THE SYSTEMS ANALYST AS A KNOWLEDGE ENGINEER: CAN THE TRANSITION BE SUCCESSFULLY MADE?

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INTRODUCTION

The general view evident in current expert systems literature is that personnel requirements for development of expert systems are quite different from those for conventional information systems. The necessary knowledge, skills, and personality traits for expert systems development are embodied in a new breed of computer professional called the Knowledge Engineer. The purpose of this paper is to: 1) examine the similarities and differences between the personal characteristics of the systems analyst and knowledge engineer and the work they perform, and 2) define an action plan specifically dealing with the personnel issues for management information systems (MIS) managers introducing expert systems technology into the organization.

IMPORTANCE OF ISSUE

The potential for use of expert system technology in business, industrial, academic and other environments is great, and, indeed, successful expert systems are already in use. Expert systems are being developed to satisfy a number of key objectives.

1. Improved Quality/Accuracy of Work Activities -- spreading required expertise, in the form of automated tutorials and advisor systems, throughout organizations.

2. Improved Customer Service -- offering new, **innovative** services to customers and providing organizations with the edge they need to remain competitive.

3. Reduction of Manual Labor -- automating manual processes that cannot be addressed by conventional data processing.

The question for forward-thinking MIS managers is not if expert system technology should be brought into the MIS organization, but rather how it should be introduced. However, as the manager begins developing an implementation strategy, he or she is faced with several difficult personnel-related issues. Is a knowledge engineer really needed? If so, what qualifications should one look for? Can systems analysts already on staff successfully develop expert systems? If so, what training must be provided and what other factors would affect their chances of success? Should a new group be formed to specialize in expert system development and support or should this responsibility be distributed within the existing MIS organizational structure? Answers to these questions depend chiefly upon the extent of the disparities between systems analyst and knowledge engineer qualifications, the tools and techniques of their trade, and the expert system and conventional information system technologies themselves. These topics are addressed in the remainder of this paper.

THE SYSTEMS ANALYST VERSUS THE KNOWLEDGE ENGINEER

Clarifications

It is important to clarify that this paper refers to a systems analyst experienced in the latest techniques for developing conventional information systems; for whom, for example, the use of structured analysis and design methods and prototyping is second nature. A comparison of a knowledge engineer to a systems analyst who still clings to development methods prevalent in the 1960's and 70's would be quite different from a comparison with the more up-to-date systems analyst.
There seems to be no agreed upon list of qualifications for a knowledge engineer. For purposes of this paper, the knowledge engineer is assumed to have an academic background in computer science (with strong emphasis on artificial intelligence), probability, and psychology, as opposed to the relatively soft MIS background of the systems analyst.

Duties

Typical duties for a **systems analyst** are:

1. Identifying potential applications for conventional information systems technology in user departments.

2. Developing project proposals, including cost and schedule estimates, for management review and approval.

3. As project manager, developing detailed plans for conducting approved projects, assigning work to project team members, and monitoring and reporting project progress to management.

4. Conducting user interviews to obtain information about the processes being automated.

5. Identifying and analyzing alternative system design and implementation strategies and working with users in selecting the appropriate route.

6. Directing prototype development and final system construction, testing, and implementation.

7. Overseeing ongoing maintenance of the system after implementation or turning over the system to another group for maintenance support.

Duties of a **knowledge engineer** are quite similar, but there are some differences. The knowledge engineer is involved in:

1. Identifying potential uses for expert systems rather than conventional information systems technology. A survey of members of the American Association of Artificial Intelligence showed that knowledge engineers participate more in goal-setting than other IS professionals, possibly because upper management is not as familiar with artificial intelligence as in other areas of information technology (Couger and McIntyre 1988).

2. Formulating these ideas into concrete project proposals is an important duty for a knowledge engineer, just as it is for a systems analyst.

3. Developing project plans, assigning work, and monitoring and reporting progress to management is also an important duty for the knowledge engineer. However, since it is likely the project team will typically consist solely of the knowledge engineer and the domain expert, the effort required to perform this duty should be much less for the knowledge engineer than for the systems analyst. See Other Similarities and Differences for further discussion of project team sizes.

4. Acquiring knowledge from the domain expert on how certain decisions are made, as opposed to the systems analyst's

concern with visible processes and data, is an important difference. Knowledge acquisition is a harder task (Hart 1986).

5. Evaluating design and implementation strategies, overseeing construction, testing, and implementation, and maintaining or turning over production systems to another group are the same for both job classifications.

Roles

The systems analyst and knowledge engineer must fill some common roles: Change Agent, Investigator/Monitor, Diplomat, Mediator, Architect, Buyer, Builder, Tester, and Salesperson. As mentioned earlier, the size of the project team will typically be larger in conventional projects than in expert system projects, requiring the systems analyst to assume additional roles of Project Planner, Contractor, Motivator and Quality Inspector (Awad 1988). Since often an expert system is actually constructed by the knowledge engineer rather than a team of programmers, the knowledge engineer is expected to spend more time in the role of Builder than does the systems analyst. In addition, the knowledge engineer must often fill the role of Psychologist to effectively define the domain expert's thought processes.

Knowledge and Skills

The required skill-set of a systems analyst is well researched (Cheney 1988, Jenkins 1986, McCubbrey and Scudder 1988). Unfortunately, surveying the literature did not produce a similar list of required skills for a knowledge engineer, although some general comments were found about this subject (Bredin 1990, Couger and McIntyre 1988, Roberts 1988). However, considering the potential usefulness of the transition from systems analyst to knowledge engineer, we are interested in exploring common and unique skills and knowledge categories required for the two job classifications. Knowledge and skills required for the systems analyst **and** the knowledge engineer should include:

1. In-depth knowledge of computer technology -- specifically:
   a. General software design and modeling methods
   b. Programming
   c. File I/O
   d. Data base
   e. Data communication
   f. Hardware platforms

g. Operating systems
h. Job control language
i. Graphics interfaces
j. Familiarity with issues of concern such as legal mandates, security, testing, documentation, ease of maintenance

2. Knowledge of general fact-finding techniques such as interviewing and review of manual records

3. Training in prototyping techniques

4. Experience in "buy" versus "make" decisions and software product evaluation

5. Appreciation for human engineering factors in designing user interfaces

6. Project planning skills

7. Understanding of business functions

8. Excellent verbal and written communication skills

9. Marketing skills

10. Human relations skills

11. Organizational skills

Knowledge and skills critical to the success of the **systems analyst** include:

1. Project management

2. Group dynamics

3. In-depth knowledge of process definition and representation techniques such as data flow diagramming, entity relationship diagramming, and structure charts

4. In-depth knowledge of conventional system construction techniques such as fourth generation languages, CASE, and reusable code

5. Familiarity with application software vendors and packages in the marketplace

Competency in the following knowledge and skills should be critical to the success of the **knowledge engineer:**

1. Knowledge acquisition techniques such as concept analysis, domain and task analysis, process tracing and protocol analysis, and simulations

2. Knowledge representation techniques such as rules, frames, semantic networks, and first-order logic

3. Inferencing strategies pertaining to backward chaining, forward chaining, breath-first search, depth-first search, and problem reduction

4. Familiarity with expert system shells in the marketplace

Personal Attributes

With regard to personal attributes, the successful systems analyst and knowledge engineer seem to be cut from the same mold, with a few exceptions. Both professionals should be:

1. Intelligent
2. Self-driven
3. Creative
4. Realistic
5. Diplomatic
6. Responsible
7. Persistent
8. Logical

There are other attributes that, while certainly desirable in both, are key to the success of the systems analyst, but not the knowledge engineer, or vice versa. Because the systems analyst is often charged with management of a large project team, he or she must also be authoritative, decisive and persuasive to be successful. With few standards currently established for expert systems development, the knowledge engineer must be particularly inquisitive, innovative, self-motivated, open-minded and willing to take risks when dealing with single or multiple domain experts and constructing a satisfactory end product for the user organization.

Conventional Versus Expert System Development Methodologies, Tools, and Techniques

System Development Methodologies

While there is a significant difference between the traditional systems development life cycle and the expert systems development life cycle (ESDLC), there are many similarities between the structured systems development life cycle (SSDLC) and ESDLC (Awad 1990). Basic phases in each life cycle are:

SSDLC	ESDLC
Problem Definition	Problem Definition
Analysis & Prototyping (iterative)	Knowledge Acquisition (iterative)
Selection of Design Alternative	Tool (Shell) Selection
Detailed Design/ Prototyping	Rapid Prototyping & Final System Construction
Implementation	Implementation
Maintenance	Maintenance

Early construction of the system in the form of a prototype, iterative refinement of the system, less need to backtrack in the life cycle as changes occur, and extensive user involvement are hallmarks of both life cycles. Emphasis on prototyping and involvement of users consistently throughout the life cycle is heavier in expert systems development. Another difference between the two life cycles is that while the task of systems analysis is usually completed early in the SSDLC, knowledge acquisition is a process that continues throughout the ESDLC.

Tools

The conventional information systems environment is rich with tools for development, testing, and maintenance. The systems analyst has extensive choices for technical platforms on which to build the conventional system: fourth-generation languages, CASE, relational data bases, to name only a few. Interactive program testing and coverage aids, documentation tools, and program impact analysis aids are also available to automate and improve the quality of conventional program development and maintenance tasks. In contrast, tools available for the expert systems environment are far less extensive and mature; however, the ones that are available are quite sophisticated. For most applications, the knowledge engineer can employ expert system shells which greatly facilitate development of user interfaces, corporate database interfaces, and the like.

Techniques

Techniques for developing conventional information systems that automate visible, manual processes are quite different from those for developing expert systems designed to capture and emulate expertise. The systems analyst relies on information-gathering techniques (interviewing, sampling of manual records, forms and other documents, etc.). Although the knowledge engineer uses some of the same techniques early in the knowledge acquisition process, additional techniques must often be used to supplement and refine knowledge acquired. Concept analysis, domain and task analysis, and process tracing and protocol analysis are appropriate techniques. The systems analyst uses data flow diagrams, entity relationship diagrams, and structure charts to model processes to be automated, while the knowledge engineer represents knowledge through techniques such as rules, frames, semantic networks, and first-order logic.

Other Similarities And Differences

In evaluating the broad scope of conventional versus expert systems development, additional differences and similarities surface:

Problem Domain

Basic to the understanding and successful use of expert systems technology is the recognition that the technology, through its ability to store knowledge and infer decisions from it, allows problems to be solved which cannot be addressed by conventional systems technology. Expert systems automate thought processes; conventional systems automate manual processes.

Users

Both the systems analyst and the knowledge engineer must be at ease working with business professionals. While a systems analyst may interact with a number of people in a user organization during the life of a project, he or she will deal primarily with user management. The knowledge engineer usually works with a single domain expert who may be at any level of the organization.

Project Team Size

It is the straightforward nature of conventional systems, i.e. clearly defined inputs, processes and outputs, which makes functionally decomposed system designs possible. Because small, independent program modules can easily be parceled out to multiple programmers for construction, medium to large project teams are typically employed in conventional system projects (Parsaye, et al 1988). Although knowledge chunking in expert systems development may be somewhat analogous to functional decomposition (Gallagher 1988), the degree to which modules can be isolated is significantly less. Consequently, an expert system project team will typically consist solely of the knowledge engineer and the domain expert whose knowledge is being captured in the system.

Testing

There are many similarities between conventional and expert systems testing, but also some important differences. They are alike in the sense that there are multiple levels of testing (unit, integration, stress and user acceptance testing) and testing is never quite done. However, testing of conventional systems, where programs are either right or wrong, can be much easier than testing expert systems, where uncertainties affect the degree of rightness and wrongness. Additional testing techniques are needed to judge quality of expert systems (Laswell 1990).

Implementation

Obtaining user acceptance of an expert system can present some unique challenges to the knowledge engineer. Users rarely have cause to question the accuracy of conventional information systems. Since expert systems render decisions, conclusions, and/or advice which were previously the sole domain of the human mind, users may have trouble developing confidence in the systems.

Maintenance

Expert systems, like conventional systems, will quickly lose value if not kept up-to-date. Users of conventional systems know when changes are needed and will trigger maintenance to occur; however users of expert systems may not know when knowledge on which the system is based becomes obsolete or needs to be enhanced with additional information. The knowledge engineer needs to carefully plan the process by which ongoing knowledge acquisition will occur within the system.

CONCLUSIONS

From the previous discussion, one may conclude that a systems analyst can make a successful transition to a knowledge engineer, <u>but if</u>, <u>and only if</u>, the following key factors are present:

1. <u>The systems analyst must adopt the unique personal attributes of the knowledge engineer</u>.

   Often an experienced systems analyst can be too skeptical of new technology. As with all humans, the systems analyst may be reluctant to try a new approach if the old one has worked well, especially when project deadlines are tight. This attitude can result in the technology not being used at all, or being used to do things the old way. One example from the past is the generally poor implementation in the 1970's of database management systems. Many organizations used this sophisticated technology as simply a new file access method and developed many independent, redundant databases instead of corporate-wide data repositories for which the technology was intended. If the systems analyst, like the successful knowledge engineer, is innovative, open-minded, self-motivated and willing to take risks, he or she is more likely to effectively exploit the unique capabilities of the technology.

2. <u>The systems analyst must undergo extensive training in expert systems technology</u>.

   Most systems analysts know very little about expert systems technology. As has been explained, there are some skills and knowledge on which a systems analyst can draw in developing expert systems. However, there are several new techniques required for knowledge acquisition and representation that must be learned.

3. <u>Some standards need to be established within the organization for expert systems development</u>.

   Systems analysts rely on extensive standards and guidelines to construct systems and may easily become frustrated with the amount of required rework usually associated with development without standards.

4. <u>Expert system projects should be on familiar ground and of simple to moderate complexity</u>.

   With the introduction of any new technology, it is desirable to minimize change where possible. If the systems analyst is assigned projects in areas of his or her application expertise (e.g. human resource systems), at least one change factor is removed. Since most systems analysts are experienced in developing fairly complex systems, they should have no trouble working on simple to moderately complex expert systems. Projects of greater complexity (more than 2,000 rules), where more esoteric knowledge acquisition and representation methods may be needed, will likely require the more in-depth background of a knowledge engineer.

5. <u>The systems analyst must be able to count on strong support from MIS management</u>.

   The systems analyst's supervisor must fully appreciate the potential of expert systems technology and the unique challenges in applying it. The supervisor must also allow the analyst time to experiment and experience mistakes.

Another important conclusion is that while expert systems technology is different from conventional systems technology, it is not radically so. Expert systems will be developed to solve new kinds of business problems, but will be perceived by users as simply extensions to current conventional systems. Integration of expert systems with conventional systems, e.g. shared databases and similar user interfaces, will be a necessity. After the initial aura wears off, MIS will view expert systems technology as just another instrument in the systems analyst's toolbox for solving user problems. This blending occurred with other technologies and there is no reason to think expert systems will prove otherwise. As Couger and McIntyre (1988) have pointed out, introduction of each new technology has unique problems. However, many successful strategies used for implementing other technologies should apply to the introduction of expert systems technology into the MIS organization.

ACTION PLAN

Putting together a single action plan that will insure the effective implementation of expert systems technology everywhere is not possible. Organizations are different, and each MIS manager must carefully evaluate what has worked well in the past for implementing new technology and what has not and why. The plan presented here has been developed based upon personal experiences in successfully, and sometimes not so successfully, introducing a number of new responsibilities and underlying technologies and techniques into a MIS organization (most notably microcomputer/LAN-based application development, a fourth-generation programming language, a structured analysis and design methodology, CASE, and a relational database system). Implementation experiences at Texas Instruments (Colgrove 1987) were also helpful. The plan is founded on the conviction that the introduction of new technology is more successful if it is accomplished without structural changes to the MIS organization. The plan assumes top-level support has already been obtained from MIS and user executives.

Expert System Technology Implementation Plan:

1. Clearly communicate objectives and the action plan to all MIS management and staff.

2. Identify and free up from present duties two or three systems analysts within the organization who personify the success-dependent personal attributes discussed in this paper. Do not change their job titles or reporting structures.

3. Train these selected systems analysts and their supervisors in expert system concepts. Involve them in the evaluation and selection of initial expert system tools.

4. Provide the systems analysts with extensive formal instruction and hands-on experience in the selected expert system tools, knowledge acquisition, and knowledge representation techniques.

5. Work with the systems analysts, their supervisors, and possibly an expert system consultant in developing initial development standards.

6. Allow systems analysts and their supervisors to select simple pilot projects for users they have worked with in

the past. Obtain support from user management.

7. Provide a forum for pilot project participants to share ideas, concerns, etc. during the development process. Closely monitor project progress.

8. After the pilot projects have been successfully completed, give the new systems, the technology itself, and the participants wide publicity within the company.

9. Train additional systems analysts and supervisors. Involve them in developing a list of potential new expert system applications.

10. Work with user management in reassessing conventional application projects in the backlog, eliminating any which seem out of date given expert system technology and adding the newly identified ones.

11. Rely on the pilot team members to gradually sell others in the MIS organization on the technology and to serve as resident experts in expert systems.

As expert systems developed by the MIS organization become more sophisticated, consideration should be given to hiring an experienced knowledge engineer to provide assistance with complex projects. This professional might possibly be added to the MIS organization's Development Center, if one exists. Consideration might also be given to training users to develop their own department-specific, simple applications.

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