REDUCING RISK IN THE ENTERPRISE
Proposal for a Hybrid Audit Expert System

Susan Clemmons, Kenneth Henry
Decision Sysetms and Information Systems Department
Florida International University, Miami, Florida, USA

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Abstract: This paper theorizes the use of a hybrid expert system to support a complete audit of financial statements for an enterprise. The expert system proposed would support the audit process by using two types of artificial intelligence technologies: case-based reasoning and fuzzy logic technologies. The case base and automated reasoning recommendations would give the auditing firm another insight on the audit. Unlike previous audit expert systems, this system is intended to focus broadly on an enterprise's entire financial statement audit process; it combines a case based knowledge representation with fuzzy logic processing. The attempt at capturing a wide domain is necessary to support organizational decision-making. Focusing on narrow decision points within an audit process limits the users and usefulness of the system.

1 INTRODUCTION

Accounting firms and researchers have devoted significant effort to the use of decision support applications to assist in audit work. Many of these systems have been developed combining the knowledge and rules of the practice in the form of knowledge based expert systems. The use of expert systems as decision support tools in narrow auditing specialty areas is well documented (O'Leary, 1993). However, a conceptual gap remains when the outcome of several audit decisions are combined for an overall opinion or outcome decision. It has been noted that business expert systems lack a strategic focus for organizational decision-making support (Wong and Monaco 1995).

This paper theorizes the use of a hybrid expert system to support a complete audit of financial statements for an organization. The financial statement audit consists of more than one hundred action steps, and reviews four specific financial documents. It is conducted through a process that is triggered by many different decisions. Some of the decisions can be supported through tax codes and audit rules of generally accepted auditing standards (GAAS). Other decisions rely on the auditing firm's knowledge of the client company, the industry practices, and the firm's prior experiences, to assist in determining the proper course of action. The audit of financial statements is a complex series of judgments that leads to an opinion about the financial health of organizations. The audit is a critical financial information validation process for all organizations.

As the use of expert systems started to grow, Bailey et al (Bailey, Hackenbrack et al, 1987) outlined an expert system research agenda in the accounting and audit area. They stress that the contribution of academia is not one of software development and creation, but one of thought leadership about the decision making process used in auditing. They advocate this direction as the fundamental research objective of the academic community. In this paper, we try to follow this agenda and offer a method suited for the audit environment to support the decision making process of the auditing firm.

The expert system proposed would support the audit process by using two types of artificial intelligence technologies: case-based reasoning and fuzzy logic technologies. The case base and automated reasoning recommendations would give the auditing firm another insight on the audit. Typically, the domain of expert system applications is very narrow. This allows for complete exploration and rule development to support the area of expertise (Giarratano and Riley, 1998). The domain suggested for this hybrid system is much

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more general, and broader in scope, as it would encompass the entire financial statement audit process. The use of fuzzy logic or reasoning would allow the representation of uncertainty or a degree of certainty in the case data. Some of the decisions used in the audit process are not simply “either or” situations but use some gradation of the answer. The use of fuzzy variables would assist in the representation of this type of data (Fetter and McMillan, 1987). This approach focuses on organizational decision-making with the combination of technologies, the wide decision support domain, and makes this design unique.

The body of this paper is organized into three sections. The first section gives a brief explanation of expert systems use in business and auditing. It highlights important elements that must be considered when building an auditing expert system. The second section describes the details of the planning audit step as a case for processing in an expert system. It uses pseudo code examples and reasoning logic to describe the case structure and definition. The last section gives a brief discussion of the validation options for this approach.

2 AUDIT CONCEPTS

Expert systems are classified different ways. A system may be classified by the way a problem is addressed, the problem or expert domain, or by the intended user group of the system. Generic problem classifications can be overlapping due to many expert systems containing more than one method of problem resolution. The audit domain expert system proposed in this paper combines problem interpretation and prediction.

There are three commonly cited types of expert systems: rule-based, model-based, and case based. A fourth category, hybrid systems, has been used recently that describes systems that overlap these definitions. Hybrid systems combine different types of technology, and may have several knowledge presentation and inference modes. Most of the business applications developed during the 1980s and 1990s were rule-based expert systems. These systems represent knowledge in the form of a rule stated by an IF-THEN format. When a certain event occurs or relationship is present, then the certain outcome is likely; and this outcome points to appropriate actions. The application of sequential rules leading to the most likely conclusion is referred to as chaining (Turban, 1992). The chain is formed as the action or result of a rule is linked to the condition of the next rule or relationship. Inference engines with a rule-based design have two ways to proceed to an outcome. Backward-chaining inference engines start with a goal and the search for rules that will establish the facts to support the conclusion. Forward-chaining inference engines are data driven searches that arrive at a conclusion based on the data presented. Typically, the auditing expert system will fall into this category.

There are several advantages to using rule representation to recommend a course of action. Rules are easy to understand. They are a natural form of knowledge and can be found in everyday life. Inferences and explanations are also easily derived from rules. Rules make modifications and maintenance of the system simple. However, rules also have limitations when used to represent knowledge (Hayes-Roth, Waterman et al. 1983). Complex knowledge may require thousands of rules, as is the case with audit experience and judgment; this could create a problem in the system maintenance issue. Due to the common use of rules, builders of expert systems tend to rely on this knowledge representation, when other methods may be more appropriate (Turban, 1988).

Model-based expert systems are based on knowledge that represents the structure and behavior of devices that the system is designed to understand. They are useful in diagnosing equipment problems. The system draws conclusions directly from knowledge of the structure and behavior. One feature of model-based expert systems is their "transportability". A rule-based expert system may be of no value for repairing a different type of device that does not match its rules. A model-based system could be used to diagnose or repair the problem of any type of device based on the model (Turban, 1992).

Case based expert systems use case based reasoning to adapt solutions that were used to solve old problems and use them for the basis of a new solution for a new problem. Case based reasoning is a problem solving approach based on the retrieval and adoption of episodes with descriptions of problems and their associated solutions. One advantage of using case based reasoning is that the existing data and knowledge is leveraged and can be included in the database. The knowledge does not have to be translated and coded into rules. This makes knowledge acquisition a much faster process (Kesh, 1995), critical for the audit domain expert system. The system learns from both successes and failures of cases. The more interaction or learning that takes place, the richer the case database. Case base reasoning systems provide information for questions. Explanations then can be provided by rule-based systems. A rule-based system provides the explanation by the rules used to create the solution. In a case based system, actual cases that come close to matching the input case are used to describe the solutions. Case based reasoning mimics the human cognitive process for problem solving better than other types of expert systems. Recall usually takes the form of remembering the entire case or episode rather than a set of rules. In this way, case based expert systems are seen as more flexible and friendly to system users (Kesh, 1995).

Hybrid systems are systems that use a combination of knowledge base and reasoning engines to derive a solution. They use the strengths of each of the solutions to produce a result superior to those of just a single method. Soft computing techniques are being applied where uncertainty and learning a part of the systems requirement. Soft computing refers to techniques such as fuzzy logic, neural networks, and genetic algorithms. Examples of hybrid systems are expert systems utilizing production rules in the knowledge base and fuzzy logic as part of the inference engine. Nolan (Nolan, 1998) found that fuzzy technology enables the improvement of approximate reasoning by three different methods: (1) through efficient numerical representation of vague terms, (2) through increased range of operations in ill-defined environments, and (3) by decreasing sensitivity to noisy data.

Some research (Lenard, Alam et al. 2001) suggests the use of fuzzy clustering applied to qualitative questions asked during the audit can be successfully used in a hybrid system. Their work focused on combining fuzzy clustering and a proven statistical model to support an auditor's decision about going concern. Their expert system hybrid model provides statistical support and expert knowledge for use in the audit opinion. The success of their system with bankruptcy predictions indicates using both quantitative and qualitative information has the potential for better accuracy than each model being used separately. Strategic expert systems is still an under addressed topic in business (Wong and Monaco, 1995). This type of expertise is difficult to extract, and due to wide domain areas, the issues may be very complex and interrelated. While researchers have recognized the importance of these systems, there is a void in the business literature with regard to this topic.

3 BUILDING PROCESS

The domain of auditing is defined as: "a systematic process of objectively obtaining and evaluating evidence regarding assertions about economic actions and events to ascertain the degree of correspondence between those assertions and established criteria and communicating their results to interested users" (Concepts, 1973). There are three types of audits: (1) financial statements audit, (2) compliance audits, and (3) operational audits. The financial statements audit encompasses the process of collection and evaluation of evidence about an organization's financial statements. Its goal is to express an opinion as to the statements' fair representation of the financial position, results of operations, and cash flows of the organization; and whether they are prepared in conformity with Generally Accepted Accounting Principles (GAAP) and other applicable criteria.

Briefly described, the financial statement audit process consists of four phases: (1) Planning and design of the audit approach, (2) performing tests of controls (TOC) and substantive tests of transactions (STOT) (3) Performing analytical procedures and tests of detail balances (TDB), (4) Completing audit fieldwork and issuing the audit report. This formal structure lends itself easily to the application of a case-based approach. Each set of case data generated by the performance of the annual audit for a given client is conveniently stored in a matrix format, wherein a specific set of tasks must be performed in a specific order. This is done overall for audit planning purposes, and more specifically for each "audit cycle" performed for the financial statement line item classification.

Each audit performed by the audit firm will generate data and expert system recommendations in each of the four phases for a wide variety of circumstances. The collection of facts, rules, inferences, and conclusions will be represented by one case in the expert system's case database. Every successful audit firm will normally perform multiple audits during the course of a year, with each audit generating a new case for the database. Furthermore, as the years pass, additional cases are generated for new conditions as a given audit client's financial statements undergo the annual auditing process.

Within each cell of the defined case matrix, a specific set of data (facts) must be gathered about the planning for that phase or about the financial statement line item for the other phases. Also for each cell, a specific set of rules (production rules) must be applied to the facts (asserted or bound). The inference engine of the expert system must then apply the rules to the facts gathered, typically using fuzzy logic algorithms, and generate recommendations for specific audit conclusions derived, and procedures to be performed.

For illustration purposes, the next section of the paper gives a detailed description of the facts to be gathered (audit evidence) and the rules to be applied (generally accepted auditing standards) in phase I of the plan and design of an audit: making the audit decision on acceptance/renewal of a client. Selected sets of facts and rules are shown using CLIPS-like pseudo-code to demonstrate how the facts are asserted or bound, and how the rules are applied to produce expert audit conclusions.

3.1 Accepting or Rejecting a Client

The expert system, being used as an audit firm's assistant, has four decisions to make at this early stage of the audit. First, the audit firm must decide to accept (or not) a new client or continue (or not) serving an existing one. An individual auditor will review and recommend the course of action to the audit firm's management. Typically, the recommending auditor is experienced and in a position to make important decisions. This decision needs to be made early, before the audit firm incurs any significant audit costs that cannot be recovered. Therefore, the more information about this type of decision in the case database, the better decision the expert system can make. Second, the audit firm identifies why the client needs or wants the audit. This information is likely to affect the remaining parts of the planning process, because it directly affects the audit scope. Third, the audit firm obtains an understanding with the client about the terms of the engagement to avoid any misunderstandings. Fourthly, the audit firm must select staff for the engagement, including any required audit specialists.

Stated in terms of audit risks, an audit expert is unlikely to accept a new client or continue serving an existing client if acceptable audit risk (AAR) is higher than the CPA firm's risk threshold. This suggests the first of the facts to be asserted and rules to be defined by the audit expert system[1].

```
(assert AAR-threshold)
…
(bind ?AAR-value
…
(defrule accept-or-reject1
 (>  ?AAR-value  AAR-threshold)
 =>
 (assert (reject-client)))
```

3.2 New Client Investigation

An audit firm should evaluate a prospective client's standing and reputation in the business community, its financial stability, and the relations with its previous CPA firm. For example, many audit firms are very cautious in accepting new clients in newly formed, rapidly growing businesses. From experience, many of these businesses fail financially, and expose the audit firm to significant potential liability. For prospective clients previously audited by another CPA firm, the new successor audit firm is required by SAS 84 (AU §315)[2] "to communicate with the predecessor audit firm", to help the successor audit firm evaluate whether to accept the engagement. Communications may inform the successor audit firm that the client lacks integrity, or that there have been disputes over accounting principles, audit procedures, or fees.

Even when another CPA firm has audited a prospective client, other investigations are often made. Sources of information include local attorneys, other CPA firms, banks, major suppliers and customers, and other resources. In some cases, the audit firm may hire a professional investigator to obtain information about the reputation and background of key members of management. A more extensive investigation may be necessary when there is no previous audit firm, when a predecessor audit firm will not provide the requested information, or when any problems arise from the communication. In expert systems terminology:

```
(bind (?client-integrity "high"))
(bind (?disputes  "none"))
…
(defrule accept-or-reject2
   (client-integrity = "high") AND
    (disputes "none")
   =>
   (assert (accept-client)))
```

[1] The series of audit judgments made is illustrated in this section using pseudo-code. This is intended merely to convey the facts to be considered and rules to be applied, and is not intended to represent portions of a syntactically correct CLIPS program.

[2] AICPA *Codification of Statements on Auditing Standards* AU §315.01 to §315.23

3.3 Continuing Clients

Many audit firms evaluate existing clients annually to determine whether there are reasons for not continuing to do the audit. Previous conflicts over such things as the appropriate scope of the audit, the type of opinion to use, or professional audit fees, may cause the audit firm to discontinue association. The audit firm may also determine if the client lacks integrity and therefore should no longer be a client. If the client files a lawsuit against an audit firm or vice versa, the firm cannot do the audit. Similarly, if there are unpaid fees for services performed more than one year previously, the CPA firm cannot do the audit. To do an audit in either of these circumstances violates the AICPA's *Professional Conduct Rules* on independence.

Even if none of the previously discussed conditions exists, the audit firm may decide not to continue doing audits for a client because of excessive risk. Just as for new clients, excessive risk for a continuing client is when acceptable audit risk (AAR) is above the audit firm's threshold. For example, a CPA firm might decide that the client's tax position *vis-à-vis* changing IRS regulations gives rise to considerable risk of regulatory conflict between the IRS and the client, which could result in financial failure of the client, and ultimately lawsuits against the CPA firm. Even for a profitable engagement, the risk may exceed the short-term benefits of doing the audit.

Investigation of new clients and re-evaluation of existing ones is an essential part of deciding acceptable audit risk. Assume a potential client in a reasonably risky industry, where management has a reputation of integrity, but is also known to take aggressive financial risks. If the CPA firm decides that acceptable audit risk is extremely high, it may choose not to accept the engagement. If the CPA firm concludes that acceptable audit risk is high but the client is still acceptable, that is likely to affect the fee proposed to the client. Audits with a high acceptable audit risk would normally result in higher audit costs that will be reflected in higher audit fees.

```
 (assert  (AAR-value “low” ))
…
(assert  IRS-regulation)
(assert  tax-position)
(bind  ?industry  “risky”  )
(bind ?client-integrity “high”)
(bind  ?management-aggressive
   “high”)
…
(defrule  accept-or-reject3
   (<>  tax-position
   IRS-regulation)
   =>
   (assert (AAR-value “very
   high”))
…
(defrule  accept-or-reject4
   (=  ?industry  “risky”  ) (  =
   ?client-integrity  “high”  )
   (=  ?management-aggressive
   “high”)
   =>
   (assert  (AAR-value “high”)))
…
(defrule accept-or-reject5
   (=  ?AAR-value  “low”)
   =>
   (assert  (accept-client)))
…
(defrule accept-or-reject6
   (=  ?AAR-value  “high”) )
   =>
   (assert  (accept-client))
   (assert  (increase-fee)))
…
(defrule accept-or-reject7
   (=  ?AAR-value  “very-high”)
   =>
   (assert  (reject-client)))
```

4 VALIDATION OF THE SYSTEM

One of the most important steps in expert system development is the validation of the decision model and domain boundaries. Typically, validation entails comparing outcome measures between the computer model and that of the experts used during the knowledge acquisition process. If differences are found, developers must fine-tune the model to reflect accurate representation of the expert's knowledge. The next step in the process adds additional expert opinion to address the same questions and outcomes. Outcomes are compared and if any significant variations are found between the original expert opinion and the secondary experts, information is sought to explain the differences. The validation process occurs through two methods. The first method is using a statistical approach to analyze judgment outcomes. The second approach is tracing the process for understanding the sequence and relationships. Process tracing is used to capture the outcome of a judgment leading to the outcome used in the problem domain. Each of these methods generally explains significant levels of variation and yield interesting results. However, the methods do not provide satisfactory explanations for the observed differences. Understanding the domain judgment requires more than knowledge. To generate possible hypotheses, to recognize potential relationships, and to create strategies for using the knowledge, a greater understanding of the domain is necessary.

Four integral steps are used in the proposed Expert System Research Approach (ESRA): knowledge acquisition, knowledge representation, computational modeling, and theory validation. In the first two stages, the researcher identifies and organizes the many processes that constitute the domain expertise. The modeling stage then takes this expertise and translates it into a computer compatible representational framework. Once confidence is achieved in the computer model adequately emulating the experts' process, the theory validation phase has begun. The computer model is seen as a validation of the researchers understanding of the emulated domain. Any additional efforts to extend this degree of confidence can only improve the representation of the experts' judgment. This approach does not rely on a single expert's opinion. It uses many sources of expert domain knowledge to create the system. The breath of the domain is critical to the depth of understanding achievable in the system [2]. Typically, the broader the domain the more shallow representation of understanding the judgment process is achieved. However, if the domain has a well-established process and high degree of governance, the domain may be more accurately represented. Having a well-defined domain establishes much of the necessary knowledge for the experts to use in their judgment making. The expert system described in this paper uses the well established auditing process and auditing governance to represent the domain.

Instead of focusing on a single decision that an expert's judgment is critical for successful outcome, the auditing expert system focuses on the entire domain and guides the user to a logical result based on the past audit decisions. Using a case based system the validation of the correct outcome is found in prior decisions made with similar domain parameters. If the theory validation process suggests agreement between the computer case model and the test cases, a researcher can be reasonably assured that the domain and judgment tasks have been represented correctly.

5 CONCLUSION

This paper has set forth a design for an expert system in the audit domain. Unlike previous audit expert systems, this system is intended to focus broadly on the entire financial statement audit process and combines a case based knowledge representation with fuzzy logic processing. The attempt at capturing a wide domain is necessary to support organizational decision-making. Focusing on narrow decision points within an audit process limits the users and usefulness of the system. Narrow domain systems typically support only individual decision-making. By widening the domain, the judgment process is also widened. This holistic approach to organizational decision-making strives to support the audit process and the audit organization. In addition, the case based model allows the system to store results of multiple experts with the firm so that as the case base grows and knowledge increases, the quality of the decisions made by the system will improve. This heuristic component of the proposed expert system is yet another significant improvement over previous audit expert system designs.

A number of factors remain unaddressed in this approach. The complexity and size of the expert audit system may make it too difficult and cumbersome to process outcomes in a useful timely manner. Development of the actual system would be necessary to understand the limitations of computing power and processing for this wide of a domain. After development, empirical testing will need to be employed to validate the approach and attempt to duplicate the domain. The audit domain needs to confirm the usefulness of this type of system. Reality of the interaction complexity of the process steps needs to be accounted for in the design. Most expert system use a hierarchical decision making process. Being organizational driven, the decision making approach needs to be more matrix in nature.

The value of using this audit system will be represented in many ways. The first way is the support and assists individual auditors gain from using the system. It may assist them in feeling more confident about their decisions and create new environments to learn the audit process within without having to be in a real-world situation. Another contribution may be in the reduction of professional errors in judgment with regard to audit conclusion. This is a well-documented phenomenon and the negative results have resulted in resent industry and government corrective action. The last and foremost contribution of the use of this system may be in organizations making better and more effective decisions using the captured knowledge of experts over time. Such a system that can support organizational decision making by approximating process and judgment of a human expert would be a valuable contribution to real-world application areas. Although this system will never replace the actual audit firm, it may increase its ability to better service clients and the industry, and improve on the judgment capabilities in the audit process.

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