A Framework for Conducting Technology Assessment for Expert Systems

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ABSTRACT

Expert systems have been used to solve a number of business and industrial problems. However, as several corporations have learned the hard way, expert systems are not a panacea for all problems Before an organization commits resources to the development of expert systems, three areas should be studied: information needs of the organization, nature of the problem domain being modeled and end-user profile. This paper outlines some key issues that should be evaluated in each of the above three areas before making a decision to invest in expert system technology. Preliminary analysis and evaluation of these issues will result in the successful development and deployment of expert systems.

INTRODUCTION

Expert systems have been successfully applied to solve many complex business and industrial problems. One of the primary reasons for the continued and sustained interest in expert system technology is its many tangible and intangible benefits, such as cost savings, increased productivity, improved decision-making and the capture and dissemination of valuable expertise [4]. However, the road to developing and deploying expert systems is both difficult and expensive. Developing expert systems is frequently a time-consuming, labor-intensive and resource-greedy proposition. A critical success factor in the successful implementation of any new technology is the ability to perform a thorough and systematic technology assessment analysis prior to committing resources. Technology assessment is different from cost-benefit analysis in that it precedes it and lays the foundation for a well thought out cost benefit analysis. In the case of expert system technology, the conduciveness to prototype such systems is often used as a poor excuse for weak and inadequate feasibility analysis. In many cases, technology assessment is simply not done at all, resulting in systems that are difficult to integrate within the existing information infrastructure of the organization. This paper provides a framework for performing technology assessment for expert systems.

PROBLEM STATEMENT

Assessing the need for any given technology is a complex and detail-oriented task that requires detailed analysis of technical requirements, internal organizational factors and external environmental considerations. Conducting technology assessment for expert systems is further complicated by factors such as ambiguous requirement specifications (for eg. "a system that is as intelligent and capable as Expert A"), difficulty in evaluating system outputs, complexities that arise from a prototype development environment, and finally testing systems that often lack a measurable performance yardstick (for eg. how do we measure the "intelligence" of a system and compare it with its human counterpart?). Unfortunately, the complexity of the task often deters developers and hence technology assessment is either poorly-done or not done at all, resulting in significant losses in terms of resources and poorly developed systems that often fail miserably in their operational environment. Hence technology assessment is a critical and essential first step in the development of robust and reliable systems.

This paper provides a framework for performing technology assessment for expert systems. It addresses the primary question "Is there a match between the technology and the needs and profile of the organization and if so, what are the significant benefits that the company can derive by using this technology?" We propose a preliminary analysis to determine the suitability of the technology for a given problem domain and then identify critical success factors in four areas, namely, information needs of the organization, nature of the problem domain being modelled, profile of the domain expert and lastly, profile of the end user. The combined

impact of different factors from each of the four areas mentioned above should be taken into account in order to make a comprehensive assessment of the suitability of expert system technology.

TECHNOLOGY ASSESSMENT FOR EXPERT SYSTEMS

As a first step in assessing the technology of expert systems, we propose a preliminary screening that analyzes system attributes and domain considerations. Unfortunately, this step is frequently overlooked resulting in a mismatch between the chosen technology and the problem to be solved. If the preliminary investigation indicates that expert systems may be appropriate for the problem at hand, only then is a further analysis, such as cost-benefit analysis, warranted. The attributes and components of expert systems are summarized in Table 1 and Table 2.

Table 1
Characteristics of Expert Systems

1. Possess domain knowledge consisting of facts, theorems, heuristics and judgement. Knowledge and control are separate.
2. Symbolic reasoning and symbol manipulation are integral part of the problem-solving process.
3. Provides explanations about why and how problem-solving strategies were used.
4. Ability to deal with uncertain and incomplete information.

Table 2
Components of an Expert System

Knowledge Base	a reservoir of facts, theorems, principles, rules-of-thumb and judgement.
Knowledge Acquisition Module	a medium that facilitates acquiring domain knowledge from domain expert.
Inference Engine	the "reasoning mechanism" that selects and processes "chunks of knowledge."
User Interface	a piece of software that allows users to interact with the system.
Explanation module	provides explanations to differ-types of user queries.

Preliminary Screening

It is proposed that expert system technology assessment be conducted in two parts: a preliminary screening in which broad issues are addressed and a secondary level analysis in which organizational factors are combined with technological considerations for a more detailed evaluation. The primary objective of the preliminary screening is to deter decision-makers from succumbing to the temptation of forcing a problem to fit a given technology rather than fitting the technology to the problem. Table 3 lists some issues that should be considered and evaluated in the preliminary phases of technology assessment.

This is not an exhaustive list. But issues such as these should be addressed up front, prior to investing time and resources in a feasibility study. Further, answers to these questions may not be a simple 'yes' or 'no', but instead may involve some subjective assessment. For example, there may not always be consensus among the experts regarding solutions to problems but they may agree on most of the solutions most of the time. However, if answers to most of the above questions are "No" or tend not to be in the affirmative, then it indicates that expert system technology may not be a viable proposition for the problem at hand. For problems that appear to match well with expert system technology (based on the preliminary analysis), a more detailed and comprehensive analysis is integral for effective technology assessment.

Table 3.
Prescreening the Suitability of Expert Systems

1.	Is domain expertise rare and expensive?
2.	Is the knowledge likely to be inconsistent and incomplete?
3.	Does problem-solving involve judgement, heuristics and rules-of-thumb?
4.	Is it difficult to state precisely what the system should do?
5.	Is it difficult to determine the right or best solution to the problem?
6.	Is common sense required to solve domain problems?
7.	Are the problems encountered mostly unique and difficult to solve?
8.	Can significant benefits be derived by distributing domain expertise?
9.	Is top management committed to new technology?
10.	Can the expert system be easily integrated into the existing information infrastructure?

Technological Assessment Factors

The literature identifies several factors that should be considered as part of a feasibility study for expert systems. These issues can be broadly categorized into four areas: a) information needs of the organization, b) the attributes and characteristics of the problem domain being modeled, c) the profile of the domain expert, and d) the profile of end users. While some of these issues have been identified in the literature, what is lacking is a comprehensive framework and assessment methodology for expert systems. We propose a framework that brings together issues that are critical for conducting an effective technology assessment.

INFORMATION NEEDS

Expert systems are a repository of knowledge. If the knowledge is rare and expensive and provides the firm with a competitive edge in the market place, then such knowledge becomes a valuable strategic resource in and of itself. Some of the factors that should be considered while assessing the worth of domain knowledge are as follows:

Knowledge as a Resource

The value of knowledge as a key resource must be evaluated. This should take into account factors such as consequences of loosing an expert, the difficulty in acquiring knowledge, the benefits of knowledge dissemination and the competitive edge derived from domain knowledge.

Accuracy and Timeliness of Decisions

If the need to make accurate and timely decisions is paramount to success, then expert system technology can help. Well-developed systems consistently give correct answers and support the learning skills of novices through detailed and customized explanations.

Organizational Training Needs

If training and re-training employees is integral to the company, then an expert system can serve as a valuable training and development tool. An expert system is a patient teacher that can be tailored to meet the individual training needs of its users [4 ,6, 7].

Commitment to Technology

While the information needs of a company are often driven by both internal and external factors, the way information is used in decision-making is often a product of the culture of the organization and top management philosophy. If top management is committed to the use of technology to preserve and disseminate information effectively, only then can new technologies succeed.

NATURE OF PROBLEM DOMAIN

If an organization's information needs can be effectively met or enhanced using expert system technology, a detailed analysis of the problem domain should be done.

Expert Availability

Some domains have very few acknowledged experts and this can be a deterrent to adopting expert system technology. An expert system cannot be built without a willing and acknowledged expert!.

Need for Common Sense

Problem solutions that rely on common sense are not amenable to being modeled as expert systems [3]. Common sense is an intricate combination of knowledge and experience that experts find difficult to articulate and knowledge engineers find difficult to represent in a system.

Problem Complexity

The problems in the domain should not be too simple (the returns will be low) nor too complex because it is difficult to model such problems. A guideline that is frequently used in selecting the appropriate domain is a human expert should not take more than two hours to solve a given problem. [3].

Stability of Domain Knowledge

Domain knowledge should be fairly stable because unlike human experts, who effortlessly update their expertise with new knowledge, machines have very limited learning capabilities. The more unstable the domain knowledge is, the more difficult and expensive it is to maintain the system [2, 4, 9].

Evaluating Problem Solutions

An accepted yardstick for measuring system performance is absolutely essential. In the absence of performance standards, it is difficult, if not impossible, to evaluate the quality and reliability of system solutions.

Problem Boundaries

The current state of expert system technology is such that they are capable of solving only those problems that have clear and well-defined boundaries. If the problem is ambiguously defined, brittleness (or rapid system degeneracy) can become a bottleneck during implementation [1].

PROFILE OF DOMAIN EXPERT

Communication Skills of the Expert

The expert must have excellent verbal and written skills.

It has been found that an expert is not necessarily a good teacher [8] and hence the implicit assumption that a good expert will also be an effective source for acquiring knowledge may not be true.

Cost and Availability of Expertise

Sometimes the cost of expertise becomes a deterrent to investing in expert systems. However, if expertise is rare and expensive, then expert systems become a valuable and viable source for capturing and disseminating such expertise.

Acknowledged Expert

The expert should be recognized as an expert by other experts in the domain. This is particularly important since parochial evaluations can result in undermining user confidence in system performance and reliability.

Application of Expertise

The extent to which the expert handles repetitive cases must be assessed. If a problem-solving strategy requires specialized expertise but the information applied is largely repetitive, an expert system may be an appropriate tool for increasing expert productivity.

END-USER PROFILE

The success of a system, to a large extent, rests in the hands of its end users. In spite of the obvious and important role that they play in the success of a system, end users are often ignored during system design and development phases. Some user-related issues that should be considered during technology assessment are identified below:

Level of Computer Literacy

The computer literacy of the end user should be evaluated during technology assessment. System attributes such as user interfaces, explanation facilities and on-line documentation should be designed to match the skill level of the end user.

Learning Curve

When new technology is introduced, users frequently have to learn new skills. Technology assessment should include an estimation of the time and resources needed to train people.

End User Domain Knowledge

End users can be broadly divided into two categories: decision-implementors and decision-makers. While decision-makers should have a thorough knowledge about the problem domain, decision-implementors, on the other hand, may need only a framework or a set of guidelines about the problem domain for implementing decisions that the system proposes. Such users may need a more step-by-step approach in helping them to implement the decisions proposed by the system [5].

CONCLUSION

Technology assessment is a critical and important task that is frequently either completely overlooked or poorly done. Cost-benefit analysis should follow technology assessment and cannot replace or substitute some of the qualitative evaluations that are done in the technology assessment phase.

Expert systems is a new and vibrant technology that has been successfully applied to solve a wide variety of problems. In this paper, we discuss a framework for technology assessment of expert systems that takes into account four areas, namely, the information needs of the organization, characteristics of the problem domain, profile of the domain expert and end user profile. Factors in all the above four areas should be considered and assessed before investing in expert systems.

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