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As the business environment becomes more complex and more competitive, accountants and other business managers must exploit the advantages of the computer to remain competitive. Even though managers have long used data which was collected, stored, summarized, and reported using computer technology, managers have not traditionally used computers to manage. Only recently have managers realized that the computer is a cost-effective tool which can directly aid and support business decisions (i.e., not only can computers generate data to be used in making decisions, they can also make comparisons, evaluate alternatives, weigh the costs and benefits, and perhaps even make certain decisions).

The new awareness of the computer, particularly the microcomputer, has caused the demand for decision support software to skyrocket. The result has been an explosion of products, each more capable than the last. Some of these products solve specific classes of problems; others help the manager create programs to solve problems unique to a specific business. Many of these products advertise that they incorporate concepts of decision support systems (DSS), expert systems (ES), or artificial intelligence (AI). Unfortunately, the field is changing so rapidly that these terms have almost become code words, with little meaning to most potential users.

Accordingly, one purpose of this article is to introduce the reader to the distinguishing characteristics of computerized decision support systems, expert systems, and artificial intelligence. We will describe the process of designing expert systems in order to emphasize the fundamental difference between these systems and more traditional DSS. The illustration also clarifies the critical role of accountants and other practicing managers in the future development of this area.

**DEcision SUPPORT SYSTEMS**

The concepts of decision support systems, expert systems, and artificial intelligence are closely related, and it is not always clear where one leaves off and another begins. Neither is there a generally accepted definition for each of these ideas. Nevertheless, most experts would agree that state-of-the-art DSS share four basic characteristics:

*Computer-based.* It is possible to implement a DSS without a computer, and certainly many paper-based systems exist. But it is the ability of the computer to process vast amounts of data quickly and without error that makes most modern systems practical.

*Interactive.* Interactive may mean that the computer interrupts processing to request input from the user or the computer may provide intermediate results for the user to verify and re-
spond to before further processing. In another form of interaction, the user interrupts the computer to request data and/or intermediate results or recommendations.

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Data Retrieval and Manipulation. Decision support systems commonly support access to large information data bases in order to selectively retrieve, summarize, classify, or manipulate data. In some DSS applications, such as data base management systems, data retrieval and manipulation is the main function of the system.

Decision Model. Many DSS applications have as their main function the implementation of a decision model. A decision model combines data and decision rules to suggest a course of action. The “make or buy” problem in management accounting is a classic decision model. Another example suggestive of potential computer-based decision processes is the automatic reorder model included in many integrated inventory control systems.

Again, these are characteristics shared by most decision support systems. In this article, we use the term decision support system broadly to refer to any interactive computer application that helps a decision maker by providing access to large data bases or by implementing a decision model or both.1

Decision support systems in public accounting range from the rudimentary to the sophisticated. They may help in the collection and organization of data, perform checks for completeness and consistency, and execute the retrieval and manipulation of data. Decision aids such as ASK, AUDITAIID, BASE, CARS, PROBE and others are computer-based, but provide little interactive support, relying on the auditor to select from among the available models for data collection, organization and manipulation. Many such decision aids are equipped with normative models for data analysis purposes. Common examples in auditing would be the many statistical sampling packages currently in use.

During the last several years, many of these systems have been improved by adding user-friendly features such as menu driven interaction systems. As a result of these additions, Deloitte Haskins & Sells’ STAR system, Peat Marwick Mitchell’s SEACAS, Coopers & Lybrand’s PREADIT, Arthur Young’s ASQ and numerous others in place and under development have become true decision support systems. They are computer-based and interactive, with data retrieval and manipulation capabilities and normative model components.

There seems to be no question that these trends in decision support software will continue, since it is generally accepted that these systems can be useful to accountants and other managers. While cost/benefit analyses are seldom carried out in detail, it seems that the demand for decision support software will continue to produce more and more sophisticated systems. The next step is upon us: products which incorporate expert knowledge in solving problems. Decision support systems of this type are referred to as expert systems, but what are ES and can experts really be replaced by computer hardware and software?

ARTIFICIAL INTELLIGENCE
AND EXPERT SYSTEMS

It must be made clear from the start that computers will not make accountants obsolete any more than telephones made mailmen obsolete a century ago. The question in the previous paragraph is the “red herring” of the day, posed by those who do not understand and fear change. Certainly, the expert’s realm will change with the introduction of new decision support tools, just as it has changed in the past. The introduction of ES should be viewed in the same way in which the introduction of past decision support systems have been viewed: as a tool for the decision maker, who will continue to make the critical judgments in the process. Expert systems are in this sense simply another DSS.

Nevertheless, expert systems are different from existing decision support systems. Earlier DSS have generally made no attempt to emulate or copy an expert’s decision process. They have either used well-accepted normative models to solve specific problems or provided data support for the human expert.

Expert systems apply basic concepts of artificial intelligence. Artificial intelligence is “that part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics we associate with intelligence in human behavior — understanding language, learning, reasoning, solving problems, and so on.”2 ES are “... problem-solving programs that solve substantial problems generally conceded as being difficult and requiring expertise. They are called knowledge based [systems] because their performance depends critically on the use of facts and heuristics used by experts.”3 ES are an application of AI concepts. ES capture the specific knowledge of the acknowledged expert concerning a specific problem domain and attempt to duplicate the
expert’s decision process. These programs differ from traditional decision support systems in two ways: they rely on a rich base of specific knowledge about a problem, and they attempt to solve a problem using the “thought” processes used by an expert (i.e., they emulate the human expert).

Not every problem is appropriate for the development of an expert system. First, the process to be modeled must be important enough to justify the high cost of creating the ES. Importance may be measured in immediate cost savings, revenue increase, or in the longer-term reduction of risk. Second, the area of concern should be sufficiently ill-defined as to be unlikely to yield to more traditional problem-solving techniques. Third, there must be an acknowledged expert in the area. This is not a trivial consideration, since expertise is itself not well defined. Fourth, experience to date indicates that while the area can be ill-defined, it must have enough structure so that the expert can identify and acquire the specific domain knowledge required. It is the fact that experts solve these important problems in ill-defined settings that makes it useful to consider emulating their behavior in computer-based expert systems.

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It is not easy to tell whether a machine emulates the human intelligence process. In some sense, as soon as the machine can do “it,” “it” is no longer a fundamental part of the definition of human intelligence. Generally, the current test is whether other experts consider the machine’s problem solving and explanation process to be that of an intelligent human. Tests designed to establish the existence of this condition often involve settings in which human experts are asked to distinguish between computer-generated decisions and decision process descriptions and those of other experts. If the human cannot tell whether the interactions are those of a computer or a human, the computer is judged to be an expert.

CREATING EXPERT SYSTEMS

The creation of an expert system is a four-step process which begins by obtaining an understanding of a particular judgment problem and the expert’s thought processes in solving the problem. This is followed by the creation of a computational model or computer program intended to reproduce the expert’s decision process. Finally, the model must be validated and tested before it can be accepted as an expert decision support system. These steps are referred to respectively as knowledge acquisition, knowledge representation, computational modeling, and model validation.

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Each of these steps is difficult when taken separately; the complete process represents a substantial investment in time and resources. Each step is also required before the expert system is usable. Researchers have turned primarily to the cognitive sciences (such as psychology) to complete the process of knowledge acquisition and portions of the knowledge representation problem. Discovering and deciphering experts’ decision processes in order to understand a problem requires working closely with experts. A key obstacle to understanding expert’s decision process is that the expert is often unable to explain, in a straightforward fashion, how she or he makes a decision. In a sense, the expert does not know how the decision is made. Over time the process has become a subconscious one that the expert does not explicitly consider. For example, none of us explicitly consider all the processes required to drive a car; we just get in and go. When asked to explain the process, we are likely to give a textbook description, if we can describe it at all. Thus, substantial effort has been devoted to developing techniques for extracting knowledge from experts.

The techniques applied are time consuming and demanding of both the researcher and the expert. One method calls for the expert to solve problems while “thinking aloud” about the process being followed. The expert’s “thinking aloud” is transcribed and becomes what is known as a protocol. These protocols are then analyzed by the researcher. Descriptive methods that rely to some extent on text and professional literature descriptions, questionnaires, and interviews can also be helpful. Finally, intuitive techniques that rely on the researcher’s own experience contribute to the process. In most cases this work requires close cooperation of an expert in the area.
and a researcher with substantial knowledge of the area, applying all of these techniques.

Armed with an understanding of how the expert approaches the problem, the researcher must then produce a conceptual representation of the knowledge, a way of organizing the knowledge that is as close to the expert's organization as possible and yet can be programmed for the computer. Various methods have been devised for this purpose. The most successful to date has been a rule-based representation scheme. In a rule-based scheme, the expert's knowledge is represented as a series of IF-THEN-ACT rules. Often these rules will include probability weightings to represent the expert's uncertainty about the rule.

The earliest models of expert systems required that every new system be programmed individually. Recently, a number of decision support systems have been created to support the ES developer. These systems, known as "shells," require the ES developer to input only the specific domain knowledge obtained from the expert and to describe the decision or inference process used by the expert in solving the problem. The shell then combines the two elements of knowledge and inference process to create the ES. The separation of the task-specific problem knowledge from the inference process makes these systems relatively easy to change should the setting change or should new information about the process be obtained from the expert.

"A well-developed system will either ask for more information or state that the problem submitted for solution is inappropriate for the system."

Validating these models involves testing them against as many situations as possible within the domain of the system. Ideally, the system will, like a human expert, be able to distinguish between problems that it can solve, problems that are within its domain but for which it lacks sufficient information for solution, and problems which are completely outside its area of competence. A well-developed system will either ask for more information or state that the problem submitted for solution is inappropriate for the system. This process is called "graceful degradation" and is important because a system that attempts to solve problems for which it lacks the necessary knowledge or inference process is likely to produce solutions that are wildly in error.

**ANALYSIS OF RISK IN INTERNAL SYSTEMS CONTROL**

Two of the authors of this article, in conjunction with a team of colleagues, have carried out the complete process described here in developing a prototype expert system called ARISC (Analysis of Risk in Internal Systems Control) for the evaluation of internal accounting controls in an audit setting. It would have been impossible to create ARISC, as it would be impossible to create any effective ES, without the complete participation of an expert. In the case of ARISC, Peat Marwick Mitchell (PMM) provided substantial time commitments from, and the whole-hearted participation of: 1) one expert on whom the model is based; 2) three additional experts against whom the original expert and resulting model were compared; and 3) three additional experts who compared the performance of the original expert, the model, and the first three additional experts. An expert software shell developed at the University of Minnesota called GALEN was used as a decision support tool in creating the computational model of the expert decision processes.

ARISC accepts as input the PMM SEACAS/SEADOC internal control documentation embodied in the firm's standard working papers. This data plus the encoded expert heuristics developed during the knowledge acquisition phase are represented in a form acceptable to the GALEN inference process. GALEN was selected because it employed an inference process similar to that used by PMM experts. ARISC then analyzes the input and provides the user with an assessment of the quality of various controls, likely controls that might be tested, and a list of unanswered questions that the auditor may wish to pursue before proceeding. Unfortunately, ARISC is not yet sufficiently user-friendly to be used in practice.

**CONCLUSIONS**

We are convinced that the impact of computer-based decision support systems is only beginning to be felt in public accounting. Substantial improvements in existing decision aids will rapidly lead to the widespread use of conventional DSS.

Expert systems, on the other hand, are somewhat less likely to be generally applied in the next five years. A few fairly small systems are currently being introduced, but few truly expert systems have reached the field application stage and none of them are in the area of auditing. The long development times, the necessary expertise that must be diverted from immediate income-producing activity and the shortage of qualified systems developers should result in relatively slow development over the next sev-
eral years. As these limitations are overcome, the development of ES will increase its pace.

In the meantime, we suggest support for the development of these ideas, caution in buying software that currently asserts that it is "expert," and increased computer training at all levels within the organization. This latter step will allow the full use of existing DSS and will prepare personnel for the future, a future which will be replete with expert decision support systems.

FOOTNOTES


4 Bailey, et al., op. cit.

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