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Introduction to artificial intelligence and expert systems : a special report developed for CPAs seeking to become familiar with artificial intelligence and expert systems technology; Management advisory services special report

American Institute of Certified Public Accountants

A Management Advisory Services Special Report

An Introduction to Artificial Intelligence and Expert Systems

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AICPA American Institute of Certified Public Accountants

NOTICE TO READERS

A Management
Advisory Services
Special Report

An Introduction to Artificial Intelligence and Expert Systems

A special report developed for CPAs seeking to become familiar with artificial intelligence and expert systems technology.

AICPA American Institute of Certified Public Accountants

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Preface

Artificial intelligence, the technology of making computers able to reason, make judgments, and even learn, has generated considerable interest among members of the accounting profession during the past year and a half. Many trade publications and general interest newspapers and magazines, as well as the *Journal of Accountancy*, have carried articles discussing artificial intelligence and predicting the impact it will have on the business world and on society as a whole.

In its 1985 annual report to the Board of Directors, the Future Issues Committee of the American Institute of Certified Public Accountants stated that it believed artificial intelligence (which includes expert systems) is an issue of major significance confronting the accounting profession. The committee posed this question: How can the accounting profession utilize the benefits of the emerging issue of artificial intelligence, particularly expert systems technology, to provide services, improve performance, and reduce costs? The committee also analyzed the importance of the issue and the driving forces shaping it, identifying some of the current initiatives, addressing aspects of the issue, and setting forth possible options to deal with the issue.

This special report is a response to the rising level of interest in artificial intelligence and expert systems among AICPA members. The goal of the report is to concisely present practical information about expert systems—their basics, the opportunities for the accounting profession, the ways accounting firms might begin using expert systems, issues to consider, and prospects for the future. This information is neither new and original nor highly technical. It is basic coverage intended to help AICPA members understand the possibilities that expert systems offer for problem solving and productivity improvement.

Hopefully this report will be not only informative but also thought-provoking. The prospects offered by these new technologies are exciting in their positive aspects and somewhat threatening in their unfamiliarity. But, in any case, they pose a challenge that we encourage our fellow professionals to begin addressing today.

EDP Technology Research Subcommittee (1985–86)

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Summary

Artificial intelligence is a field of science and technology that over the past thirty years has developed into three principal branches—expert systems, natural language communication, and robotics. Expert systems is the branch currently of most interest to the accounting profession.

Expert systems are computer programs that emulate the thinking processes of human experts in solving problems in a specialized area. For example, they have been created for medical diagnosis, geological prospecting, and computer hardware configuring, as well as many other research and commercial applications. Expert systems are used as advisors or consultants to human users; the goal of their developers is to enable them to produce the same advice that a human expert would produce.

Expert systems are more appropriate than conventional data processing in applications that require judgments and that use rules of thumb as part of the decision-making process. Expert systems also differ from conventional computer programs in the ease with which they can be changed; this facilitates incremental system design.

The benefits of expert systems in the accounting profession could include preservation and distribution of specialized expertise, improved personnel productivity, assistance in quality control and education efforts, and increased ability to analyze complex problems.

Expert system applications that are currently in use or under development include audit planning, internal control evaluation, account analysis, quality review, accounting decisions, tax planning, management consulting, and training.

For a CPA firm interested in exploring the potential of expert systems, the first step should be gaining a full appreciation of the technology. This may involve developing a relatively small application with clearly defined boundaries as a research project. The effort and expense of such development can be minimized by utilizing commercially available software packages that are expert system shells. The personal computer is the most likely delivery vehicle (hardware) for expert systems.

Future developments in expert systems will include—

- Desktop and portable computers becoming more powerful and cost-effective expert system delivery vehicles.
- Implementation of artificial intelligence capabilities in single integrated circuits that can be installed in conventional computers.

- Increasing availability of software products that combine the capabilities of an expert system shell with more conventional computer applications, such as spreadsheets, data bases, graphics, and word processing.
- Embedding expert systems within conventional computer applications.
- Increasing availability of end-user expert systems—that is, totally prewritten expert system packages, including the knowledge base.

As with any new technology, the ultimate effect of expert systems on the accounting profession is uncertain at this time. But to some degree they will affect professional development, quality control, staffing models, training, the nature of audit evidence, and the profession's image and competitive environment.

Contents

Introduction

Artificial intelligence (AI) is a field of science and technology so diverse that it is difficult to define precisely. It incorporates concepts and techniques of several disciplines ranging from sociology and cognitive psychology to electrical engineering and computer science. For practical purposes, however, it is a set of techniques whose processes give computers the humanlike abilities to see, hear, speak, reason with imprecise or incomplete information, and learn.

A Brief History of Artificial Intelligence

Artificial intelligence has existed formally as a technology for only about thirty years. Over that time it has had two parallel thrusts. The first is the thirty-year ongoing research effort to shed light on human thought and decision-making processes by attempting to model them with computers. The second is the newly emerging commercial effort to create and sell artificial intelligence-based products. A chronology of significant developments includes the following:

- In 1957, LISP, the first AI programming language, was developed.
- During the 1960s, AI labs were established in several major universities.
- During the mid-1970s, the Stanford University AI lab developed a system for assisting in the diagnosis of meningitis and other bacterial infections in the bloodstream. This system, called MYCIN, had a high accuracy rate in correct diagnosis. It proved that AI techniques could be applied to real-world problems.
- During the late 1970s, AI techniques were extended to solve problems in business, and Carnegie-Mellon University developed a system for Digital Equipment Corporation to assist technicians in the complex task of minicomputer configuration. This expert system, called XCON, was one of the first significant commercial successes for AI.
- During the early 1980s, AI moved from the laboratory into the commercial marketplace when Symbolics, Inc., and LISP Machines, Inc., both spin-offs from the MIT AI lab, began providing computer hardware designed to process AI programs written in LISP. At about the same time, Teknowledge and Intellicorp, commercial software ventures that grew out of Stanford's AI lab, began providing sophisticated software tools for developing expert systems.

- During the mid-1980s, AI products were adapted to conventional computing systems (instead of specialized machines) and traditional end-users.

Artificial Intelligence Technologies

Within the field of artificial intelligence, there are currently three growing commercial technologies: expert systems, natural language communication, and robotics.

Expert Systems

Expert systems are computer programs that emulate the thinking processes of human experts to solve problems in specialized areas. For example, they have been created for medical diagnosis, geological prospecting, and computer hardware configuring, among many other research and commercial applications. Expert systems are the principal focus of this report, because they hold considerable immediate and long-term promise for the accounting profession.

Natural Language Communication

Natural language communication permits computers to "understand" human languages. *Understand* means that a computer can accept ordinary human language as input, execute the corresponding command, and generate the proper output. The initial applications of natural language communication are in data base inquiry and control commands for computers or robots. Other systems are being developed to read through huge amounts of text (tax cases, for instance) and understand the information well enough to summarize important points and to store information in order to respond to inquiries about the contents.

Robotics

With some gimmicky exceptions, today's robots do not look much like the classics of science fiction. *Industrial robots* are machines programmed to manipulate parts or tools to perform a variety of tasks. *Mobile robots* are machines that move and navigate around obstacles to perform tasks such as carrying parts to factory workstations or delivering mail to offices. *Flexible manufacturing systems* are clusters of robots and other machines that can be quickly reprogrammed to switch from making one version of a product to another.

An important part of robotics is developing vision and touch sensors—the eyes and hands of robots. This involves linking ingenious machinery to computers running artificial intelligence programs that analyze the data relayed by the sensors and determine what is seen or felt. Computer-driven feedback mechanisms continuously reposition the robot and move and coordinate its parts so that it accomplishes its task.

Expert Systems Basics

What Is an Expert System?

The AI technology of most commercial interest today is expert systems, which use the encoded knowledge of a human expert and a computer program to emulate the expert's behavior. They do this by breaking a problem down into its elements, looking for patterns in information related to the problem, combining conclusions about individual problem elements, and eventually choosing the solution that seems to have the most evidence in its favor.

An expert system is not a decision maker; rather, it serves as an advisor or consultant to human users who make decisions. Developers of expert systems aim to have them produce the same suggestions, advice, or solutions to a problem that a human expert would. An expert system's data base can incorporate knowledge that a human expert acquires from many years of experience. Then, using a pattern of reasoning also supplied by the human expert, the system uses that data base to assist nonexperts in solving a problem.

Components of an Expert System

The working parts of expert systems are a *knowledge base* and an *inference engine* program. In addition, expert systems include a *user interface* program, and the most powerful expert systems also include an *explanation facility* as the fourth component.

Knowledge Base

The knowledge base consists of facts about a specific topic area, or *domain*, and rules for using those facts. For example, the knowledge base might include facts and rules that explain procedures, describe objects, and identify relationships. The knowledge base includes not only the known facts and concepts about the particular topic area, but also the rules of thumb the expert has developed through experience. These rules of thumb in an expert system knowledge base are known as *heuristics*.

Software engineers who specialize in expert systems, known as *knowledge engineers*, abstract this information from *domain experts* (people who are experts in the topic area for which the system is being developed) and load it into the knowledge base.

Current commercial expert systems typically store the knowledge an expert provides in the form of *production rules*. These are "if...then..." rules that represent condition and action knowledge. The *if* portion of the rule specifies the condition, and the *then* portion indicates the appropriate action in this form: *if* condition X is true, *then* take action Y. That is, if the condition part of the rule is true, then the action part is performed. For example, *if* the room temperature is less than 65 degrees, *then* turn on the furnace. An expert system that uses production rules is called a *rule-based system*.

More sophisticated methods of knowledge representation enable a system to address more difficult problems. Some expert systems construct their knowledge bases as structured lists of facts, relationship networks, or hypothetical situations.

Inference Engine

Once the knowledge of an expert has been encoded, the next step is to use it. A computer program called the inference engine is the expert system component that does this. The inference engine drives the system as it successively draws an inference by relating user-supplied facts to a knowledge base rule and then proceeds to the next fact-and-rule combination. At each step, the inference engine recognizes the most appropriate rule from the knowledge base and matches it with information supplied by the user. This process forms a *chain* in which the *then* part of one rule forms a link to the *if* part of the next and eventually leads to the most likely conclusion.

Inference engines differ in the way they chain their inferences. *Backward-chaining* inference engines are the most common; they start with a goal and then look for rules that will establish the facts to support the conclusion. For example, the goal might be to identify a plant as belonging to a particular species; the system would search for a chain of rules that accounts for all the plant's attributes and concludes with the species name.

On the other hand, a *forward-chaining* inference engine starts with elementary data and builds up a collection of facts to arrive at a conclusion. Rules are examined to see if, based on the available information, they are true. If a rule is true, then it is added to the collection of facts and the system examines the rules again. This continues until no new rules emerge and a conclusion is stated.

Often the knowledge abstracted from the human expert and loaded into the knowledge base is neither always true nor always false. It may follow this form: if *a* and *b* are true, then it often implies that *c* is true. To deal with this kind of knowledge, some inference engines have an ability to handle a *certainty factor*, or degree of belief, about various facts in the knowledge base. They also take into account several redundant or confirming factors and use an algorithm for determining a cumulative level of certainty.

User Interface

The user interface is the expert system component that provides communication between the inference engine and the system user. The inference engine uses the user interface to conversationally ask the user for facts about the rules in the knowledge base, deliver its conclusions, and—in conjunction with the explanation facility—explain the system's reasoning. It then relates these user-supplied facts to knowledge base rules to make a decision or form a hypothesis about the problem.

Explanation Facility

The current commercial expert systems that are most successful also include an explanation facility component. It helps the user understand why certain questions are asked or why specific conclusions are reached. In some systems, this consists of providing a list of the steps the system follows in reaching its conclusion. Other systems explain not only conclusions but also the reason for asking a particular question during dialog with the user. A good explanation facility can enhance an expert system by increasing the user's confidence in the system's conclusions, providing some instruction to the user about how an expert approaches the problem, and providing a system developer with the means to monitor the system's operation.

Differences Between Expert Systems and Conventional Data Processing

Since expert systems use computers and many expert systems use the production-rule (if... then...) form of knowledge representation, there is a tendency to associate them with data processing and conventional computer programming. However, there are significant differences between expert systems and conventional data processing.

Ability to Perform Nonalgorithmic Processing

Conventional data processing requires certain and complete input, uses primarily computation in algorithms, and produces specific, predictable results. In contrast, expert systems are appropriate for applications that solve problems by means of judgmental decisions. Expert systems can use uncertain or incomplete information, manipulate it without following a rigid algorithm, and draw conclusions or find alternative solutions to a problem. When a problem and the related knowledge are firm, fixed, and formalized, conventional programming and data processing are appropriate. But when the problem is complex and the domain knowledge is not firm, heuristics, or rules of thumb, are part of the decision-making process, and expert systems are more appropriate than conventional methods.

Ease of Change

Expert system programming differs from conventional programming most notably in the ease with which it can be changed, because the program that controls the processing is separate from the knowledge that the program applies. In conventional computing, the knowledge is embedded in the program when a programmer creates control instructions that set one solution path for each situation the program is designed to handle. The program applies control instructions, such as "if... then..." statements to the content of variables, and determines the flow of processing accordingly. As a result, in a conventional program the "if... then..." statements can be very hard to update because their order is significant to the control of processing. On the other hand, in a rule-based expert system, it generally does not matter where a new rule is inserted because execution is controlled by the inference engine, not by the sequence of the production rules in the knowledge base.

Ability to Use Incremental System Design

Since expert system programming makes it easy to extend or modify the knowledge base as more is learned about the subject, *incremental system design* is possible. In situations in which the design of the solution to a problem is not completely known, a *prototype solution*, or a solution to part of the problem, can be rapidly developed and put into use. As use of the prototype produces a better understanding of the problem, the capabilities of the prototype can be enhanced incrementally, with eventual evolution of a system that completely achieves the solution originally desired. (Of course, the same approach would be applicable to a system that has known design requirements at a point in time but that is subject to frequent and rapid change—that is, a system "shooting at a moving target.")

Hence, in some circumstances, the expert system enjoys a significant advantage over the conventional data processing system because it can be put into production more quickly, and it is easier to enhance in response to user feedback on its performance or to changing external design requirements. This has been demonstrated in many current expert systems, which were originally implemented at only 30-percent to 50-percent completion levels and have generated productive benefits for their users while proceeding incrementally to higher completion levels.

Examples of Expert System Applications

Expert systems have already been applied in many problem domains. For example, they have been used successfully in determining malfunctions in equipment, diagnosing diseases in humans, choosing fertilizers and insecticides, and locating natural resource deposits. Briefly examining some of these applications illustrates the current use for the technology and suggests its future potential.

MYCIN

MYCIN is one of the most famous expert systems. Although it is not a real-world application because it has been developed and used primarily for research purposes, it does demonstrate the components and processes underlying today's expert systems technology. Its innovations and successes led to the modern view of how to construct expert systems, and its features are the foundation for many commercial systems.

MYCIN was developed at Stanford University in the mid-1970s. It was designed to provide physicians with advice about meningitis (infections involving inflammation of the membranes surrounding the brain and spinal cord) and bacteremia (infections involving bacteria in the blood). Its objective is to provide the physician with advice comparable to that from a consulting physician who specializes in meningitis and bacteremia infections.

When a physician uses MYCIN, its user interface initiates a dialog. The physician responds to questions asked about the patient (for example, age and sex), laboratory test results, the patient's symptoms, and so forth. Based on the physician's responses, the inference engine directs the system to ask the next most appropriate question, much as a consulting physician would do. If uncertain about particular information requested, the physician can assign a certainty factor to the response by indicating a degree of confidence in the answer. Likewise, if an item of requested information is not known, the physician may answer "unknown."

The physician can query MYCIN about why it has asked a particular question or why it has reached its stated conclusion. The physician can respond with "why?" when MYCIN is asking for data, and MYCIN's explanation facility will explain what hypothesis it is considering and how the answer to the present question will provide data that will help to either support or rule out that hypothesis. The physician can also request MYCIN to trace its entire diagnostic trail, and it will list the chaining of inferences from fact-and-rule combinations that led to a conclusion.

Eventually, MYCIN provides a diagnosis along with a detailed drug therapy recommendation. In tests conducted using MYCIN and human experts in diagnosing meningitis and bacteremia infections, MYCIN's prescriptions proved "correct" in 65 percent of the cases, compared to the human experts' range of 42.5 percent to 62.5 percent.

XCON

XCON is one of the largest and most intensively used expert systems in commercial operation. It was developed in the late 1970s at Carnegie-Mellon University for use by Digital Equipment Corporation technicians configuring minicomputer systems.

DEC's VAX minicomputer line consists of hundreds of components that can be combined in thousands of ways to configure a computer system. Because a large proportion of VAX systems are unique custom configurations, there is no standard configuration of the system components. Before XCON, engineers would examine each VAX customer's purchase order and determine which computer components to add, delete, or substitute to make the configuration complete and consistent. XCON has taken over this job. A technician inputs a list of the specifications needed to complete a customer's order—hardware and other components, cable lengths, power requirements, and other technical details. XCON then makes any necessary changes or corrections to the original order to arrive at the best configuration, and it produces a set of detailed diagrams to assist in assembling the system on DEC's plant floor and at the customer's site.

The system reportedly saves DEC millions of dollars a year by reducing the number of false orders for unneeded components and the number of rush orders for essential components omitted from the original configuration.

XCON provides a good example of the incremental system design possible with expert systems technology. The initial system was developed quite rapidly, and it has been continually tested, refined, and expanded during actual use. The initial implementation version of XCON included only five hundred rules, and it was produced in less than one person-year. Since its original implementation in 1981, features that were neither included nor even anticipated in the original design have been easily added to the system by incorporating new rules to expand the system's capabilities. Engineers still configure orders that are not within the scope of XCON's capabilities, and as they do so they develop new heuristics for solving more specialized problems and add these to the knowledge base. The current version of XCON uses over four thousand rules and performs most configuration tasks in less than two minutes.

DELTA

The General Electric Company developed DELTA in 1981 to assist maintenance engineers in diagnosing problems with its diesel-electric locomotives. Its development was motivated specifically by a desire to *capture the knowledge of a human expert.*

Prior to DELTA's development, GE frequently solved problems with their diesel-electric locomotives by flying a maintenance expert to the location of the malfunctioning engine. The maintenance engineer most often involved in this process, and the company's acknowledged expert in the area, had been with GE for over forty years and was due to retire. DELTA's development was initiated to capture his knowledge so that it could be preserved and also readily delivered to maintenance personnel in remote locations.

A team of knowledge engineers from GE's Research and Development Center worked with the expert maintenance engineer to develop DELTA. Over a three-year period, DELTA progressed from a 45-rule prototype to a system that contained 1,200 rules and was capable of handling 80 percent of the problems encountered. It is currently used in production and is updated and refined by adding rules to cover more problem situations.

DELTA now not only helps maintenance personnel diagnose problems but also prescribes procedures for repairing them. It asks the user a series of questions about symptoms and develops a diagnosis-and-repair strategy based on the responses. The system also interfaces with a video disk player and can selectively retrieve diagrams of parts and subsystems to show where particular components are located on the locomotive. Once the problem is isolated, DELTA can display the step-by-step procedure for repairing it.

New Systems

Some examples of expert systems under development or recently implemented for business purposes are as follows:

- General Motors' Delco Products division has a system intended to reduce the time needed to design brushes and brush springs for electrical motors.
- Honeywell, Inc., has a system that runs on a portable microcomputer and helps field technicians diagnose mechanical problems in air conditioning systems and spot problems before they cause a failure.
- A system for Northwest Orient Airlines optimizes revenues for each flight by helping inventory control agents determine the number of discounted-fare seats to make available. It takes into account the competition's price, the number of bookings already completed, the historical volume of traffic on the flight, and so forth.
- Northrop Corporation's aircraft division developed a system to determine the operations needed to manufacture specialized airplane body components and then produce a detailed routing sheet and operations list for shop floor managers.
- A system for Metropolitan Life Insurance Company helps its actuaries assess the risks of underwriting the interest rate and principal of guaranteed investment contracts.

Opportunities for the Accounting Profession

Types of Tasks

Many expert system applications currently used in the business world display some common characteristics. These suggest expert systems are appropriate for the accounting profession to use with certain types of tasks, such as–

- Analyzing diverse data to identify, or "diagnose," possible problems or malfunctions, to prescribe the proper response, or both.
- Analyzing situations in which the known data may be incomplete or imprecise.
- Selectively distributing specialized knowledge about a subject area.

Benefits

Preservation of expertise. Every accounting firm has personnel who have expertise–great depth of knowledge and extensive experience–in particular subject areas. The firm can use expert systems to collect and preserve this knowledge. The effective extraction and encoding of such knowledge into expert systems saves current knowledge because an expert system will not retire, die, or leave the firm to work for another organization. In addition, the current knowledge thus captured can become the foundation for increased future knowledge through the use of expert systems' incremental development capability.

Distribution of expertise. A firm's human experts are often in short supply. Since expert systems offer a means of duplicating an intellectual resource, they enable a firm to selectively distribute the knowledge of its human experts in the form of systems that other personnel can use as intelligent assistants or consultants. These systems permit the distribution of expertise to locations where a human expert is not available or in situations in which the cost of a human expert's services might otherwise be too high. Consequently, the firm's personnel can develop the capacity to address problems previously solvable only by certain individuals, and the firm may also attain the ability to enter new markets it cannot penetrate now.

Improvement of personnel productivity. Expert systems offer a firm a way to put the acumen of its veteran professionals at the disposal of junior personnel throughout the organization. This capability offers the potential to improve personnel productivity by enabling junior personnel to effectively handle tasks for which they might otherwise need more training or experience and by freeing experienced personnel for more important tasks.

Assistance in quality control. The ability of expert systems to encourage consistent and uniform performance of professional tasks may be one of the biggest benefits for the accounting profession because it can facilitate the vital function of quality control. Expert systems embodying the firm's standards for performing particular functions can not only provide guidance for the task, but they can also help to ensure that people have addressed the key questions in performing a procedure or making a decision.

Education. A firm's development and use of expert systems can provide several educational benefits. First, the attempt to create an expert system can in itself be educational by producing a deeper understanding of knowledge. This undertaking forces the firm's experts to "dissect" experience and thought processes that they may have taken for granted. Second, less experienced personnel can gain knowledge by utilizing expert systems as practice aids in performing professional tasks. And third, expert systems can be used specifically as computer-based training tools.

Increased ability to handle complex analyses. Some problem domains and functions in accounting involve masses of data in which the elements are relatively simple when taken individually but are virtually overwhelming, to anyone but an expert, when taken as a whole. This might be the case when there are masses of regulations, such as in corporate tax consultation, or when there are masses of facts, such as in analytical review. Expert systems can increase the professional's ability to undertake complex analyses in these areas by identifying hidden patterns, predicting the effects of changes, and so forth.

Potential Applications

In general, CPAs are just beginning to consider using expert systems in their practices. Few serious expert systems have been developed for day-to-day use in conjunction with the delivery of professional services. However, several firms have developed prototype systems, and some systems are ready for production implementation on a limited basis. Given the nature of the work in the accounting profession and the current capabilities of expert systems technology, applications likely to become common in the near future include the following:

Audit planning. To aid in evaluating risks and establishing audit objectives in particular circumstances and in prescribing corresponding audit steps and procedures.

Internal control analysis. To classify the internal accounting controls in particular client organizations and to diagnose actual or potential weaknesses.

Account attribute analysis. To review the attributes of specific accounts (for example, accounts receivable or loans receivable) and to assist in evaluating the adequacy of related valuation reserves.

Quality review. For prefiling or second-opinion reviews in areas such as SEC compliance and annual report disclosure and content.

Accounting decisions. To help in reaching decisions about the proper accounting treatment of complex transactions, such as those involving leases, foreign exchange, acquisitions, pensions, and income taxes.

Tax planning. To perform complex specialized analyses and to provide supporting documentation in tax planning consultations.

Management consulting. To identify patterns and relationships, to match alternative solutions to circumstances, and to evaluate the effects of changes in consultation engagements dealing with areas such as materials management, inventory control, plant site selection, plant layout, EDP systems development, data security, pension plans, and valuation services.

Training. To provide simulated on-the-job experience by using the same expert system a professional uses in doing a job. For example, a junior accountant could be instructed to perform a certain practice task that is supported by an expert system. The system could lead the junior accountant through the task in much the same way that a human supervisor would. The system could ask for the required information, then ask for decisions at subpoints along the way, and finally point out and explain any errors as they are made. The practice tasks could be based on past real situations, and they could thus expose the junior accountant to more real-world situations in a shorter period of time and provide more experience than actual on-the-job training.

A Case in Point: Coopers & Lybrand's ExperTAX^{sm}

Tax accrual involves identifying differences in book and tax computations and explaining the differences between statutory and effective tax rates. Many accounting firms have developed questionnaires, forms, or checklists that help in gathering the information necessary to perform tax accrual and planning. Audit staff accountants in the field usually complete the questionnaires. Typically, they are principally concerned with the tax accrual computation. Therefore, they tend to give little attention to the significance or relevance of the information for tax planning purposes, even though this may be important to the client and may be a fertile area for consulting opportunities.

Coopers & Lybrand has developed an expert system called ExperTAX^{sm} to actively guide and direct the audit and tax staff accountant through the process of gathering the information necessary in tax accrual and planning. At the same time, ExperTAX^{sm} has the ability to point out the importance of the information being requested. It can be a very effective training and education tool, providing the professional with the experts' reasons for requesting specific information. Unlike a questionnaire, which does not provide any insight into why a specific question is being asked, ExperTAX^{sm} can provide an explanation for each question. An example of a user dialog with ExperTAX^{sm} is presented in the Appendix.

ExperTAX^{sm} was developed in a programming language called Common LISP. It runs on the IBM PC-XT, the IBM PC-AT, and compatible microcomputers with 640K memory, a 10-megabyte hard disk, and an attached printer. Coopers & Lybrand developed the system by extracting and encoding the expertise of over thirty of its senior tax and audit professionals. Its knowledge base now contains over three thousand rules, frames, and facts. As of this writing, the system is currently operational after having undergone field tests within selected offices.

ExperTAX^{sm} consists of three modules: the expert system shell (called QShell), the knowledge base, and the knowledge base maintenance system.

The Expert System Shell

QShell is rule based and designed specifically to accommodate the requirements of the tax accrual and planning process conducted at Coopers & Lybrand. While it was designed for ExperTAX^{sm} in particular, QShell has also been used as a flexible

Exhibit 1

Sample Screen Display

ARTIFICIAL COMPANY SEPTEMBER 3, 1986
Coopers & Lybrand — ExperTAX(sm) —
Tax Accrual & Planning Expert System Inventory

Any inventory: Yes

Does the client include any of the following items in inventory for TAX purposes?
Real Estate
Materials and supplies not held for sale (e.g., office supplies)
Deferred cost under the Completed Contract method
Consigned goods to which the client does not have title

Summary: Noninventory items
QB3 Answer one of: (Y N) Y
The items mentioned above may be treated as inventory items for BOOK purposes, but may not be treated as inventory items for TAX purposes (Ref. Atlantic Coast Realty v. Comm., Rev Rul 59-329, Reg. 1.471-1)

F1 — Note F2 — Skip F3 — More WHY

programming environment for other questionnaire-driven expert systems. It consists of two main components: the inference engine and the user interface.

The inference engine controls the logic search through the knowledge base by firing (executing) the appropriate rules, tracking the inference process, and communicating with the user through the user interface.

The user interface controls (1) the screen display and keyboard used to communicate with the user and (2) the printer commands for formatting and issuing reports.

The screen layout consists of three active horizontal windows. The top window displays information identifying the section being analyzed. The middle window displays long and short forms of the questions being asked, the precondition that caused the current question rule, and the valid answers. The lower window presents clarification messages ("why?" messages) or allows the user to type in *marginal note* information, which the system may request or the user may desire. Exhibit 1 is a sample screen display.

The information the user interface displays comes directly from the knowledge base, and the information it takes in is used by the inference engine to direct its search processes and to enrich the output documentation.

The printed reports generated by the user interface include lists of all issues identified by ExperTAX^{sm}, audit trails of all questions asked and answers received, notes taken during the sessions, and specialized forms issued when additional documentation is required. Exhibit A-5 in the Appendix is a sample report.

The user operates the user interface through a system of nested menus that allows substantial control of the inference process. At virtually any point in the process, the

Exhibit 2
Sample Question Frame

Coopers & Lybrand — ExperTAX(sm) — Tax Accrual & Planning Expert System

Question:
What is client's bad-debt write-off method for TAX purposes?
S — Specific charge-off
R — Reserve method

Possible Answers:
S — Specific charge-off
(Clarifying explanation required.)
R — Reserve method
Follow-up Questions:
QAI9 — Bad-debt reserve method
QA20 — Difference between BOOK and TAX reserve
QA2I — Bad-debt recoveries to reserve

WHY message:
In a typical environment, the Reserve method over time will result in larger tax deductions than the Specific charge-off method.

user can return to a menu that allows for an orderly interruption of the process or for the resumption of the process at a different session or frame.

The Knowledge Base

The knowledge base contains the frames, rules, and facts that constitute the system's expertise, and it makes these available on request to the inference engine and the user interface. Several kinds of information are attached to each frame. Some information relates to how and when to use the frame, some is used to determine what should happen next, and some determines what to display or print. A frame can include several rules.

The ExperTAX^{sm} knowledge base has two types of frames: question frames and issue frames. They differ in the number and type of *attributes* (also called *slots*), procedures, and facts associated with them.

The question frames (exhibit 2 is an example) include the following attributes:

- Questions
- Preconditions, which appear as antecedents, and if true, cause the questions to be asked
- Rules that perform a variety of functions, including structure control and documentation control
- "Why?" messages

Exhibit 3

Sample Issue Frame

Coopers & Lybrand — ExperTAX(sm) — Tax Accrual & Planning Expert System

Rule:

(QB6 IS L): Inventory valuing IS Lower of cost or market
AND
(QBl4 IS L): Method of accounting for inventory IS LIFO
OR
(QBl4 IS B): Method of accounting for inventory IS Both
LIFO and FIFO

Display:

LIFO inventory may not be valued for tax purposes using the lower-of-cost-or-market method!! The IRS may terminate the taxpayer's LIFO election if LIFO inventory is valued at lower-of-cost-or-market. See Rev Proc 7923. In limited situations, a taxpayer may be able to change to the Cost method and preclude the IRS from terminating its LIFO election. See Rev Proc 84-74. Market write-downs are required to be included in income under the provisions of SEC. 472(d) when LIFO is elected.

The issue frames are simpler than the question frames. They include only a *rule* attribute and a *display* attribute. The rule in the frame is tested, and if true, the display attribute appears on the screen or in a printed report. Exhibit 3 is an example of an issue frame.

The Knowledge Base Maintenance System

The knowledge base maintenance system supports the modification of frames, rules, and facts in the knowledge base. It is independent of the other parts of the system and is designed to facilitate the maintenance of the knowledge base by the designated organizational group.

Getting Started With Expert Systems

"Everyone knows it's the wave of the future, but few people know how to get on that wave." This statement by Eugene Wang, a vice president of Gold Hill Computers, Inc. (a vendor of development tools for microcomputer-based expert systems), refers to artificial intelligence in general, but it could be particularly pertinent to the accounting profession vis-à-vis expert systems technology. The possible applications and the potential benefits of expert systems in CPAs' work are abundant; and, of course, the computer software market offers numerous products related to expert systems. But expert systems represent a relatively new technology not yet commonly used in commercial environments, and the new products offer an array of unfamiliar functions. So, members of the accounting profession might ask: How can an expert system be applied in my firm? What would it take to develop an expert system for use in my firm?

Currently it is not possible to give universal answers to these questions, but it is possible to gain insight from the experience of people who have already put expert systems to work in business applications. Information obtained by the EDP Technology Research Subcommittee about getting started with expert systems is summarized in the subsections that follow.

Understanding the Technology

Understanding expert systems technology is an essential first step in introducing expert systems into a firm. A firm that is seriously exploring the potential of expert systems needs to educate its management and staff about expert systems. When personnel are aware of the potential of these systems, they can begin thinking about the problems the systems could solve for the firm. In addition, the firm needs to *have at least one member develop detailed knowledge* of the specific capabilities an expert system can provide.

It's especially important to understand how expert systems use an incremental development cycle. While conventional data processing requires the entire system to be complete before it is usable, expert systems become functional with a prototype – a partial solution to the application problem – and then expand over time through incremental additions. As knowledge in the subject area grows, incremental development permits ongoing changes in design requirements to accommodate this growth; the system eventually becomes a complete solution to the application problem.

Identifying an Expert System Application

After gaining an understanding of expert systems technology, the firm wishing to develop its first expert system needs to list its possible applications and pick one that has a high probability of success. Two key factors in this regard are as follows:

- Don't use financial payoff as the basis for evaluating the success of the first expert system, at least not in its initial implementation. Many of the current books and articles on expert systems cite high value, or high payoff, as a criterion for selecting applications. This criterion is valid in general, but not for the very first application. Consider the initial implementation of the first application as an investment in research and training, with the return on investment coming in the future. After an initial successful application of the technology, subsequent versions of the application or additional applications can concentrate more on financial payoff.
- Try a relatively small first application so that it can be easily understood and developed rather quickly. (A good application might be a task that would take a human expert an hour or two, excluding purely mechanical activities such as filling in forms.) A small application permits early demonstration of the feasibility of using expert systems technology. Although only a small number of people can use a relatively small initial application, it will nevertheless accomplish a great deal because interest will grow as other people see the benefits and begin thinking of applications in their own areas.

(The idea of a relatively small expert system application may require some people to adjust their thinking. This is because the artificial intelligence research of the 1960s and 1970s, which was conducted in academic environments and led to systems such as MYCIN, fostered the perception that an expert system had to be large and complex to do genuinely useful work. However, the experiences of expert system developers and expert system users in commercial environments offer persuasive evidence to the contrary. Their experiences suggest that many of the decisions that propel business are neither large and far-reaching nor enormously complex. Rather, these decisions require specialized but relatively small domains of knowledge and straightforward reasoning.)

Other factors to consider in selecting an expert system application include the following:

- An expert system depends on human experts for its knowledge. Therefore, if a firm does not have a human expert to solve a problem, it cannot develop an expert system to solve the problem.
- A good application deals with a subject area that has clearly defined boundaries and on which there is general agreement on the facts.

- A good application may deal with a subject area that changes rapidly—that is, new knowledge is constantly acquired or solutions are changing.

Developing an Expert System

Once a firm has selected an application, there are two ways to develop an expert system. One is to custom develop all the elements—the knowledge base, inference engine, user interface, and explanation facility—as Coopers & Lybrand did with its ExperTAX^{sm} system. The second is to use tools or shells—commercially available software packages that provide some or all of the features of the inference engine, user interface, and explanation facility—and custom develop only the knowledge base.

Custom Development

Custom development is the most difficult way to develop an expert system. It involves building from scratch—from the programming language up—and it requires specialized capabilities in expert systems technology. In particular, the firm needs not only a domain expert but also an experienced knowledge engineer/software programmer. Some hardware vendors, such as Digital Equipment Corporation, Sperry, and IBM, sell such services to their customers. In addition, artificial intelligence software/consulting firms, such as Teknowledge, Intellicorp, Carnegie Group, and Inference Corporation, provide consulting or development services or both for custom systems.

From whatever sources, however, the domain expert and knowledge engineer need to work together to design the knowledge base and the inference engine. The knowledge engineer or other software programmers write programs for the inference engine, user interface, and explanation facility.

Traditional programming languages can be used to develop expert systems, but they lack the built-in special capabilities of AI-oriented languages and are much more time-consuming to use. Therefore, two AI-oriented languages, LISP and PROLOG, are the most widely used programming languages for developing expert systems. LISP has been the language of choice in the United States, while PROLOG has been adopted extensively overseas, most notably as the language for the parallel processing computers the Japanese hope to build in their fifth-generation computer project.

Both LISP and PROLOG are particularly well suited to expert system development because they provide the programmer with powerful capabilities for the symbol manipulation and predicate calculus logic expression required. Some people consider PROLOG easier to use than LISP because PROLOG programs tend to be smaller and easier to read. But LISP is a more mature, sophisticated language; and a standard has been developed (Common LISP) to stabilize its development and provide portability among hardware environments. Both languages are substantially different from conventional programming languages, such as FORTRAN or COBOL, and neither is easily learned on one's own.

Shells

Although custom development may be the preferred approach for a firm whose application is especially complex or sensitive or is affected by proprietary considerations, it can be time-consuming and expensive. It may require several months or years for the knowledge engineers and the software programmers to encode the domain expert's knowledge and refine the system. And the costs for software, hardware, and time may be substantial.

Firms that don't want to undertake so much effort and expense can use one of a rapidly growing assortment of expert system development shells to help shortcut the process. These are commercial software packages that essentially consist of a preprogrammed expert system with an empty knowledge base. They are conceptually similar to an electronic spreadsheet program such as Lotus 1-2-3 in that Lotus is a shell – an empty spreadsheet – until a user fills in row and column labels, formulas, and data. Just as Lotus can perform different applications when its spreadsheet is filled in differently by its users, an expert system shell can perform different applications when its knowledge base is filled in differently by its users.

Although their use still requires knowledge of expert systems technology and development methods, shells can often bring an expert system into production substantially faster and less expensively than custom-developed software. They also offer the potential for the same people to simultaneously be the domain experts, the knowledge engineers, and the software programmers for an expert system application.

Considering Hardware for an Expert System

An expert system's value can be realized only when it is delivered to the users who put it to work. Computer hardware is a key factor in the delivery of an operational expert system, and a great deal of activity is currently under way in technical areas affecting computer hardware.

Minicomputers

Much of the pioneering research in artificial intelligence was done on large minicomputers. For example, the famous MYCIN system was implemented on a Digital Equipment Corporation minicomputer, and the LISP and PROLOG languages were first implemented on similar machines. Therefore, it is not surprising that the expert system hardware most widely used today consists of large minicomputers such as DEC's VAX. Many research and commercial organizations already have such machines, and nearly every artificial intelligence programming language and tool can be run on them.

Specialized Computers

Since LISP has been the programming language of choice for expert systems development in the United States and LISP makes heavy demands on hardware, companies such as LISP Machines, Symbolics, Texas Instruments, and Xerox have developed specialized computers as dedicated LISP processors. They provide features that improve both programmer productivity and computing performance—for example, microcoding to optimize running a LISP program; high-resolution, bit-mapped screens with mouse-driven graphics software; and integrated programming environments using graphics, windowing, intelligent editors, and so on.

The relatively high prices of specialized AI computers, generally between $60,000 and $100,000, and their incompatibility with general-purpose computers have been significant impediments to their use as a delivery vehicle for expert systems in the commercial environment. However, new product developments and price reductions within the past year may better position these machines to deliver commercial expert system applications. For example, Xerox introduced its Xerox 1186, which costs less than $16,000 and has application development capabilities comparable to other specialized computers costing over $60,000. In addition, the Xerox 1186 can be configured to support IBM PC application software and to interface with office automation systems, minicomputers, and mainframe computers.

Desktop Workstation Computers

Competition for the specialized computers has emerged in the form of high-powered desktop workstation computers. Many of these machines, from manufacturers such as Apollo Computer, DEC, Hewlett-Packard, and Sun Microsystems, have enough power to provide nearly the same performance as the specialized computers. They sell for about the same price as the new Xerox machine.

Personal Computers

Another emerging low-priced contender—and the hardware likely to be most suitable for many expert system applications in the accounting profession—is the personal computer. It is already the hardware of choice for productivity tools such as audit workpapers software and electronic spreadsheets, and it is likely to become popular for expert systems delivery. New hardware technology provides the computing power, internal memory capacity, and data storage capacity necessary for personal computers to run expert systems applications. In addition, versions of LISP, PROLOG, and the majority of expert system shell software can be run on personal computers.

Future Prospects for Expert Systems

The Desktop Computing Environment

Increasingly sophisticated technology in computing and data storage hardware will permit desktop and portable computers to become powerful and cost-effective expert systems delivery vehicles. The availability of 32-bit microprocessors, and software that can use their processing and memory capabilities, will increase the power of personal computers and workstations to levels that surpass the capabilities of many large computers. A new generation of magnetic disk storage units and the advent of optical disk technology will dramatically increase the external data storage capacity of desktop and portable computers. At the same time, there will be increasing availability of AI programming language processors and expert system shells for desktop computers.

Artificial Intelligence on a Chip

A hardware technology likely to affect future expert systems is the development of AI capabilities in single integrated circuit chips, which can be installed in conventional computers as coprocessors or add-on boards. One such development will be microprocessors that perform the functions of current specialized AI computer systems. For example, in 1985 Texas Instruments announced its Compact LISP Machine, a single-chip LISP processor that could be incorporated into a larger system. Another development will be expert systems on a chip—an integrated package of processing hardware, software, and knowledge base data. The chip will contain an inference engine and knowledge base in its own random access memory. And since the knowledge base is encoded in silicon, the chip will process data much faster than conventional expert systems that retrieve information from mass storage devices.

Integrated Expert System Environments

Availability of expert system software products, which could be characterized as integrated expert system environments, will increase. They will combine the capabilities of an expert system shell with more conventional computer applications, such as spreadsheets, data bases, graphics, and word processing. For example, a CPA could assist a client in evaluating a business opportunity by using an expert system for advice, then performing additional calculations and modeling with the spreadsheet, and finally writing the results with a word processor.

One such product is already available from Micro Data Base Systems, Inc. This company, primarily known for its KnowledgeMan software package for business personal computer users, now offers GURU, which integrates the capabilities of data base management, spreadsheet analysis, and graphics with an expert system development tool and consultation capabilities.

Expert Systems Embedded in Conventional Applications

Expert systems will more and more often be embedded within conventional computer applications. This is especially likely with application areas that are difficult to establish parameters for and that frequently require human intervention to deal with exception conditions or cases. For example—

- A credit authorization package could incorporate an expert system module to deal with marginal cases.
- An inventory control application could incorporate an expert system module to determine the allocation pattern for items running out of stock.
- An order entry system could incorporate an expert system module to handle substituting items or shipping from alternate warehouses.

End-User Systems

End-user systems are commercial software packages that are totally prewritten expert systems, including the knowledge base. At present, relatively few end-user systems are available; but an increasing number are likely to appear for specialized applications or vertical markets. A currently prominent example is PlanPower, an expert system for personal financial planning developed by Applied Expert Systems, Inc. (APEX), which is marketing it to major financial institutions and CPA firms. PlanPower provides assistance and consultation to the financial planner through a knowledge base containing rules and facts about financial products.

Issues

Implementation of important new technology often causes a period of significant change and adjustment. It is also frequently associated with a period of uncertainty as the technology evolves and its relative costs and benefits (or disadvantages) are explored and evaluated. Eventually, a technology is adopted and implemented because its benefits exceed its costs and justify the operational adjustments required.

Expert systems technology has already scored a number of striking successes and appears to hold great potential for the accounting profession. However, it is still new and evolving, and its potential benefits and costs are not yet fully understood. Issues need to be studied to maximize advantages and to identify and control or minimize potential adverse effects. Some of these issues are discussed below.

The Long-Term Effects of Expert Systems on the Development of Judgment and Intuition

The most likely areas for expert systems in the accounting profession fit into one of two general categories:

- A technically complex area of knowledge in which there are relatively few true experts
- An area of knowledge that is not particularly complex and in which many individuals (indeed, probably all end-users) are experts

The use of computer-based expert systems in each category will have a different effect on the future development of professionals' judgment and intuition. In either case, however, there could be concern that nonexperts will rely on the computer-based systems so much that they will become dependent on them and never develop skills equal to those of the original human experts. Eventually, expert system users might not hone their intuitive edges on the grindstones of trial and error. How, then, will future human experts develop?

On the other hand, the users of an expert system in the first category might never have become experts, and in the second category human expertise is never too far in the background. Furthermore, several years ago some in the accounting profession worried that increasing computerization of tax return preparation would endanger the development of tax professionals' skills. Time has proven this fear to be overstated, and the fear of the effects of expert systems on professionals may also prove to be overstated.

The Effect of Expert Systems on the CPA's Public Image

Many argue that an important hallmark of a professional is the ability to draw conclusions about relatively subjective information. But an expert system reduces this process to a more objective and structured analysis. It encodes professionals' thought patterns and judgmental rules of thumb into statements of logic, combines them with facts, and then processes them through the computer. The result is an answer similar to the human expert's answer. Will this cause the public (and, indeed, the profession itself) to view the CPA's work as relatively less subjective and more objective and compliance-oriented? Will it adversely affect the image of professionalism?

Some argue that more rules and standards indicate increasing complexities and a maturing process for the profession. Others argue that these cause lamentable diminution in the "art" of the profession. In any event, such changes have been occurring for many years, and the spread of expert systems is likely to hasten them.

The Impact of Expert Systems on Engagement-Level Quality Control

Many of the problems solved by CPAs do not involve a readily determinable "right" answer. Consequently, an expert system's "wrong" answer could go undetected for some time. Using expert systems for problems typically dealt with by CPAs could be quite different from using them to emulate a physician's diagnosis and prescribed treatment. If the illness is not precisely diagnosed or the treatment does not effect a cure, these errors provide evidence that the computer's advice is incorrect. Hence, undetected medical errors would be less frequent than undetected auditing errors.

To lower the risk of undetected errors, the individual professional's work is usually subject to the rigors of cross-checking and review by other professionals. If the computer-based expert system's work is not frequently checked by a human expert, will the chance of undetected errors be intolerable? Will no one really be checking the computer program – using the human's ability to correctly assess context, perspective, and nuances? The negative results of such a situation may be observed only after it is too late.

The opposite situation may also subject the profession to additional risks. For example, suppose the expert system yields one answer but the human professional chooses another course, either because the human did not use the expert system or chose to overrule the system. In hindsight, should the computer system be found correct and the human decision erroneous, will the professional be in a precarious legal position? Over time, such events may make the human professional gun-shy about overruling the expert system.

However, even with these particular risks, it seems clear that expert systems may help increase the consistency of quality performance and, therefore, reduce overall risk. Availability of a second opinion in the form of an expert system could help maintain the highest level of healthy skepticism. Improved defensibility might result from more consistent documentation of conclusions and supporting explanations. Indeed, using an expert system to double-check the human may be the highest use of the technology.

The Impact of Expert Systems on Staffing Models

The kinds of services provided by CPA firms influence their staffing models, that is, the number and characteristics of their personnel. Using expert systems will affect personnel in CPA firms in various ways as they progress in their careers. Two different levels illustrate this concept.

Initial Stages

In the initial stages of an accounting professional's career, most activities relate to information gathering, analysis, and basic decision making. The effects here will be twofold.

- The more routine parts of this activity will become more focused and will usually be done by paraprofessionals.
- Professionals using expert systems will better understand their roles in these activities and how they relate to the final service performance.

Advanced Stages

Personnel who have used an expert system as an aid will gain the benefits of experience with the structure and expertise of the system. Those who have let the expert system make the decisions will find they have clearly exceeded their levels of competence when such aids are not available.

The Effect of Expert Systems on the Accounting Profession's Competitive Environment

Expert systems promise a new level of effectiveness in accounting work. At the same time, the capital and skills needed to develop expert systems are likely to be substantial. Therefore, it is likely that the increasing use of expert systems by CPAs will noticeably affect the competitive environment.

Concentration of the Profession

If expert systems do provide a new level of effectiveness in professional work, then to be either denied their use or required to meet inequitable demands for their use could cause intense competition and disruption. The concentrated development or limited availability of a tool that can lead to more effective professional service is not new; computer audit software is one of many historical examples. What is new is that expert systems will address more pervasive practice issues.

If the availability of such expert systems is overly restricted, then large segments of ordinary practice could become far more competitive, even excessively competitive, for many firms and practitioners. This could lead to significant and accelerated concentration of the profession in a smaller number of major firms or other entities.

On the other hand, this phenomenon could result in third-party software companies or members of the profession developing end-user expert systems for licensing to others. Likewise, broad elements of the profession or professional associations could pool capital necessary to develop and deliver expert systems.

Emergence of New Competitors

The nature of expert systems may make it economically feasible for nonaccounting enterprises to actively compete with the accounting profession in the future. Indeed, the capital-intensive nature of software investment in expert systems may cause CPAs to form alliances with other enterprises to invest in or implement expert systems based on the CPA's knowledge and expertise. Enterprises having wide-distribution networks may employ non-CPAs to operate (or sell the services of) an expert system developed by CPAs under a contract or joint venture arrangement. Electronic networks may link an electronic value-added service (the expert system) to scores of users paying access fees. For example, CPA-developed expert systems might be among the many services offered on computer time-sharing and data base networks.

The Impact of Expert Systems on Audit Evidence/ Workpapers, Engagement Documentation and Retention, and Professional Training

Expert systems provide a logical and supported structure for both information gathering and decision making. Consequently, they should provide an improved basis for developing sufficient competent evidence to support a professional service or conclusion. And as with any new tool, the amount of training necessary to use it needs to be considered. Therefore, the use of expert systems may provide the framework for more focused and pertinent training.

Professional Guidance on Auditing Clients' Expert Systems

Clients will soon be using expert systems in applications that affect financial statements. Accordingly, auditors will soon be faced with auditing expert systems. CPAs may be asked to report to users and potential users on whether the systems operate appropriately.

Professional guidance will be needed on how to address changing conditions, data bases, and the corresponding development of new rules that would require revision of the expert system. Acceptable probability tolerances also need to be addressed.

Appendix

A Sample ExperTAX^{sm} Session*

The first step in ExperTAX^{sm} is a choice between starting work with a new client or continuing a job for a recurring client. For illustrative purposes, assume the user starts with a new client, Artificial Company, a highly successful manufacturer of smart computers. ExperTAX^{sm} first asks some questions from the preliminary section of its knowledge base. It quickly finds out that Artificial Company accounts for its transactions on an accrual basis, is a privately held company, and is interested in tax minimization strategies. This general information helps ExperTAX^{sm} structure its search procedures and access frame sections to minimize unnecessary paths; then ExperTAX^{sm} loads into memory those subsets of the knowledge base containing rules more likely to be fired (executed).

Exhibit A-1 is an ExperTAX^{sm} inventory question related to the write-down of obsolete goods.

Exhibit A-1

Sample Question on Inventory

ARTIFICIAL COMPANY SEPTEMBER 3, 1986

Coopers & Lybrand — ExperTAX(sm) —
Tax Accrual & Planning Expert System Inventory

Obsolete goods write-downs: Yes

How does the client value these obsolete goods?

C — Cost

S — Selling price less direct cost of disposition

Summary: Net realizable value method

QBI0 Answer one of: (C S) C

F1 — Note F2 — Skip F3 — More WHY F5 — Back

*The examples shown in this Appendix are from the version of the system in use during 1986; therefore they do not reflect changes resulting from the new tax law that became effective in 1987.

Exhibit A-2

Next Inventory Question

ARTIFICIAL COMPANY SEPTEMBER 3, 1986

Coopers & Lybrand — ExperTAX(sm) —
Tax Accrual & Planning Expert System Inventory

Net realizable value method: Cost

Do the obsolete goods include any excess inventory items which are sold under an agreement which allows the client to repurchase the items at a predetermined price?

Summary: Thor Power Sham Transactions

QBI2 Answer one of: (Y N)

F1 — Note F2 — Skip F3 — More WHY F5 — Back

The user has the option of answering the question, asking why the question is being asked, or skipping the question altogether. In the example, the user elects the answer *C*, and ExperTAX^{sm} changes its display to show exhibit A-2.

At this point, the user elects to press the "why" key. Exhibit A-3 shows the "why" message.

Having read the explanation, the user answers the question and continues in a similar manner until ExperTAX^{sm} finishes with the section and returns to the selection menu. After finishing the inventory section, the user might elect to continue with another section, look at the issues raised so far, or print those issues and the accompanying documentation. If the user looks at the issues raised, they would appear in the middle window, one at a time, together with the specific answers that triggered them. Exhibit A-4 is a sample display.

Having answered all relevant sections, the user can generate a complete printed report. The report lists all issues raised, grouped by type (for example, accrual and planning). It also lists all questions asked and responses received during the session and all notes taken by the user, whether voluntarily or because of prompts by the system to further explain an answer.

The audit and tax managers or partners in charge of the engagement then use the ExpertTAX^{sm} report to prepare the final tax accrual and issue their tax planning recommendations to the client. Exhibit A-5 is part of the planning issues section of a typical ExperTAX^{sm} report.

Exhibit A-3
Next Inventory Question With "Why" Message

ARTIFICIAL COMPANY SEPTEMBER 3, 1986

Coopers & Lybrand — ExperTAX(sm) —
Tax Accrual & Planning Expert System Inventory

Net realizable value method: Cost

Do the obsolete goods include any excess inventory items which are sold under an agreement which allows the client to repurchase the items at a predetermined price?

Summary: Thor Power Sham Transactions

QBI2 Answer one of: (Y N)

The IRS has held that a sale of items under an agreement to repurchase at a predetermined price is not a sale and thus the excess inventory must be continued to be valued at cost.

F1 — Note F2 — Skip F3 — More WHY F5 — Back

Exhibit A-4
Planning Issues — Inventory

ARTIFICIAL COMPANY SEPTEMBER 3, 1986

Coopers & Lybrand — ExperTAX(sm) — Tax Accrual & Planning Expert System
Planning Issues — Inventory

LIFO inventory may NOT be valued for TAX purposes using the lower-of-cost-or-market method!! The IRS may terminate the taxpayer's LIFO election if LIFO inventory is valued at lower of cost or market. See Rev Proc 79-23. In limited situations, the taxpayer may be able to change to the Cost method and preclude the IRS from terminating its LIFO election. See Rev Proc 84-74. Market write-downs are required to be included in income under the provisions of Sec. 472(d) when LIFO is elected. **(C)

Reasoning:

Any inventory: Yes

Method of accounting for inventory: LIFO

Inventory valuing: Lower of cost or market

Strike any key to continue:

**These issues require a change in accounting method for which IRS approval must be requested within 180 days of the beginning of the taxable year.

Exhibit A-5

Sample Planning Issue From an ExperTAX[sm] Report

Coopers & Lybrand

ExperTAX[sm]
Planning Issues and Ideas

April 8, 1986

The practitioner should review the following planning ideas and issues to determine their applicability to the client.

Inventory

- Section 1.471-2(c) allows obsolete goods to be written down to bona fide selling price less direct cost of disposition. Such write-downs reduce taxable income. However, excess inventory does not come under this provision. See Thor Power v. Comm.*
- LIFO inventory may not be valued for tax purposes using the lower-of-cost-or-market method! The IRS may terminate the taxpayer's LIFO election if LIFO inventory is valued at the lower of cost or market. See Rev. Proc. 79-23. In limited situations, a taxpayer may be able to change to the cost method and preclude the IRS from terminating its LIFO election. See Rev. Proc. 84-74. Market write-downs are required to be included in income under the provisions of Sec. 472(d) when LIFO is elected.

*These issues require a change in accounting method for which IRS approval must be requested within 180 days of the beginning of the taxable year.

Glossary

backward-chaining An inference method that begins with the goal to be proved and then searches the knowledge base for facts and rules to use in attaining that goal.

certainty factor A measure representing the degree of belief attached to facts and assertions based on those facts.

domain experts People who are experts in a given topic area or task domain.

expert systems Computer programs that emulate the thinking processes of human experts to attain a level of performance comparable to those experts in a specific task.

explanation facility The component of the expert system used to display the reasons underlying the system's recommendations.

fired Executed. When a production rule is executed, it is said to be fired.

forward-chaining An inference method that begins with current facts and searches the knowledge base for rules that use those facts.

frames Data structures that group related facts and rules together and that can often specify default values.

heuristics Rules of thumb, developed through experience, that facilitate the solution of difficult problems.

incremental system design An iterative approach to systems design in which a prototype version is built and then refined through use. Often additional features and requirements are identified during the refinement process. In contrast, traditional computer programs are completely specified at one time and then programmed.

inference engine The part of an expert system that guides the use of domain knowledge. The inference engine is itself a program for accessing and using the facts and rules stored in the knowledge base.

integrated expert system environment A system that combines the capabilities of an expert system shell with a spreadsheet, data bases, word processing, and other traditional computer applications.

knowledge base The set of facts about a particular task domain and the rules for using those facts.

knowledge engineers Software engineers or systems designers who specialize in building expert systems. Their main task is to elicit the important facts and rules from acknowledged experts and then to code that knowledge in a manner that an expert system can use.

natural language communication An artificial intelligence application whose objective is to have computers understand human language, that is, interpret the meaning of the input.

nonmonotonic reasoning A technique that supports multiple lines of reasoning and the retraction of facts or conclusions, given new information. It is useful for processing unreliable knowledge and data.

person-year A measure of the amount of work done by one person working for one year. Thus, five person-years equal the amount of work done by one person for five years, five people for one year, or any combination totaling five years of effort.

production rules A programming construct in the form of a conditional statement (if... then...) that represents important aspects of problem-solving performances.

prototype solution The initial version of a solution.

robotics The technology of using computer-controlled machines to perform humanlike physical movements, such as those on a production line, to carry out repetitive actions involving limited physical arm and hand manipulation.

rule-based system An expert system that stores heuristic knowledge in the form of production rules.

shell A software program or package used to build an expert system. A shell is an expert system with an empty knowledge base. Thus the development effort is limited to identifying the knowledge needed to perform the task being modeled.

user interface The component of an expert system that guides the interaction and use of the system.

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