaluation is required. The simulation model, integrated with the reasoning models and design decisions, will be fed into the business architecture.

TABLE 2: INFLUENCING FACTORS

Influencing Factor	Description
Market growth rate	The e-learning market in Saudi Arabia grew by 6% in 2012, and is expected to increase by 8.2% in 2016.
Competitor increase rate	Twelve new SMEs offering e-learning services were registered in 2012, an increase of 2% is expected in every year until 2017.
Customer profile	Market research has proved that the customer profile has an impact on their decision to pay for services. However, the customers' profile here will have the value of increase purchasing expectations by 7% of the total leads. In contrast, a poor customer profile will lead to a loss of potential customers by 14%.
Relationships	Good market and customer relationships will increase potential purchasing by 5%.
Partners' products	Product quality, price, warranty, and features will play roles in market leadership; if a competitor is able to gain more help from its partners then the adverse influence of these factors will increase to 25%.
Partner support	The level of sales support, implementation support, training, and promotion all help to advertise the brand.

Marketing spending	The company cannot rely on word of mouth to advertise its products. The company assumes marketing spend with a k\$ increase acquires customers by fractions: .0001 for each k\$.
Business capabilities	Internal business capabilities, mainly the ability to lead enterprise projects successfully (employee numbers, skills, financial stability, and technical ability) will increase the possibility of more deals.

The model in [Figure 10](#) describes the market dynamics and the factors influencing the numbers of sales and customers gained. The results are based on a simulation run of this model, which assumes that Learndia has better performance in two variables over their competitors: 1) the effort they make to build customer relationships, and 2) the value provided by their business partners are higher. The market influencing factors were identified with Learndia's managers during interviews. The figure illustrates the dynamics of the market, the number of available customers in the country, and the customers acquired by Learndia under certain circumstances in comparison to the average competitor. Four positions are captured to show change in the market over time where Learndia is performing better than the average competitor. In order to understand how Learndia will perform in comparison with all competitors, the value of the average competitor should be multiplied by the number of competitors in the market. In this model, each competitor can be assigned specific values for their influencing factors, which can vary as the simulation progresses based on market position, marketing strategy, or product/service attractiveness. When the competitor spends half as much on marketing as Learndia does, Learndia wins more market share, as shown in the simulation.

Formatted
Script Font
(States)

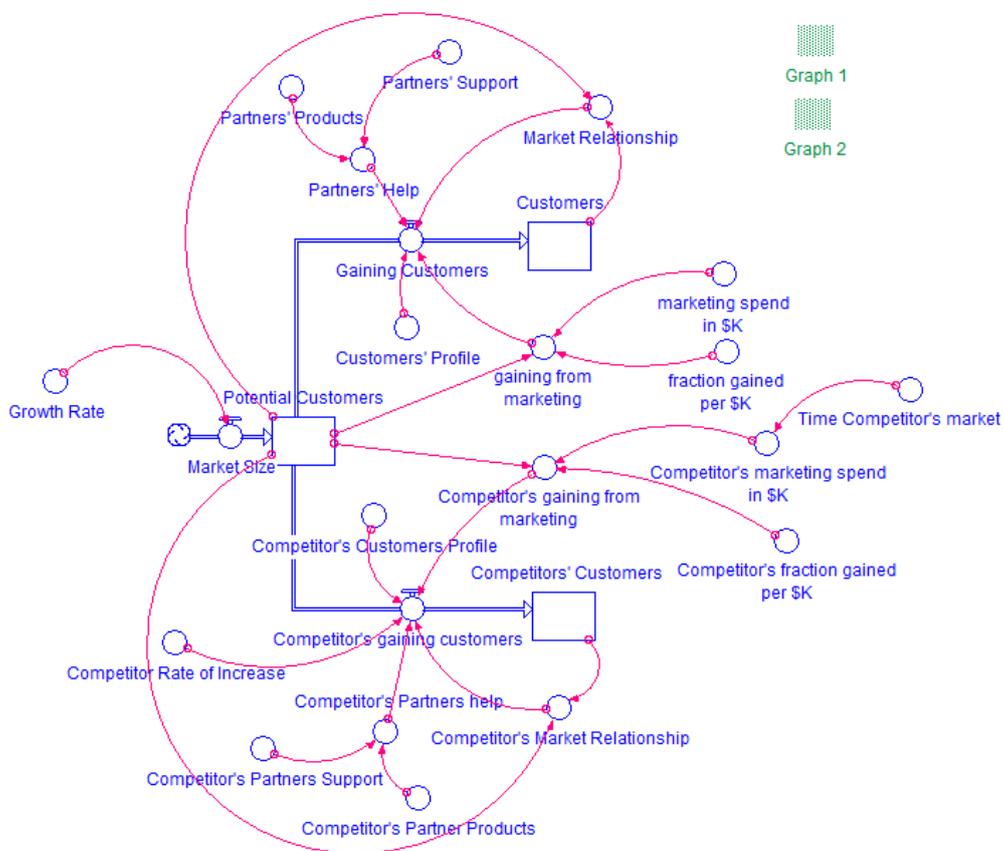


FIGURE 10: DYNAMIC MARKET ANALYSIS MODEL

In this simulation, we assume that the competitor enters the market at the same time as Learndia and that the available potential customers are equal to 100. This is not usually the case in the real world. If all the variable values are equal for both companies, but the competitor company enters the market one year later, the end result will be different. Different values should be given for many other influencing factors, such as market position and market relations. Here, the model includes a variable for the competitor increase rate within the Saudi market: this can be used if we are looking to understand Learndia's market position compared to a group of competitors. Figures [Figure 11](#) and [Figure 12](#) show the simulation result.

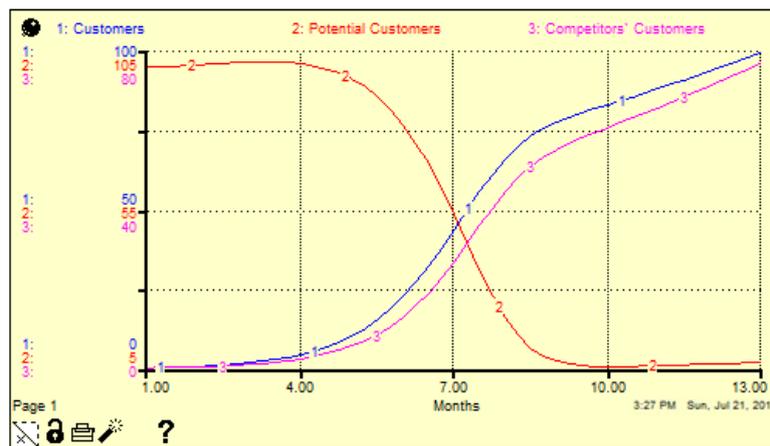


FIGURE 11: SIMULATION RESULT (TIME SERIES)

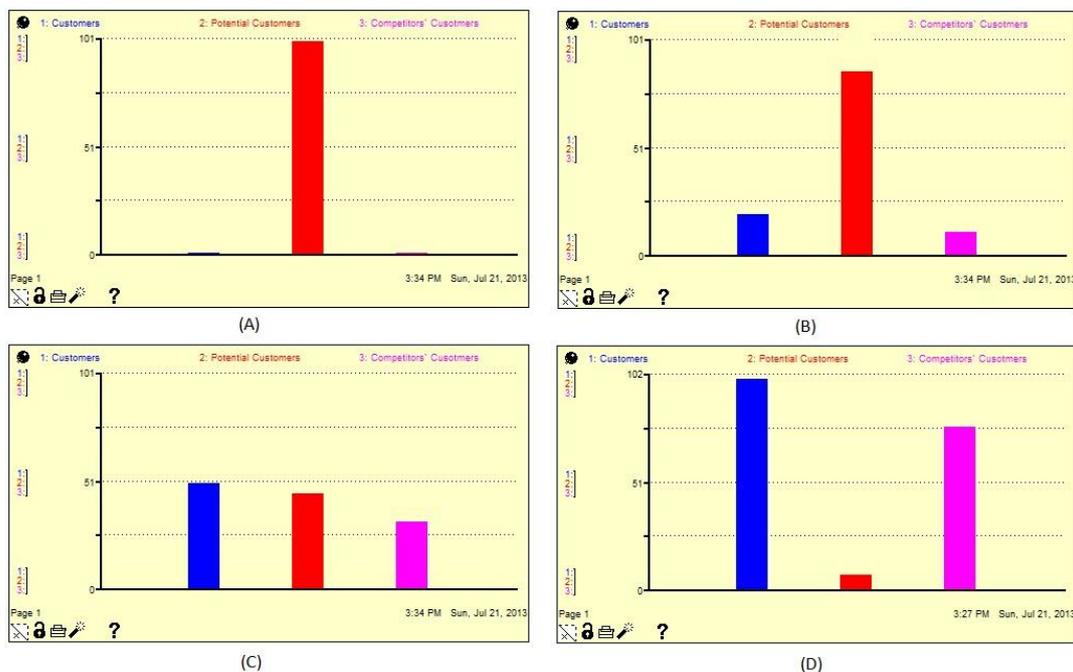


FIGURE 12: SIMULATION RESULT DURING TIME (BAR GRAPH)

Formatted
Script Font
States)

Formatted
Script Font
States)

This model neglected the assumptions related to the factors that influence the e-learning market development for a particular product or service. Also it does not include competitors or customers leaving the market. For an entirely new product or service, the potential market share will likely grow faster than the average market growth. We may want to consider modeling these factors in our future work. However, when modeling a developing market (e.g. Saudi Arabia), it is unlikely for us to be interested in the shrinking of the market that occurs after saturation at this point in time.

4.6 Design business operation models (process models)

To describe Learndia's business processes in this section we provide examples that could be implemented for marketing. Learndia can decide which of the alternatives to implement based on the evaluation criteria specified in [Table 3](#) and with confirmation of the organization's main objectives.

TABLE 3: EVALUATION CRITERIA AND QUALITY FACTORS

Evaluation criteria	Description
Implementation cost	The total cost of the implementation (hardware, software, consulting, training, recycling, security, upgrading, maintenance, and any other relevant issues)
Implementation time	The time required to implement the process and launch it.
Process execution time	The average for executing the process end to end under normal circumstances.
Process efficiency	The ratio of the process performance to the total cost expended.
Process maturity	Measured by level of visibility, control, measurement and agility
Sustainability	The process lifespan with the same level of diversity and productivity. Also it can be determined by the level of scalability, extendibility

A number of operational (process) models were developed to fulfill the particular task of choosing a tactical business design (marketing). This tactical choice was confirmed in response to the strategic goal (to provide market-leading customer services). Several processes were developed to offer Learndia different implementation options, the process design also determined the level and type of technology involved in the process execution.

Process 1: using traditional marketing, the process will use traditional methods of marketing and advertisement. The market research will consist of paper-based questionnaires and marketing through brochures and posters. Networking with potential customers in the major business and technology events will be a key marketing technique.

Process 2: limited use of technology, the process will help Learndia to better manage their marketing documents. Market research will still be done manually, however, the data should be stored and analyzed using software tools. Marketing objectives can be fulfilled by building a website, using email marketing, and deploying mobile and SMS marketing. Customers' information also will be stored in either office documents or lightweight customer relationship management (CRM) application.

Process 3: using e-marketing tools, Learndia can make the most of the available either free or paid e-marketing tools, e-questionnaires, conference calls, online adverts, online forums to execute their marketing plan. Creating profiles/pages on social media such as Twitter, LinkedIn and

Facebook, updating the content regularly, can be of great value and improve communication with customers. A CRM system should be in place to manage customers and potential customers' records.

Process 4: fully automated and intensive digital marketing, this process can provide high sustainability to Learndia, relying on investing in technology such as business intelligence systems and data mining. It requires continuous market analysis by aggregating big data from social media, market researches, CRM and communications with customers or potential customers (call records and emails).

In [Figure 13](#) ~~Figures 13~~ ~~Figure 16~~ ~~16~~ we show these alternative design patterns for marketing processes and their associated descriptive information.

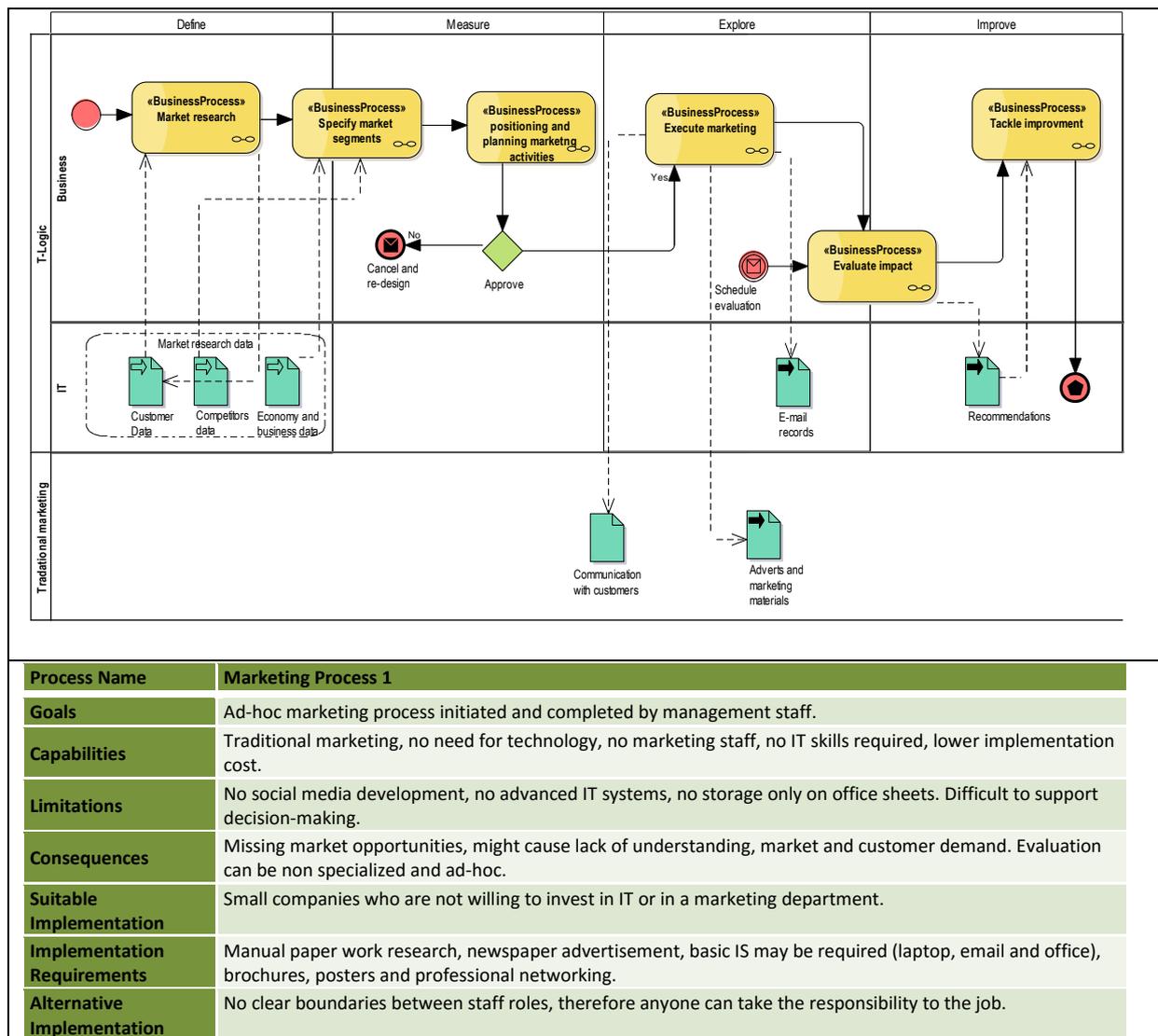
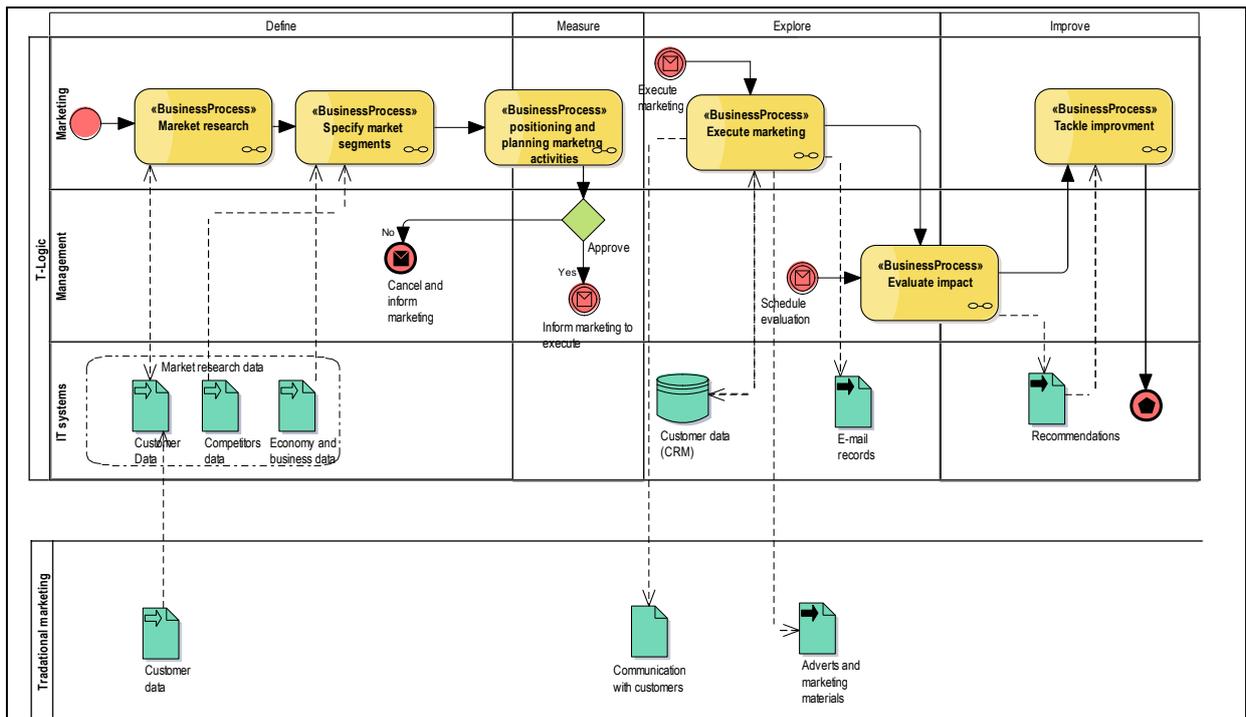
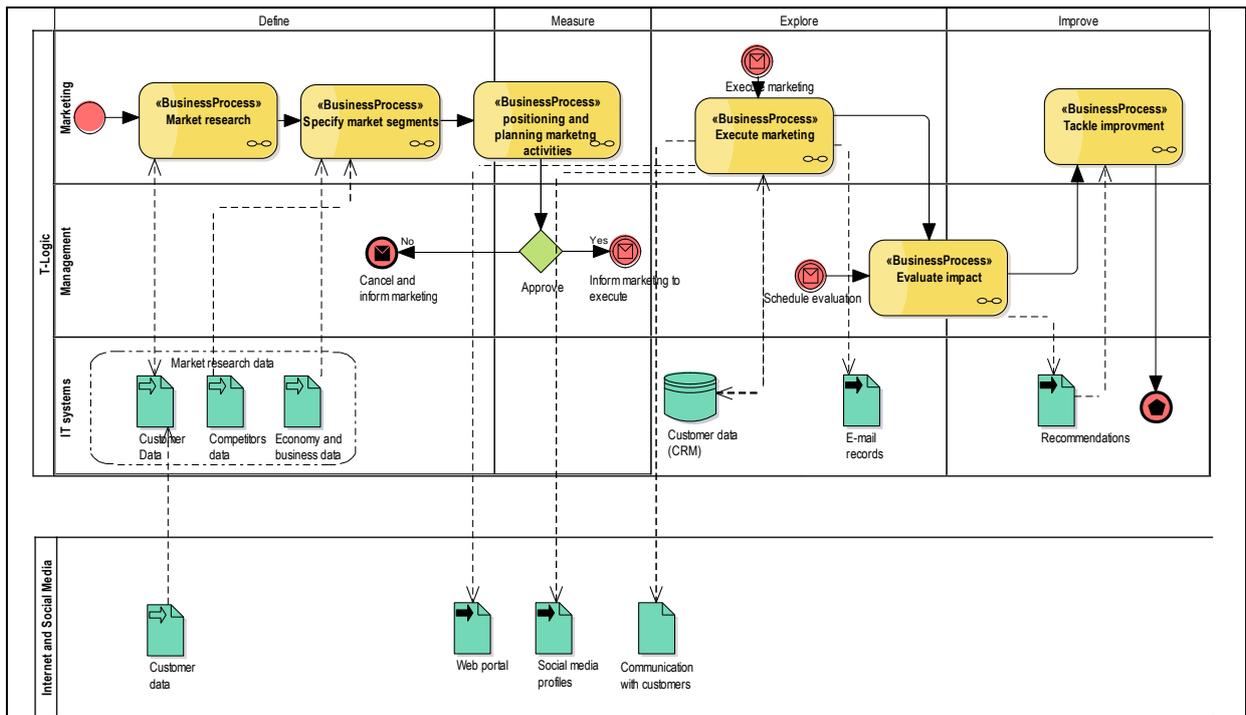


FIGURE 13: ALTERNATIVE PROCESS PATTERNS FOR MARKETING OPERATIONS (PROCESS 1)



Process Name	Marketing Process 2
Goals	Deliver marketing process initiated and completed by marketing department and supported with traditional IT tools.
Capabilities	No heavy investment in technology needed. Relatively low implementation cost.
Limitations	No storage of history and applications, no data analytics or decision-support applications.
Consequences	Missing the opportunity of improving communication with customers, probably less ability to understanding market and customers' behavior. Less ability to understand the company performance. Potential loss of some historical data.
Suitable Implementation	SMEs who are not willing to invest heavily in IT and marketing but still looking for maximum low cost benefit from technology.
Implementation Requirements	Some manual work, office applications, newspaper advertisement, lightweight CRM system and website.
Alternative Implementation	If there is no marketing team, staff at any management level can take responsibility for the advertising, researching and communicating with customers/potential customers.

FIGURE 14: ALTERNATIVE PROCESS PATTERNS FOR MARKETING OPERATIONS (PROCESS 2)



Process Name	Marketing Process 3
Goals	Deliver mature and systematic marketing process initiated and completed by marketing department using IT tools and web-based application.
Capabilities	<ul style="list-style-type: none"> - Use web and online tools/data to support market research - Enhanced communication with customers - Use of social media to present the company - Use of website and social media to communicate with customers - Decision made collaboratively.
Limitations	<ul style="list-style-type: none"> - Not necessary to involve top management - In some cases, it is not enough to have one interview with the candidate.
Consequences	Less high-level management governance
Suitable Implementation	Holding and shareholder companies, universities and federal independent entities.
Implementation Requirements	Marketing and social media staff, database, CRM, website, work flow, communication and ticketing application.
Alternative Implementation	Market research, web development and social media handling can be dealt by external agency (outsourced). Marketing department can take responsibility for evaluation and measuring impact, therefore to suggest recommendations for future direction.

FIGURE 15: ALTERNATIVE PROCESS PATTERNS FOR MARKETING OPERATIONS (PROCESS 3)

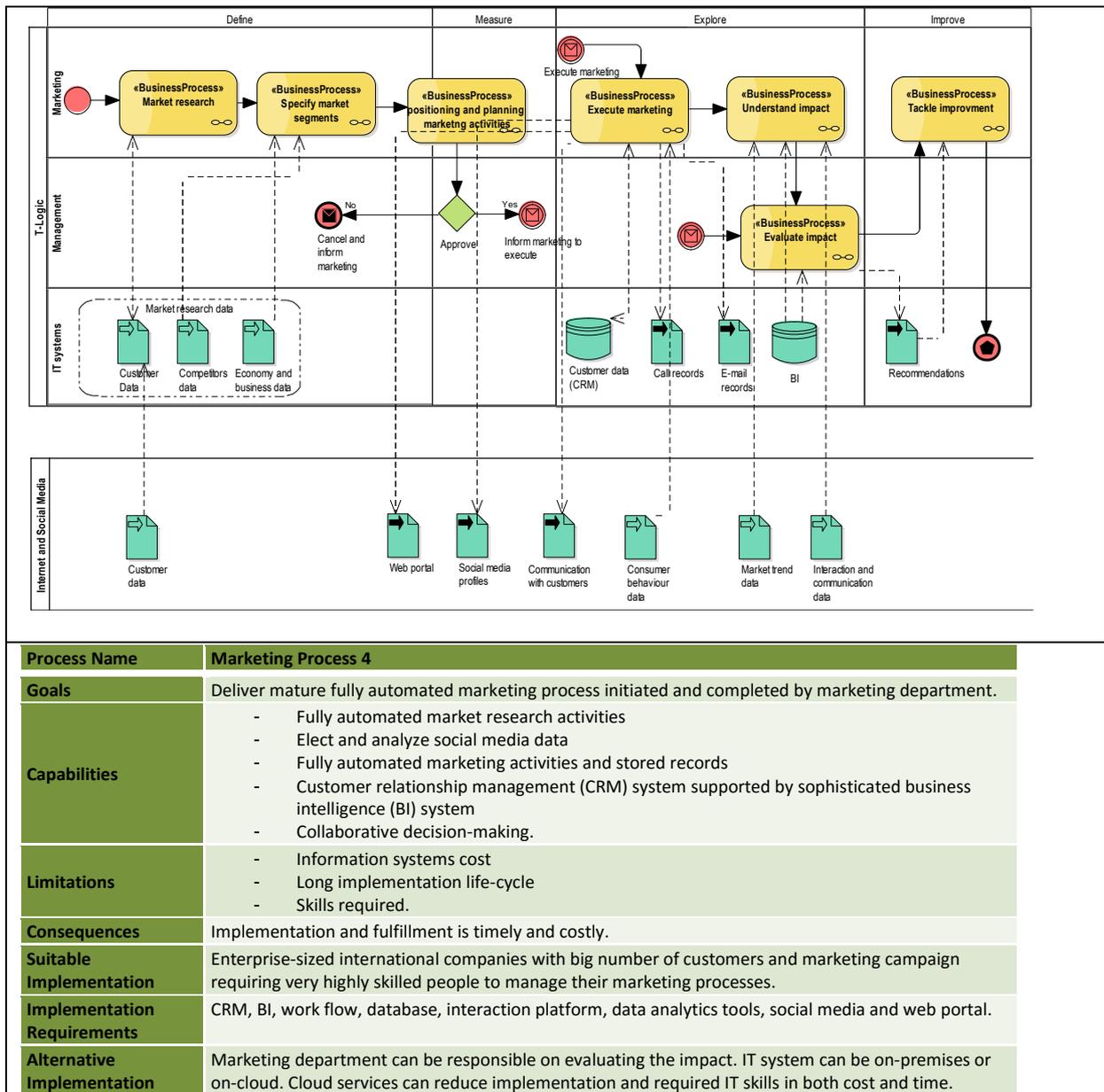


FIGURE 16: ALTERNATIVE PROCESS PATTERNS FOR MARKETING OPERATIONS (PROCESS 4)

To select the most suitable process, Learndia evaluated the alternatives against the set of pre-defined criteria. A scale from 1 (very low) to 5 (very high) was used in this assessment in order to evaluate and select from the alternative processes, as shown in [Table 4](#).

TABLE 4: PROCESS EVALUATION AND SELECTION CRITERIA

	Marketing Process 1	Marketing Process 2	Marketing Process 3	Marketing Process 4
Cost	1	2	3	4
Implementation time	2	3	4	4
Execution time	2	3	2	3
Efficiency	2	2	4	4
Maturity	1	2	4	5
Sustainability	1	2	4	5

Learndia decided to implement Marketing Process 3, to be assessed after a year for potential upgrading to Marketing Process 4.

4.7 Build rule models (Process-related rules, constraints and decisions)

[Table 5](#) describes Learndia’s business rules and decisions related to process 3.

TABLE 5: RULES AND DECISIONS RELATED TO BUSINESS ACTIVITIES

Activity	Related Rules	Related Decisions																																			
Activity 1 - Market research	It is obligatory that marketing manager identifies the internal research. It is obligatory that marketing manager identifies the external research. It is necessary that marketing staff identifies the market research methods and tools.	N/A																																			
Activity 2 - Market segmentation	Marketing manager must define partners’ segments. Marketing manager must define brands and brands’ segments. Marketing manager must define customer segments. Marketing manager must identify marketing budget.	<table border="1"> <thead> <tr> <th colspan="5">Partner selection process</th> </tr> <tr> <th>Demand on the product?</th> <th>Partner provides consulting support?</th> <th>Partner offers technical support and free license?</th> <th>Partner is international company?</th> <th>Recommend selection?</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>Yes</td> <td>-</td> <td>-</td> <td>Yes</td> </tr> <tr> <td>Yes</td> <td>No</td> <td>Yes</td> <td>-</td> <td>Yes</td> </tr> <tr> <td>Yes</td> <td>No</td> <td>Yes</td> <td>-</td> <td>Yes</td> </tr> <tr> <td>No</td> <td>Yes</td> <td>Yes</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>No</td> <td>Yes</td> <td>Yes</td> <td>Yes</td> <td>Yes</td> </tr> </tbody> </table>	Partner selection process					Demand on the product?	Partner provides consulting support?	Partner offers technical support and free license?	Partner is international company?	Recommend selection?	Yes	Yes	-	-	Yes	Yes	No	Yes	-	Yes	Yes	No	Yes	-	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Partner selection process																																					
Demand on the product?	Partner provides consulting support?	Partner offers technical support and free license?	Partner is international company?	Recommend selection?																																	
Yes	Yes	-	-	Yes																																	
Yes	No	Yes	-	Yes																																	
Yes	No	Yes	-	Yes																																	
No	Yes	Yes	Yes	Yes																																	
No	Yes	Yes	Yes	Yes																																	
Activity 3 - Positioning and planning	It is obligatory that the marketing manager identifies marketing mix strategy. It is obligatory that marketing manager identifies brand loyalty and company loyalty tactics.	N/A																																			
Activity 4 - Execute marketing	Marketing activities must be within the allocated budget.	<table border="1"> <thead> <tr> <th>Request within the budget</th> <th>Decision</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>Approve request</td> </tr> <tr> <td>No</td> <td>Decline request</td> </tr> </tbody> </table>	Request within the budget	Decision	Yes	Approve request	No	Decline request																													
Request within the budget	Decision																																				
Yes	Approve request																																				
No	Decline request																																				
Activities 5 - Evaluate impact	It is obligatory that marketing manager identifies marketing KPIs For each KPI value there must be an upper-limit and lower-limit accepted value. Value under lower-limit indicates shortage in business achievement.	N/A																																			
Activities 6 - Tackle improvement	Business improvement can be strategic improvement or operational improvement	<table border="1"> <thead> <tr> <th>marketing on target?</th> <th>Any new event impact current strategy?</th> <th>Short-term strategy due?</th> <th>Any other observation?</th> <th>Decision?</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>No</td> <td>Yes</td> <td>-</td> <td>Improve</td> </tr> <tr> <td>No</td> <td>-</td> <td>-</td> <td>-</td> <td>Improve</td> </tr> <tr> <td>Yes</td> <td>Yes</td> <td>No</td> <td>-</td> <td>Improve</td> </tr> <tr> <td>Yes</td> <td>Yes</td> <td>Yes</td> <td>-</td> <td>Improve</td> </tr> <tr> <td>No</td> <td>No</td> <td>No</td> <td>Yes</td> <td>Improve</td> </tr> </tbody> </table>	marketing on target?	Any new event impact current strategy?	Short-term strategy due?	Any other observation?	Decision?	Yes	No	Yes	-	Improve	No	-	-	-	Improve	Yes	Yes	No	-	Improve	Yes	Yes	Yes	-	Improve	No	No	No	Yes	Improve					
marketing on target?	Any new event impact current strategy?	Short-term strategy due?	Any other observation?	Decision?																																	
Yes	No	Yes	-	Improve																																	
No	-	-	-	Improve																																	
Yes	Yes	No	-	Improve																																	
Yes	Yes	Yes	-	Improve																																	
No	No	No	Yes	Improve																																	

4.8 Alignment of business processes to IS services

From the previously selected process patterns, we can identify the use-cases where a human actor will interact with an IS application that will support the automation of a process activity. Other activities that are not specified here as use-cases will be assumed to be either fully automated or fully manual. Developing the service requires an understanding of the functional and non-functional requirements that need to be fulfilled by service participants. To do this, we first need to define the participants of the service delivery. Then, we need to identify the software services (functional requirements) associated with each participant, as shown in [Table 6](#).

TABLE 6: SOFTWARE SERVICES

Service	Actor	Description
Customer communication point	Customer	Customer need to be able to contact the company through the website, email and social media channels.
Staff communication point	Marketing staff	Marketing staff will be able to communicate with customers using the communication points such as sending messages or emails through the CRM system, emails, social media channels.
CRM service	Marketing staff	The service should allow the marketing staff to fill lead, customers and potential customers details, retrieve them, get notifications, update, transfer, contact, track and generate reports related to all sort of customers, communications with them and the products or services they are interested in.
Questionnaires service	Marketing staff	This service should allow marketing staff to create a new questionnaires and enter its details. It should also allows marketing staff to edit the details, change the status and retrieve results.
Data analysis service (historical and statistical)	Marketing staff	The marketing staff should be able to analyze data in order to generate insights and make decisions. type of analysis required are: historical data analysis, statistical analysis and predictive analysis. The service must allow the marketing staff to creating and updating the required analytics scenarios.
Data visualization	Marketing/M anagement staff	Managers should be able to visualize data on dashboards, generate business intelligent (BI) reports in order to inform future decisions

From this point onward, Learndia need to make a decision on whether they are going to buy the services from the cloud or develop them in-house. If the development will take place in-house, the software engineers can tackle the development tasks in one of the specific software engineering methodologies or software development life-cycles (SDLCs). A most effective approach nowadays is to develop RESTful or SOAP services for easy integration with other legacy systems or deploy it within either SOA or a cloud environment. The scope of the case study presented is limited to aligning business best practices and IS development through a business architecture that allows reasoning to support decision-making on business design. Learndia decided to implement the following IS components in response to the required services as described in [Table 7](#).

TABLE 7: IMPLEMENTATION COMPONENTS

IS Component	Description
Website	Developing a website for the company, the website should contain information about the company, products and services, owners, news and contacts details.
Email accounts	Associated to the website domain name. Staff individual personal emails and general purpose emails e.g. customer service email, technical support email...etc.
Cloud-based CRM	Learndia selected Zoho CRM, it is lightweight Software-as-a-service (SaaS) that is suitable for small enterprises and can scale up to cover the company needs for the next 5 years.
Online questionnaires	surveymonkey.com is a web-based SaaS allows individuals and companies to build their online questionnaires, distribute it and retrieve the results.
LinkedIn page and profiles	All staff members must have a LinkedIn profile. Marketing officers will be responsible for managing and updating the company's LinkedIn page.
Data analysis tool	To use the predictive analysis tool RapidMiner (https://rapidminer.com/) in order to blind market data, financial data, customers' data and strategic data from various sources all together to predict future potential and support decision-making.
Digital adverts through Google business services	Using Google AdWords and Google business solutions (Google, 2016) Learndia will create digital adverts, monitor their online performance, improve the searchability of the company services.

4.9 The approach validation

Industrial evaluation has a significant input into academic and research results. Wallis (2008) argued that validating a theory in a practical sense (i.e. outside academia) by gaining the recognition of external professionals provides another higher level of validation for a theory. Yin (2009) stressed the importance of strengthening the construct validity of research by asking experts their opinion of the usefulness of the approach. The aim of this industrial validation is to understand the managers' perception of the developed approach, including the value creation compared to the time, effort and cost of such enterprise modeling effort. The actual validation was carried out by asking the

managers in Learndia about their opinions and recommendations through phone interviews, which were scheduled and planned later during the analysis and modeling effort.

The manager described the framework as a guiding booklet for the firm's strategic thinking and design. This is an important indication of the usefulness of the proposed approach. He described the goal models as an extremely important entrance point for the firm: since the firm has just been established, he considers it important to start the activities right by knowing everything they do, why exactly they are doing it and how they are going to do it. Rationale models have been distributed among the stakeholders and they found it useful to think during every step about the advantages and disadvantages and the impact of every decision. Regarding the dynamic model, the manager thinks that the model is a crucial part and liked the simulation and the way of thinking proposed by the tool. He asked, "How can we define the variables and their values accurately to gain their potential benefit?" I explained that I defined the values based on the insight I gained from company staff: some influencing factors might need further research to accurately set up and quantify their values. Still the manager found the effort of making this model to be high: "Do we really need to do all this work and build this model by ourselves? It is just easier to let a market expert identify the right direction for us?" However, the author explained his belief that it is only a way to codify the knowledge of multi-source and expert minds into a model that can help to forecast change in terms of 'if this happened...', which allows the company to think about what to do, and that it is possible that market experts use similar tools to analyze market data. Nevertheless, the manager was extremely excited about the alternative processes design and the alternative methods of implementation: "This offers a good and simple way to optimize and evaluate the processes."

Regarding the alignment and service design, he added, "I have never seen anything like this before. I want to know more about the open source development environment for service-centric software enabling, though the skills required are not easy to find, if we are going to build our own IS I think this will be a great way where everything is just aligned perfectly and we build only what we need ...".

Regarding the suggested implementation model for operational and management requirements, the manager stated clearly, "I think this is an ideal environment, we are still so far from implementing such tools in the meantime, however I think the cost will be expensive too."

Overall, the manager in Learndia appreciated the effort and the essential combination of the goals, processes, rules and decision support model. He said, "The analysis design was successful in pointing out the most important areas that concern any business, although some aspects require deeper analysis and some aspects might not be required at all, the decision should be made from a strategic level to where they want the focus of the modeling to be." He wondered how many tools need to be used to do all this work but appreciated the effort and time and the results being shared with him.

5 CONCLUSIONS AND REFLECTIONS

To address dynamic requirements of today's business environments, one should go beyond static design of services that are aligned to organizational objectives and business requirements. This paper postulates that existing efforts need to be complemented by a higher-level, more strategic oriented viewpoint, one that considers the needs for the development of 'intelligent software systems' capable of reacting to fast changes in the ecologies of enterprises. To this end, this paper

presents a new approach to using conceptual modeling that combines hybrid reasoning, simulation, and IS development. The approach presented in this paper is a model-based approach to support representation and reasoning about enterprise capabilities and their relations to key components of the enterprise and its environment. The approach achieved our goals to increase visibility and support decision-making by blending traditional business best practices with a number of analysis and design tools; namely, enterprise modeling, design rationale, and system dynamics. Based on a systematic way of working, it suggests the generation of different scenarios concerning alternative capability configurations, and the simulation of these scenarios in order to understand the behaviors and consequences of implementing an alternative. Therefore, the resultant designs upon which software implementation will be based offer opportunities for agility and adaptation, two key requirements for incorporating 'intelligent behavior' in information systems capable of reacting according to changing contexts. One of the main features of the approach is that it is agile and extendable to allow practitioners covering any other enterprise artifacts or by adding on other practices that enhance the analysis and design process for any specific purpose (e.g. designing IT service delivery processes according to ITIL standard recommendations). The concepts being proposed in the paper are exemplified through examples from a case study involving a marketing use case.

5.1 Practical contribution to business practices

The proposed approach was successfully applied to Learndia, a small start-up company. During testing, the approach proved to be useful for visualizing and aligning the enterprise model; continuous reasoning and dynamic modeling were used to identify risk and design choices and make decisions about them. A 'to-be' model for the enterprise is presented in this paper; this can act as an initial point of realization for the enterprise and ISs' design. This will also act as a basis for any future enterprise-modeling efforts with the aim of improving alignment, improving predictive analytics, and increasing maturity. It was suggested that Learndia should start to implement their recruitment process according to some industrial best practices, equally to develop IT service delivery processes according to ITIL standard. It was identified that social aspects (skills, experience, problem-solving, relationships and personality) are critical factors that influence organizational performance. These aspects will be required to get more attention before and during the enterprise design.

The following observations can be made based on the lessons learned from the application of the approach on the Learndia case study:

- In order to preserve the whole benefit of the enterprise modeling, it needs to be combined with reasoning and simulation methods to aid the analysis and design activities.
- To great extent, modeling and simulation can enhance the decision-making by allowing business managers to visualize both current state and future state of the organization and chose the optimum design of strategy, operation and information systems.
- The implementation of the approach also should take into consideration the standards and best practices with specific business or organizational focus to guide organizations in developing high quality and standardized business architecture.
- As there is no dominant design model, there is no one dominant design process. The process can vary from one case to another due to the status of the enterprise, its motivation, the environment it operates in, and the resources it has available.

- Organizations need to continuously analyze and design enterprise activities to respond to variety of changes occur in the organization or the organization's context. Monitoring and performance measurement are also important to address any shortage in execution and to ensure the alignment embedment.
- Enterprises need to find a balanced approach to analysis, design, and management to allow bottom-up evolution (capabilities to goals) rather than only top-down architecture guidelines (goals to capabilities).
- A collaborative design approach that engages operational staff was essential in order to understand the nuances of the business model.
- With respect to modeling, this is no longer about artifacts that should be designed and developed through a prolonged process in order to be used. The rapid changes in the socio-technical environment require the modeling of the emerged artifacts in terms of what artifacts exist and what can be immediately embedded in the analysis and design process.
- Increasing the abstraction of the design artifacts helped new artifacts to emerge organically from the enterprise context and fuse within the enterprise system.

Modern information systems and architecture have the ability to provide business models (business to execution) during the business run-time, rather than using long-term software and system-engineering processes. Design patterns can support model's re-use, choreography, and orchestration in order to accelerate the processes of design and implementation.

Moreover, no universal framework or approach can comprehend all types of business requirements. We do not see the need to develop one, as there are a number of useful reference architecture frameworks; therefore, the analyst can adopt the required artifacts that fit business requirements. Allowing flexibility, extendibility and integrity is crucial for the success of any modeling framework. However, the essential aspects must be addressed so that they can form a strong foundation for any future improvements. Enterprises need to realize that to increase maturity, the effort and the time required to implement the approach is longer; they also need to manage their expectations with regard to the time frame for seeing a return on investment (ROI). However, it is crucial that analysts identify the suitable level of granularity required for their business analysis; to do so, they will need to decide upon the level of analysis maturity they want to achieve, weighing this up against the time and cost. In the case of Learndia the stakeholders were aware of the relation between time and quality, which helped to increase the maturity of the enterprise architecture. Enterprises also can take advantage of intelligent and emerging technology to improve agility, responsiveness, and maturity and reduce risk. The limitations of the approach can be summarized as the following: The simulation presented in this paper in only one form, which is system dynamics modeling. In the presented scenario we have limited our assumptions and consideration to a narrow set of influencing factors. This can be enhanced in the future with considering grounded assumptions and more factors in the simulation model. Also, the case study did not present the actual development of the IS services in using a model-based development approach. Moreover, the study did not consider in depth the issues relevant to organizational culture and other social aspects, with many issues being discovered before we finished the case study activities and which have great impact on performance and on the way that people in the organization adopt the new technology. Finally, one of the issues discussed with Learndia managers is that in order to use the approach we

need to move between 6 different modeling tools manually, which is considered time consuming and requires learning and training.

5.2 Theoretical contributions to EA modeling

Our proposal contributes to enterprise architecture practices, however we do not suggest a full reference of artifacts, and we assume that the required artifacts are different in each scenario. Analysts need to identify what artifacts are needed to be considered for development. Therefore, we believe our approach is more agile, as it suggests tools for a systematic analysis that leads to identifying the necessary IS services. We built assumptions that consider the rigor of the historical data patterns to create a foundation for the model. Then, we relied on the experience of the interviewed staff and the modeler to shape the knowledge into an insightful form that can create value for the organization.

We distinguish our work as business change focused, integrated with traditional business practices and consider continuous business-IS alignment. For example, requirements engineering has made strong use of conceptual modeling; nevertheless, the focus is to elect, document, communicate and formalize requirement specifications for the purpose of developing software applications (Singh & Woo, 2009). Additionally, we found an interesting approach to alignment using fact-oriented modeling (Kang, Lee, & Kim, 2010). However, although this approach provides a useful linguistic-based rationale, our approach is more comprehensive in terms of capturing knowledge and supporting simulation.

A major contribution of our approach is that it brings simulation, design rationale and enterprise modeling together in one framework. Moreover our approach takes advantage of multi-level patterns design and deployment to enhance reusability and orchestration of the enterprise components. The approach could benefit from extensions in a number of directions and could be realized using a single meta-modeling framework and support environment (Karagiannis, et al., 2008):

- Implementing the approach using the adox platform (H-G Fill & Karagiannis, 2013). Adox will help us to deploy the meta-model and create our modeling tool, embedding the capabilities of the tools combination we have used in our approach. Perspectives will provide the necessary means by which a single software tool could be developed for both modeling and intelligent querying. This follows the traditional model integration mechanism by building a UML profile for the modeling technique so the value of each artifact's variable can flow among the modeling aspects in one UML-based platform.
- Exploring the option of using other types of simulations: discrete, continuous, agent-based, graph transformation, etc) in an integrated hybrid modeling language.
- Implement the approach to different companies from different business areas and under different circumstances. In such an implementation we will overcome the limitations of the simulation assumptions, engage more with the case study, monitor performance and use quantitative methods to measure the alignment and the impact of the approach.

References

- Andreessen, M. (2011). Why Software is Eating the World. In *The Wall Street Journal*.
- APQC. (2009). Process Classification Framework (PCF) guide.
- ArchiMate. (2012). ArchiMate 2.1 specification. The Open Group. *Reading. ISBN-13, 857067441*.
- Azevedo, C. L. B., Iacob, M.-E., Almeida, J. P. A., Sinderen, M. v., Pires, L. F., & Guizzardi, G. (2015). Modeling Resources and Capabilities in Enterprise Architecture: A Well-founded Ontology-based Proposal for ArchiMate. *Information Systems, 54*, 235-262.
- Basili, V. R. (1992). Software modeling and measurement: the Goal/Question/Metric paradigm.
- Baudoin, C., Covnot, B., Kumar, A., LaCrosse, K., & Shields, R. (2010). Business Architecture: The Missing Link between Business Strategy and Enterprise Architecture. *Michelson, B.. SOA Consortium*.
- Bērziša, S., Bravos, G., Gonzalez, T. C., Czubayko, U., España, S., Grabis, J., Henkel, M., Jokste, L., Kampars, J., & Koç, H. (2015). Capability driven development: an approach to designing digital enterprises. *Business & Information Systems Engineering, 57*, 15-25.
- Black, S. A., & Porter, L. J. (1996). Identification of the Critical Factors of TQM*. *Decision sciences, 27*, 1-21.
- Brooks, F. P. (2010). *The Design of Design: Essays from a Computer Scientist*: Addison-Wesley.
- Danesh, M. H., Loucopoulos, P., & Yu, E. (2015). Dynamic capabilities for sustainable enterprise IT—a modeling framework. In *Conceptual Modeling* (pp. 358-366): Springer.
- Devane, T. (2004). *Integrating Lean Six Sigma and High-Performance Organizations: Leading the charge toward dramatic, rapid, and sustainable improvement* (Vol. 4): John Wiley & Sons.
- Digital-Europe. (2009). White Paper on 'Digital Europe's Vision 2020: A Transformational Agenda for the Digital Age'. In: Digital Europe.
- Fayoumi, A., Loucopoulos, P., & Fayyumi, A. (2014). Hybrid enterprise modelling: integrating modelling mechanisms for socio-technical systems analysis and design. *Journal of Software Engineering and Applications. Vol.7 No.1*, 6-13.
- Fill, H.-G. (2014). Abstraction and Transparency in Meta Modeling. In E. Schweighofer, Kummer, F. and Hötendorfer, W. (Ed.), *17th Internationalen Rechtsinformatik Symposions IRIS 2014*.
- Fill, H.-G., & Karagiannis, D. (2013). On the conceptualisation of modelling methods using the ADOxx meta modelling platform. *Enterprise Modelling and Information Systems Architectures-An International Journal, 8*.
- Frank, U. (2013). Domain-specific modeling languages: Requirements analysis and design guidelines. In *Domain Engineering* (pp. 133-157): Springer.
- Frank, U. (2014a). Multi-perspective enterprise modeling: foundational concepts, prospects and future research challenges. *Software & Systems Modeling, 13*, 941-962.

- Frank, U. (2014b). Power-Modelling: Toward a more Versatile Approach to Creating and Using Conceptual Models. *Proceedings of the Fourth International Symposium on Business Modelling and Software Design*, 9 - 19.
- George, M. L., & George, M. (2003). *Lean six sigma for service*: McGraw-Hill New York, NY.
- Godfrey, S. (2008). What is CMMI? *NASA presentation*.
- Goldman, J. E., & Ahuja, S. (2011). Integration of COBIT, Balanced Scorecard and SSE-CMM as an Organizational & Strategic Information Security Management (ISM) Framework. *ICT Ethics and Security in the 21st Century: New Developments and Applications*, 277-309.
- Google. (2016). Google Business Solutions In (Vol. 2016): Google.
- Gordijn, J. (2002). E3-value in a Nutshell. In *International workshop on e-business modeling, HEC Business School, Lausanne*.
- Gordijn, J., Yu, E., & van der Raadt, B. (2006). e-Service Design Using i* and e3value Modeling. *IEEE software*, 23, 26-33.
- Gregory, F. (1993). Cause, Effect, Efficiency and Soft Systems Models. *The Journal of the Operational Research Society*, 44(4), 333–344. <http://doi.org/10.2307/2584411>.
- Guizzardi, G., Wagner, G., Almeida, J. o. P. A., & Guizzardi, R. S. S. (2015). Towards Ontological Foundations for Conceptual Modeling: The Unified Foundational Ontology (UFO) Story. *Applied Ontology*, 10.
- Guizzardi, G., Wagner, G., Falbo, R. A., Guizzardi, R. S. S., & Almeida, J. P. A. (2013). Ontological Foundations for the Conceptual Modeling of Events. In *32nd International Conference on Conceptual Modeling (ER 2013)*. Hing Kong.
- Hardy, G. (2006). Guidance on aligning COBIT, ITIL and ISO 17799. *Information Systems Control Journal*, 1, 32.
- Hellsten, U., & Klefsjö, B. (2000). TQM as a management system consisting of values, techniques and tools. *The TQM magazine*, 12, 238-244.
- Hinkelmann, K., Gerber, A., Karagiannis, D., Thoenssen, B., van der Merwe, A., & Woitsch, R. (2015). A new paradigm for the continuous alignment of business and IT: Combining enterprise architecture modelling and enterprise ontology. *Computers in Industry*.
- Humphreys, K. A., & Trotman, K. T. (2011). The balanced scorecard: The effect of strategy information on performance evaluation judgments. *Journal of Management Accounting Research*, 23, 81-98.
- Iacob, M.-E., Quartel, D., & Jonkers, H. (2012). Capturing business strategy and value in enterprise architecture to support portfolio valuation. In *Enterprise Distributed Object Computing Conference (EDOC), 2012 IEEE 16th International* (pp. 11-20): IEEE.
- ISTAG. (2012). Software Technologies - The Missing Key Enabling Technology: Toward a Strategic Agenda for Software Technologies in Europe. In Brussels, Belgium: ISTAG - Information Society Technologies Advisory Group.
- Jackson, T. L. (2006). *Hoshin Kanri for the lean enterprise: developing competitive capabilities and managing profit*: Productivity Press.

- Kang, D., Lee, J., Choi, S., & Kim, K. (2010). An ontology-based enterprise architecture. *Expert Systems with Applications*, 37, 1456-1464.
- Kang, D., Lee, J., & Kim, K. (2010). Alignment of Business Enterprise Architectures using fact-based ontologies. *Expert Systems with Applications*, 37, 3274-3283.
- Kaplan, R. S., & Norton, D. P. (2004). *Strategy maps: Converting intangible assets into tangible outcomes*: Harvard Business Press.
- Karagiannis, D., Fill, H.-G., Höfferer, P., & Nemetz, M. (2008). *Metamodeling: Some application areas in information systems*: Springer.
- Karagiannis, D., & Kühn, H. (2002). Metamodelling platforms. In *EC-Web* (pp. 182).
- Kawalek, J. P. (2004). Systems thinking and knowledge management: positional assertions and preliminary observations. *Systems Research and Behavioral Science*, 21, 17-36.
- Lamsweerde, A. (2003). Kaos tutorial. *Cediti*, September, 5.
- Lamsweerde, A. (2009). Reasoning About Alternative Requirements Options. In A. T. Borgida, V. K. Chaudhri, P. Giorgini & E. S. Yu (Eds.), *Conceptual Modeling: Foundations and Applications: Essays in Honor of John Mylopoulos* (pp. 380-397). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Louridas, P., & Loucopoulos, P. (2000). A generic model for reflective design. *ACM Transactions on Software Engineering and Methodology (TOSEM)*, 9, 199-237.
- Malik, N. (2011). Enterprise Business Motivation Model. *Full Model Documentation, version, 4*.
- Martin, J. (2006). An introduction to the Architectural Frameworks DODAF/MODAF/NAF. In: Course given at the Royal Institute of Technology, Stockholm, Sweden.
- Mylopoulos, J. (2008). Conceptual modelling and Telos 1. In: Citeseer.
- OMG, B. (2008). Business Process Maturity Model (BPMM). 1.0.
- OMG, B. (2010). Business motivation model (BMM) specification. In (1.1 ed.): Technical Report dtc/10-08-03, Object Management Group, Needham, Massachusetts.
- OMG, D. (2014). Decision Model and Notation (DMN). *OMG Specification, 1.0 Beta 2*.
- OMG, S. (2006). Semantics of Business Vocabulary and Business Rules (SBVR). In: *OMG Specification*, March.
- Osterwalder, A., Pigneur, Y., Smith, A., & al., e. (2010). Business Model Generation. *Wiley published*.
- Regli, W. C., Hu, X., Atwood, M., & Sun, W. (2000). A survey of design rationale systems: approaches, representation, capture and retrieval. *Engineering with computers*, 16, 209-235.
- Reynares, E., Caliusco, M., & Galli, M. (2015). A set of ontology design patterns for reengineering SBVR statements into OWL/SWRL ontologies. *Expert Systems with Applications*, 42, 2680-2690.
- Robinson, S. (2008). Conceptual modelling for simulation Part I: definition and requirements. *Journal of the operational research society*, 59, 278-290.
- Robinson, S. (2010). Conceptual Modelling: Who Needs It?

- Rolland, C., & Prakash, N. (2000). From conceptual modelling to requirements engineering. *Annals of Software Engineering, 10*, 151-176.
- Rummler, G. A. (2007). *Serious performance consulting according to Rummler*: John Wiley & Sons.
- Samavi, R., Yu, E., & Topaloglou, T. (2009). Strategic reasoning about business models: a conceptual modeling approach. *Information Systems and e-Business Management, 7*, 171-198.
- Singh, S. N., & Woo, C. (2009). Investigating business-IT alignment through multi-disciplinary goal concepts. *Requirements Engineering, 14*, 177-207.
- Sommerville, I., Cliff, D., Calinescu, R., Keen, J., Kelly, T., Kwiatkowska, M. Z., McDermid, J. A., & Paige, R. F. (2012). Large-scale complex IT systems. *Comm. Of ACM, 55*, 71-77.
- Steinberg, R. A., Rudd, C., Lacy, S., & Hanna, A. (2011). *ITIL service operation: TSO*.
- Sterman, J. (2000). *Business Dynamics : Systems Thinking and Modeling for a Complex World*. Boston: Irwin/McGraw-Hill.
- Stirna, J., & Zdravkovic, J. (2015). Interview with Sladjan Maras on “Challenges and Needs in Enterprise Modeling”. *Business & Information Systems Engineering, 57*, 79-81.
- TOGAF. (2009). The Open Group Architecture Framework (TOGAF) V. 9. *The Open Group, 1*.
- VCG. (2012). Value Reference Model introduction. *3.0*.
- Versteeg, G., & Bouwman, H. (2006). Business architecture: A new paradigm to relate business strategy to ICT. *Information Systems Frontiers, 8*, 91-102.
- Wallis, S. E. (2008). Validation of theory: Exploring and reframing Popper's worlds. *Integral review, 4*.
- Wilby, J., Macaulay, L., & Theodoulidis, B. (2011). Intentionally holistic knowledge intensive service systems. *Int. J. of Services Technology and Management, 2011 Vol.16, No.2*, pp.126 - 140.
- Yin, R. K. (2009). Case study research: Design and methods, 4th. In: Sage Inc CA.
- Yu, E. (2009). Social Modeling and i*. In *Conceptual Modeling: Foundations and Applications* (pp. 99-121): Springer.
- Yucong, D., & Cruz, C. (2011). Formalizing semantic of natural language through conceptualization from existence. *International Journal of Innovation, Management and Technology, 2*, pages 37-42, ISSN: 2010-0248.
- Zachman, J. A. (2004). Enterprise architecture: a framework. *Zachman Institute, Colorado Spring, Colorado, USA*.