Applications of Expert Systems in Insurance Regulation

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ABSTRACT

This article describes how existing expert systems in parallel disciplines might be used to address problems facing insurance regulators. It further describes how an expert system might enhance the value of the NAIC's IRIS system. It concludes with descriptions of the processes involved in building an expert system and the costs and problems likely to be encountered.

INTRODUCTION TO EXPERT SYSTEMS

Broadly speaking, an expert system is a computer program that solves specialized problems for which no unique step-by-step solution procedure is known. Expert system developers ask experts in the chosen field—or "domain"—to explain the reasoning used in arriving at their solutions to many problems. The expert system then uses a symbolic representation of this knowledge to solve or assist others with less expertise in solving similar problems.

Features of An Expert System

Most expert systems use two important artificial intelligence techniques—heuristics and the separation of knowledge and control. These techniques are crucial in the development and maintenance of expert systems.

A *heuristic* is simply a "rule of thumb," a method that usually works but cannot be proven correct. Most areas where expert systems are used

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involve so many factors that only a few of the possible combinations can be considered in the time allotted a human expert. A heuristic estimates which of several paths is most likely to lead quickly to a solution.

The second expert systems technique is the split of data—or "*domain knowledge*"—from the control structure or the program. Separating knowledge and control facilitates several desirable things. Programs can be built in stages because only one element of the program must be changed in order to incorporate an improvement into the program as the understanding of knowledge improves. System builders can attempt a solution, see how the system performs, and then improve it. People deal best with explicitly expressed knowledge. For expert systems this means that knowledge expressed as rules is more understandable than knowledge expressed as computer code.

Separation of knowledge and control is also useful for domains where the environment changes. For example, consider a program that calculates income tax. If tax knowledge is embedded in computer code, then computer code must be modified each time the tax code changes. If, however, the knowledge about code is stored separately—much as a data base is stored—then only the information "rules" must be updated.

When knowledge and control are disentangled, the perceived complexity decreases, allowing computers to be used to tackle increasingly complex problems. A "knowledge base" is easier to use for teaching or storing knowledge, and is easier to update.

Advantages and Disadvantages of Expert Systems

Rule-based expert systems are used for solving ill-defined problems and well-defined problems which cannot be solved efficiently with an algorithm. Such systems have many advantages over human experts. One is permanence of expertise. Expert systems do not forget, but human experts may. Another advantage is reproducibility. Many copies of an expert system can be made, but training new human experts is time-consuming and expensive. Expert systems are also consistent in their behavior while the performance of human experts may vary a great deal. Although expert systems are expensive to build and maintain, they are inexpensive to operate. Development and maintenance costs can be spread over many users, so the overall cost can be quite reasonable when compared to expensive and scarce human experts.

Expert systems also have some disadvantages when compared to human experts. In addition to a great deal of technical knowledge, human experts have common sense. It is not yet known how to give expert systems common sense. Human experts can respond creatively to unusual situations; expert systems cannot. Human experts automatically adapt to

changing environments; expert systems must be explicitly updated. Human experts have available to them a wide range of sensory experience; expert systems are currently dependent on symbolic input. Expert systems are not good at recognizing when no answer exists or when the problem is outside their area of expertise.

Because of this combination of advantages and disadvantages, expert systems are most commonly and most effectively used as advisors to human decision-makers. The expert system can provide technical knowledge while the user provides the common sense. For additional general background information on expert systems there are several excellent books available.[1] There are also a number of books specifically geared to business-related applications.[2]

APPLICATIONS OF EXPERT SYSTEMS OF INSURANCE REGULATION

Much of a state insurance department's charge involves functions similar to those for which expert systems are already in use to assist other professionals. This section describes how expert systems are used to assist others with tasks similar to the following important tasks of insurance regulators:

- Improving the quality and efficiency of audits
- Monitoring and selecting priority review companies
- Assuring compliance with insurance accounting rules

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1. See, for example, D. WATERMAN, A GUIDE TO EXPERT SYSTEMS (1986) [hereafter "WATERMAN"]; D. WOLFGRAM, T. DEAR & C. GALBRAITH, EXPERT SYSTEMS FOR THE TECHNICAL PROFESSIONAL (1987); W. RAUCH-HINDIN, A GUIDE TO COMMERCIAL ARTIFICIAL INTELLIGENCE (1988); EXPERT SYSTEMS: TECHNIQUES, TOOLS, AND APPLICATIONS (P. KLAHR & D. WATERMAN eds. 1986); BUILDING EXPERT SYSTEMS (F. HAYES-ROTH, D. WATERMAN, & D. LENAT eds. 1983); R. EDMUNDS, THE PRENTICE HALL GUIDE TO EXPERT SYSTEMS (1988); A. HART, KNOWLEDGE ACQUISITION FOR EXPERT SYSTEMS (1986) [hereafter "HART"]; D. HUNT, ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS SOURCEBOOK (1986) [hereafter "HUNT"].

WATERMAN is considered a classic. HUNT is limited to including company names and addresses..

2. See, for example, P. HARMON & D. KING, ARTIFICIAL INTELLIGENCE IN BUSINESS: EXPERT SYSTEMS (1985); P. HARMON, R. MAUS & W. MORRISSEY, EXPERT SYSTEMS: TOOLS & APPLICATIONS (1988); C. HOLSAPPLE & A. WHINSTON, BUSINESS EXPERT SYSTEMS (1987); ARTIFICIAL INTELLIGENCE APPLICATIONS FOR BUSINESS (W. Reitman ed. 1984); EXPERT SYSTEMS FOR BUSINESS (B. SILVERMAN ed. 1987). Also a journal, *Expert Systems Review for Business and Accounting*, is now being published by the Expert Systems Program of the University of Southern California School of Accounting specifically to cover business expert systems. In addition, A. GARDNER, AN ARTIFICIAL INTELLIGENCE APPROACH TO LEGAL REASONING (1987) provides an excellent reference for historical review (pre-1984) of legal expert systems and legal reasoning.

- Valuing portfolios
- Valuing reserves
- Training

Improving the Quality and Efficiency of Audits

At least one insurer, the Equitable Insurance Company, has developed an expert system to assist with its internal audit function. The **Internal Audit Risk Assessor (TIARA)**[3] assists Equitable's internal auditors in selecting business units for audit. The system considers a number of subtle factors in reaching a decision. These include the experience of the management team, performance of internal controls, and external changes in the market or industry. The problem of selecting units was found to involve so many nonquantifiable elements that it proved intractable to conventional computer solutions. A 100–rule prototype system was completed at Equitable in six months.

Insurance regulators can undoubtedly find more general audit expert systems outside the insurance industry than within. For example, Coopers & Lybrand, a major accounting firm, is strongly committed to the use of expert systems for auditing. The management consulting division has developed a special program, **AShell**,[4] to develop and maintain auditing expert systems.

AShell's Personal Computer (PC)-based core expert system for the audit process is a comprehensive system that covers the entire audit process—planning, execution and automatic generation of workpapers and audit reports. The audit system is an intelligent questionnaire-based system that "leads an auditor through the entire audit process."[5] Its modular form allows different parts of an audit to be executed and reported on separately. Capabilities include the status tracking of the various audit functions and the ability to integrate and test mainframe transaction data in the **AShell** audit environment. Additional specific information about transactions is automatically requested when indicated by the results of initial tests.

The two basic parts of **AShell** include: 1) the knowledge base management system ("KBMS"), and 2) the audit system. The KBMS is used to add to and maintain the company specific knowledge of senior internal

3. Leinweber, *Chapter 2: Finance* in EXPERT SYSTEMS AND ARTIFICIAL INTELLIGENCE: APPLICATIONS AND MANAGEMENT (T. Bartee, ed. 1988) at 33–59.

4. COOPERS & LYBRAND, ASHELL: EXPERT SYSTEMS FOR THE AUDITING PROCESS (Brochure 1988) [hereafter "C.&L. BROCHURE"]; *id.*, RECENT ENGAGEMENTS OF THE DECISION SUPPORT GROUP: SECURITIES AND BANKING PRACTICES (1988); Interviews with Joseph J. DeSalvo and Marcy Wintrub, both of Coopers & Lybrand.

5. C. & L. BROCHURE, Note 4 *supra*.

auditors to the **AShell** knowledge base. The KBMS is menu-driven so that the knowledge base can be maintained by the audit staff.

AShell has been successfully used to develop two modules of a branch-compliance audit system, currently undergoing acceptance testing, for a major securities broker and investment banking firm. Employees of that firm are being trained by Coopers & Lybrand to continue the development and maintenance of the system.

Another major accounting firm, Arthur Andersen & Company has embedded an expert system module in their **Engagement Administration System ("EASY").**[6]

The module takes the form of a "smart" questionnaire and is intended to assist in determining an audit work program. The module is in field use. Arthur Andersen is currently "internationalizing" the module.

Monitoring and Selecting Priority Review Companies

Another important function of insurance regulation is identifying companies with financial problems so that a minimum of intervention is possible. The Internal Revenue Service ("IRS") faces a similar problem in its attempts to identify taxpayers whose tax returns fail to comply with tax regulations. Among expert systems currently in development by the IRS is their **Tax Return Issue Identification Expert System.**[7] This expert system is used to identify personal tax return issues with good audit potential. The expert system is not intended to replace the current discriminant function ("DIF") selection method but to augment it. This system will analyze those returns selected for further review by DIF-score to determine which issues should be audited, to what extent they should be audited and to eliminate those not appropriate for further audit. This function is currently done—though somewhat reluctantly—by tax auditors who review manually each selected return. The new system will recommend: 1) "no audit" for issues deemed unnecessary to audit; 2) a "correspondence audit," for simple issues; 3) an "office audit," for somewhat more complicated issues with limited document access require-

6. Interview with D. Haley of Arthur Andersen & Co. in Chicago, 1988).

7. Brown & Streit, *A Survey of Tax Expert Systems in Industry and Accounting*, EXPERT SYSTEM REVIEW FOR BUSINESS AND ACCOUNTING at 6–9 (May, 1988) [hereafter "Brown & Streit"]; IRS ARTIFICIAL INTELLIGENCE LAB BRIEFING PAPER FOR THE DEPUTY COMMISSIONER (PLANNING AND RESOURCES) (Feb., 1988); IRS, WHERE IS THE IRS IN AI? (July 7, 1987); J. Needham, *Trends in Artificial Intelligence* in TREND ANALYSIS AND RELATED STATISTICS (IRS Publications Doc. 6011 (1986) [hereafter "Needham"]; Beckman & Rogers, *Trends in Development of Applications Using Artificial Intelligence Technology* in 1988 UPDATE: TREND ANALYSIS AND RELATED STATISTICS (IRS Publications Doc. 6011) (1988) at 143–52 [hereafter "Beckman & Rogers]".

ments; and 4) a "field audit," for sophisticated or large audits with many documents required. The IRS hopes that this system will improve the consistency and fairness of the audit process. In addition, auditors will be relieved from a task considered tedious.

By 1987, a small feasibility prototype was successfully completed by IRS employees for review of returns with income between $25,000 and $50,000. The IRS is now working with the consulting firm of Bolt, Beranek, & Newman, Inc. to develop this original module further and to develop a second module for taxpayers with Schedule C income of $100,000 or more. A full prototype, covering all classes of Form 1040 income tax returns, is expected to be in place nationwide by 1991.

A detailed discussion at page 31 *infra* describes how a similar issues-identification system could assist insurance regulators in identifying companies whose solvency position commands concern and attention.

Compliance with Insurance Accounting Rules

A primary function of **ExperTAX®**[8] is to assure that corporate clients of Coopers & Lybrand ("C&L") have complied with the complex accounting rules for deferred tax accrual. The system assists auditors and tax professionals in data gathering and data review for tax accrual and tax planning purposes. The system gathers needed data through an intelligent questionnaire; *i.e.*, one that considers previous responses when determining subsequent questions. In use since 1986, it has improved C&L's information-gathering process in three ways: 1) productivity of staff accountants has increased; 2) information gathered has higher quality; and 3) the training process for staff accountants has been accelerated. The original release of **ExperTAX®** contained about 2000 rules and updates have grown subsequently to about 3000 rules.

An enhanced **ExperTAX®** system with industry-specific knowledge of the insurance industry and its specialized accounting requirements is also in use. The Insurance Expertax®[9] module is larger than the original **ExperTAX®** with more than 2000 rules.

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8. Brown, *Tax Expert Systems in Industry and Accounting*, EXPERT SYSTEMS REVIEW FOR BUSINESS AND ACCOUNTING at 9–16 (June, 1988) hereafter "Brown"; Interview with Tom Carroll of Coopers & Lybrand in Washington, DC (1988); Brown & Streit, Note 7 *supra*; Shpilberg & Graham, *Developing ExperTAX®: An Expert System for Corporate Tax Accrual and Planning*, 3:3 EXPERT SYSTEMS at 136–150 (July, 1986).

9. Brown, *Tax Expert systems in Industry and Accounting*, Note 8 *supra*; COOPERS & LYBRAND, INSURANCE EXPERTAX®: A TAX PLANNING TOOL FOR INSURANCE COMPANIES (Brochure 1988).

Coopers & Lybrand is happy with the performance of **ExperTAX®** and is committed to its continued use.[10] C&L has a knowledge-base manager whose primary function is to maintain and enhance the integrity of the knowledge base. This individual understands both the tax domain and the capabilities and structure of **ExperTAX®**. As knowledge acquisition is a major part of maintaining the knowledge base, the knowledge base manager acts as an intermediary between Coopers & Lybrand's tax partners and the **ExperTAX®** knowledge base.

Valuing Portfolios

One important—and difficult—task of insurance regulators is evaluating the quality of the investment portfolio of insurance companies. The difficulty in valuing private placements, concern in recent years with "junk bonds," and problems with oil and real estate loans make quality of investments a matter vital to the solvency of insurers.

In 1984, the Audit Practice Committee of KPMG Peat Marwick ("KPMG") faced a similar problem—the analysis of bank loans by its auditors to assess the appropriateness of loss reserves for uncollectible loans. KPMG undertook the development of a system to make available throughout the firm the expertise of their top partners and senior managers who were involved in bank audits. The result is **Loan Probe®**,[11] a system that "brings to an audit more than any one individual could reasonably have at his or her fingertips." The system includes more than 8,000 rules and reflects the knowledge of the firm's top banking professionals. It also holds statistics and projections updated annually for more than 150 industries and has an embedded linear programming module that assigns collateral optimally in cross-collateralized loans. **Loan Probe®** is not intended as a substitute for an auditor's judgment, but rather as a decision-support tool to assist the auditor.

The system is designed to arrive at a recommendation in the shortest possible time and to use the minimum amount of relevant information. First the user of **Loan Probe®** supplies information about the financial institution, the loan (including how the loan is secured and what guarantees exist), and the borrower. The auditor is asked to provide information about the bank's access to liquid collateral and the risk associated

10. Brown, *Tax Expert Systems in Industry and Accounting*, Note 8 *supra*; Interview with Tom Carroll, Note 8 *supra*; Schatz, Strahs & Campbell, *Expertax: The Issue of Long-Term Maintenance*, PROCEEDINGS OF THE 3RD INTERNATIONAL CONFERENCE ON EXPERT SYSTEMS at 291–300 (June, 1987).

11. Ribar, *Expert Systems Technology at Peat Marwick Main*, 1:1 EXPERT SYSTEMS REVIEW FOR BUSINESS AND ACCOUNTING (Sept.-Oct., 1987) at 1, 5; KPMG PEAT MARWICK LOAN PROBE® THE EXPERT SYSTEM FOR LOAN LOSS EVALUATION (1987) and *id.* LOAN PROBE® USER'S MANUAL (1987).

with its valuation. **Loan Probe®** then determines whether the liquid collateral special guarantees provide sufficient coverage for the loan. If so, the system recommends that no loss reserve is needed and is ready to proceed to the next case.

If a no-reserve recommendation cannot be made based on this information **Loan Probe®** requests additional information, including the borrower's current financial condition, future cash flows, and loan payment history, and analyzes the loan on an unsecured basis. If a reserve is still indicated, **Loan Probe®** then evaluates any non-liquid collateral that may be available. If, after this evaluation, a reserve is still considered necessary, **Loan Probe®** requests information on the bank's intentions to renew or restructure the loan and then takes into consideration the terms of such an action.

Finally, **Loan Probe®** suggests that "no reserve is necessary," that a "reserve is necessary within a specific range," or that "no determination can be made because of insufficient information." One factor differentiating **Loan Probe®** from other types of audit-decision aids is its capability to explain the logic used in reaching its conclusions. This enables the user to critique the explanation, evaluate the appropriateness of the system's conclusion, and if necessary, develop a more appropriate conclusion. Thus, the system recognizes that a user could encounter a set of circumstances that were not considered within the system.

Valuing Reserves

No better parallel has been located for reserve valuation than the one described above for valuing portfolios. The reader can see that many of the processes are similar and that, since a system can be designed to evaluate the assets of an insurer—*i.e.*, its loans and securities—a similar system could be designed to evaluate the liabilities of that insurer—*i.e.*, the accuracy of its reserves.

Approving Forms

Forms approval is a time-consuming, labor-intensive, and less-than-exhilarating task for most insurance department employees. Further, human reviewers may be unfamiliar with exceptions in the insurance code that allow the exclusion or require the inclusion of specific provisions for particular lines of business. Another IRS system, **Employee Plans Determination Expert System,**[12] offers clear evidence of the usefulness of expert systems to test compliance with complicated legal requirements.

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12. Brown & Streit, Needham, Beckman & Rogers, all at Note 7 *supra*.

Employee Plans Determination Expert System is an expert system intended to assist the review of proposed employee pension plans to see if the proposed plan meets the legal requirements for qualification. The system, though currently "on hold" pending the release of new IRS forms and applications for employee plans ultimately will assist in identifying shortcomings in submitted plans and will make suggestions as to how the plan might be changed to meet the requirements of the law.

Another IRS system that demonstrates the usefulness of forms approval systems is **Estate Tax Return Perfection and Classification.**[13] This expert system, in addition to identifying likely cases for audit, assists examiners in perfecting estate tax returns. Currently these returns must be checked to make sure that everything required by law is included (*e.g.*, death certificate). The expert system will assist in this process of checking the returns for omissions, a function presently performed by highly paid paraprofessionals. The IRS hopes that this expert system will reduce significantly the cost of processing each return. A possible side benefit will be identification of particular problem areas on the forms. Where unusually high error or omission rates occur, forms or instructions will be targeted for improvement. This system was laboratory tested in November, 1988, and field tests were expected to begin in June, 1989.

Training

Employee turnover is a problem for many insurance regulatory agencies because of constant budget battles and competition for highly-skilled employees. Expert systems can be used to increase the consistency of employee output and, either directly or indirectly, to train employees. **Accounting for Income Taxes: Thrift Industry: SFAS #96 Interpretive Aid**[14] is a rule-based advisory system to assist auditors with the technical aspects of the FASB Statement of Financial Accounting Standards #96. The system is intended for use within KPMG for informal training and as a reference and support tool for auditors in determining the deferred tax expense accrual for thrift institutions.

The system incorporates a number of examples for user reference as well as more traditional textual advice. A wide range of references were incorporated, including several FASB publications, several KPMG internally-published documents, a journal article and commercial publi-

13. Michaelson, *"Development of an Expert Computer System to Assist in the Classification of Estate Tax Returns,"* Working Paper (North Texas State University (1987); Brown & Streit, Note 7 *supra*; IRS, WHERE IS THE IRS IN AI?, Note 7 *supra*; Needham, Note 7 *supra*; Beckman & Rogers, Note 7 *supra*.

14. Interview with Stanley Wong, of KPMG Peat Marwick in Montvale, NJ (1988); Brown, *Tax Expert Systems in Industry and Accounting*, Note 8 *supra*.

cations. Stanley Wong, developer of a system, incorporated much of his experience and skill along with these printed materials in developing the program. Full implementation of the system, originally planned for Fall, 1988, has been postponed pending further pronouncements regarding effective dates in SFAS 96. The system took about three months to develop and has 50 to 100 rules.

HOW EXPERT SYSTEMS COULD EXPAND IRIS

The National Association of Insurance Commissioner ("NAIC") Insurance Regulatory Information System ("IRIS") grew out of a 1973 study of the financial regulatory system by McKinzie & Co. That study suggested three major improvements to its predecessor, the Early Warning System. The suggested changes were designed to 1) make the financial analysis of insurers more centralized, 2) make the scheduling of examinations more flexible, and 3) focus company examination on specific areas rather than on the whole balance sheet.[15] From this study emerged a variety of tests yielding ratios which could indicate solvency problems. The ratios are updated constantly and help the IRIS system identify "priority companies" for regulatory review. The 11 IRIS tests for property and liability companies include the following:

NAIC IRIS System

Test Number	Name of Test	Test is Outside the Normal Range
1	Premium to Surplus	300 or greater
2	Change in Writings	Less than or equal to −33%, or greater than or equal to +33%
3	Surplus Aid to Surplus	Greater than or equal to 25%
4	Two-Year Operating Ratio	Greater than or equal to 100%
5	Investment Yield	Less than or equal to 6.0%
6	Change in Surplus	Less than or equal to −10%, or greater than or equal to +50%
7	Liabilities to Liquid Assets	Greater than or equal to 105%
8	Agents' Balances to Surplus	Greater than or equal to 40%
9	One-Year Reserve Development to Surplus	Greater than or equal to 25%
10	Two-Year Reserve Development to Surplus	Greater than or equal to 25%
11	Estimated Current Reserve Deficiency to Surplus	Greater than or equal to 25%

15. Steven Brostoff, "NAIC's IRIS Program Strives to Nip Insolvencies Before They Bud," *National Underwriter* (Property-Casualty Ed.) at 3, 10–11 (April 15, 1983).

A company which fails four or more of these tests is considered to be a priority company for review. Mathematically an insurer can be outside the normal range on four or more tests with 1,816 different combinations of IRIS tests. Examiners who regularly make such determinations know—and IRIS materials clearly state—that

> a company can be financially unsound even though it fails fewer than 4 tests. Conversely a company which fails 4 or more tests may not be financially unsound.[16]

Examiners also know that different combinations or degrees of "outside normal" imply different urgency for review. Test 2, for example, is designed as a measure of a company's stability. However, the test is influenced greatly by increases or decreases in reinsurance. When viewed in combination with other tests, its reliability as an indicator of instability in a company's operation and management is enhanced greatly. An expert system can capture this type of important interrelationship among the various tests and check company statistics with greater sophistication than does the existing system. Initially such a system would examine the number of tests failed, the combination of tests failed, and the margin by which test results are outside normal. The system could then do a better job of prioritizing companies for review and assure that the most urgent examinations are tackled first.

At a more sophisticated level, the system could infer more about the problems that an examiner is likely to find within the company. It could provide direction for human examiners as to where to look, specifically what to seek, various "rules of thumb," and query the examiner for additional information. The end result, hopefully, would be to greatly speed up the process of reviewing priority companies while reducing the possibility that a critical solvency issue will be overlooked. The ability to "steer" the auditor to the most likely problem(s) increases greatly the efficiency with which a scarce resource—the auditor's time—is assigned.

DEVELOPMENT OF AN EXPERT SYSTEM

Knowledge Representation and Control Structures

In expert systems, knowledge is most commonly represented by rules. Rules are a form of "IF condition THEN fact" statement. Rules are manipulated by a logical processing mechanism referred to as an "inference engine". The rules are then chained together to produce a portion of a logic "tree" that in many instances resembles a more traditional

16. NAIC, ABC IRIS CASE STUDY (n.d.).

decision tree. Unlike decision trees, however, the rules may form a network or directed acyclic graph rather than a tree and the chaining can be forward, backward, or a combination of the two. In *forward chaining*, the inference engine checks the knowledge base for a rule whose condition is met. If one is found, the fact in its THEN clause is added to the knowledge base. This is called forward chaining because it works toward a goal or goals. In *backward chaining*, the starting place is the goal. The rules are navigated in the opposite direction (from results to conditions) to see if a group of facts exists to justify the goal. Forward chaining would likely be used for compliance functions while backward chaining might be used in an IRIS-supplement system designed to locate financial problems in companies.

Frames are also frequently used to represent knowledge. A frames representation is a structure for ordering knowledge within the system. A key feature of such frames is the ability to "inherit" characteristics from more general classifications within the structure. *A fact that is true at some point in the hierarchy is assumed to be true below that point unless it is explicitly reversed.* For instance, in a classification of animals the statement "capable of flight" would be associated with the classification of "birds." This statement is then assumed true for all kinds of birds, but can be overridden at a lower level. The subcategory "penguins" would indicate that penguins are an exception to the general rule.

A frames representation is helpful because it organizes information for easier specification and interpretation. This type of organization also assists in making default assumptions absent specific information. Using inheritance allows ready modification of the knowledge base and saves space.

Cost and Time Requirements

All of the systems discussed in this article, with the exception of the IRS systems, operate on microcomputers—either IBM-compatible or Macintosh. To the extent that such equipment is already available to insurance regulators, no significant investment in hardware would be required in order to benefit from expert systems.

Early expert systems were enormous projects. Some required as many as 50 worker-years to develop. Today, however, commercially available "shells" can speed the programming. Simple shells cost as little as $100, while the most expensive microcomputer shell is around $10,000. Costs for mainframe shells range from a few thousand dollars to $80,000 or more.[17] The August, 1988, issue of *Computer Language* contains a com-

17. Stapleton, *Embedding Intelligence: The New AI Paradigm*, COMPUTER LANGUAGE at 97–103 (Aug., 1988).

prehensive list of expert system shells for IBM-PC compatibles, Macintosh, and workstations. Much in the same fashion as today's database software facilitates the user's organization of traditional data processing information, these shells allow the user of an expert system to enter the user's "knowledge" into the system, along with the "rules" about how the knowledge fits together. No significant knowledge of programming is needed to build an expert system.

Users today may concentrate their efforts on the development of the needed knowledge base. A small system, such as the **FASB 96** system, was developed in three months using a fraction of one employee's time. Much larger-scale systems, such as **Insurance ExperTAX®**, can be developed in approximately nine months, using a team of experts. This time requirement could be cut by as much as two-thirds if the complications usually entailed in competing for the time of experts and assembling them could be overcome. Total cost, a function primarily of the amount of expert time required to develop a knowledge base, is directly related to the size of the system.

Problems to Avoid

Many of the problems encountered with expert systems development are the same ones experienced on other technology projects. Less-than-hoped-for results are usually attributed to one or more of the following reasons:

- The goals and objectives of the project are not well defined at the outset.
- The scope of the project is too large to manage within a reasonable time frame.
- The project attempts to incorporate all the "bells and whistles" that anyone could ever want resulting in budget overruns and/or operationally cumbersome systems.
- The newest technologies are more than the project requires.

Recognizing and avoiding these pitfalls in the earliest planning stages will minimize the investment and maximize the return from any expert system development project.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The development and use of expert systems is expanding rapidly. This article explores how the charge of insurance regulators can be met more effectively and efficiently by applying this technology. The principle advantage of an expert system, beyond the obvious savings in time, is the

consistency among decision makers (consensus) in reaching conclusions; *i.e.*, the results possess a higher degree of objectivity. In regulation and compliance, expert systems are particularly valuable in providing this type of "solution" to what are typically difficult and complex problems. Unfortunately, in many instances expert systems are difficult to formulate. Modeling the decision-process of "experts" is time-consuming and constrained by both software capabilities and precision. The knowledge-acquisition process has become a related research area.

Several of the successful expert systems presented here are technical assistance systems. The success of systems in the tax and auditing arenas show that technical assistance in complex or difficult portions of the law is an appropriate application of expert system technology.

When dealing with a set of rules as explicit and extensive as law—and insurance regulation is no exception—it is sometimes difficult to know which terms and concepts are defined elsewhere and which are not defined at all. Using expert system techniques to map the structure of the law can provide important insights about where further definition may be appropriate or necessary. Locating which concepts to consider basic or foundation concepts could lead to a better understanding of the nature of reasoning in this particular area.

Research potential in regulatory and compliance expert systems is tremendous. Information collection and issue identification, issue resolution, compliance, and policy formulation appear to be areas where expert systems would be useful. A possible example of the latter is testing proposed laws for interaction with current laws. Whenever new laws are being considered, it is important to understand how those changes will interact with other applicable legislation and to determine whether the result is the desired one or whether it is marred by undesirable side effects. An expert system could act as a test bed for proposed laws.