Implementation and Acceptance of Expert Systems by Auditors

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OVERVIEW

Remarkably powerful computers are now widely available at a cost that enables auditors, in principle, to achieve increased efficiency and effectiveness in their work. It is certainly true that auditors can benefit from the same generic software tools as every other professional -- they can take advantage of any of several “office” suites consisting of word processing, spreadsheet, databases, presentation software, electronic mail, and so forth. The addition of a commercial package for flowcharting might well round out an adequate set of tools for auditors. Of course, mere adequacy is an uninteresting aspiration. What additional kinds of tools could provide additional leverage for the auditor? What impact will such tools have on the audit practice?

Technology tools can have wide ranging impacts on an organization, its staff, the work that they do, and how they do it. The benefits promised by the tools can be lost if the behavioral impacts resulting from the use of the software are ignored. Many theories exist relating to sources of resistance and implementation strategies to minimize resistance. McGowan (1986) catalogued many of these theories and discussed their application to audit technology.

This paper describes two tools developed at the Price Waterhouse World Firm Technology Centre in Menlo Park, California and their current and predicted impact on the audit practice. These tools are:

- Planet: an expert system for assessing risk and selecting audit procedures; and
- Comet: a model-based system for identifying key internal controls, documenting weaknesses, and making internal control recommendations.

Planet

Background

Planet is an expert system for audit planning: in particular, for risk identification and audit procedure selection. Based on an auditor's answers to a series of questions, it makes risk assessments for the particular audit engagement and automatically chooses a set of audit procedures to satisfy the identified risks. Planet provides detailed explanations using a graphical display for all conclusions reached. Planet also has user-friendly tools for reviewing and editing the audit plan so that any member of the audit team can understand why each procedure has been included in the audit plan.

The Planet Knowledge Base

Planet is an expert system in the traditional sense: it captures the accumulated knowledge of human experts in a narrow domain. Its knowledge base was built using input from the audit partners and managers on a wide variety of engagements from around the world. The knowledge is represented by over 5000 logical axioms which are similar to if-then rules. These rules represent the

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relationships among risks, errors that could occur and procedures to gain assurance that errors have not occurred.

PWWF chose this style of expert system because audit planning is a highly studied task for which a relatively clear articulation of the problem already existed. The procedure selection problem had already been studied extensively by PWWF during the development of the software product, APEX 2.0 (Audit Planning Expeditor). During the development of APEX 2.0, the relationships between standard types of audit procedures and the financial statement assertions (or their inverse -- errors) were assigned scores. Further, generalized rules were developed to score non-standard procedures. These generalized rules were used in the development of the Planet knowledge base and, in fact, are used by Planet when the auditor adds custom procedures.

Before developing Planet, it was necessary to determine whether a similar scoring process could be used for the risk side of the equation. Boritz and Wensley (1990) described a knowledge based system for audit planning which suggested that an expert system was well suited to the inherent risk assessment task. While the final structure of Planet's knowledge differs from the structure they describe, their work facilitated the early stages of the project.

Representing the risk assessment knowledge proved to be somewhat more complex than the procedure selection knowledge; however, a similar set of rules emerged for quantifying the relationships between risks and financial statement errors. This knowledge was acquired through an interactive prototyping process where auditors, under the observation of a knowledge engineer who had a thorough understanding of both auditing and the prototype, used a succession of prototypes to plan real audit engagements.

A Planet Session

During a Planet session, the auditor is asked a number of questions about the client under consideration. Which questions are asked varies dynamically, depending on the answers given to previous questions. The questions serve two basic purposes in Planet. The first, and main, role for the questions is to identify risk factors. Based on the answers to the questions, Planet identifies risk factors and considers the impact of the risk factors on the errors which could occur in the financial statements. Planet then accumulates these findings and infers an assessment of the risk that each of the relevant error types will occur. The secondary role that the questions play is to rule in, or rule out, certain error types, audit procedures and other questions from further consideration. In this way, we show the auditor only that information which directly relates to specific situations at his or her client.

Explanation Functions

A clear explanation trail is crucial for any expert system. This is particularly true for an expert system used in a highly judgmental domain such as auditing. The auditor can review Planet's risk assessments in detail at any point during or after the question and answer process. To facilitate this review, we show the risk assessments to the auditor using bar graphs. The size of the bar reflects the relative importance of each risk factor for each error type. To obtain additional information about why a particular risk is present, the auditor can "drill down" through the detail by clicking a mouse on the relevant error type, risk category, risk factor, or question in which he/she is interested. In this way, the auditor can see the logic behind every conclusion reached by Planet.

Procedure Selection

Once the auditor is satisfied that the risk assessments are complete and appropriate, he/she asks Planet to generate an audit plan. In a matter of seconds, Planet selects a set of audit procedures which will satisfy the risks identified during the question and answer portion of Planet. The algorithm uses a number of rules and heuristics to ensure that no error types are left with risk which is not satisfied by a procedure, and that each procedure in the plan is necessary. By "necessary" we mean that no procedure could be removed from the plan without exposing a risk. The auditor
reviews the plan and can question why each procedure has been included in the plan. In addition, the auditor can add and remove procedures from the plan and immediately see the effects of those changes.

These review tools are graphical in nature, and are also based on bar graphs. If the auditor clicks on a procedure he/she immediately sees a list of all the error types for which the procedure is providing assurance, and a "what if" analysis showing which error types would have exposed risk if he/she removed the procedure from the plan. Alternatively, the auditor can view a list of all the procedures which are providing assurance for any particular error type.

Following is an example of a "What If" screen from Planet. The auditor asked, "What if I removed the procedure 'Explain movements in monthly expense purchases' from the audit plan?" The left-hand side of the screen shows a list of all the errors for which this procedure provides assurance. Across from each error are bar graphs showing the risk, the assurance provided by the current plan and the assurance which will be provided if the procedure under consideration is removed. The gauges provide an additional visual cue to help the auditor pinpoint the most important effects.

Benefits

The potential benefits of Planet, if it is well accepted by the general population of Price Waterhouse auditors, are believed to be substantial. The auditor is efficiently guided through a comprehensive set of audit considerations and each element of the resulting plan represents the best practice as agreed upon by experts from Price Waterhouse firms worldwide.

Planet will keep track of the daunting level of detail that auditors might otherwise be able to consider only implicitly. Because of this added detail, the auditor can ensure each audit procedure is closely related to the identified risks. This will result in a more efficient and focused audit plan. Related to the increased detail is the ability to explicitly show the interrelationships between the assurance gained across the various components. With the ability to show the effects of this "cross-component satisfaction," the auditor can get the advantages of breaking the audit down into small manageable pieces, without losing the overall picture. In the course of extensive testing around the world, Planet has been documented as having achieved up to twenty-five percent reduction in audit hours without sacrificing effectiveness.

Besides the substantial benefit of increasing the efficiency of the audit plans, Planet also increases the efficiency of the audit planning process itself, because the procedure selection process has been automated. In addition, Planet provides better documentation of the planning process. Because audit planning is complex and judgmental, planning documentation typically contains only the results of decisions made and rarely includes evidence of the thought process behind those decisions. With Planet, all the relevant facts behind the planning decision are captured. This will aid in communicating the objectives of the audit plan to other members of the audit team.
The benefits of new technology tools will not be realized to their fullest if the implementation of the tools is met with resistance. To minimize the risk that resistance would negate the benefits of this software, careful consideration was given to the effects that Planet might have on the firm's partners and staff. Following are some of the issues considered in this process.

**Knowledge Rationalization and Amplification**

Hirschhorn and Farquhar (1985) suggest that professionals (lawyers) will resist automation tools that rationalize knowledge, unless those tools also amplify knowledge and/or reduce the professional's need to rely on support staff. That is, they will resist something that makes their decision making more explicit, without either improving the quality of the decisions they make or the speed at which they can make them.

Planet does somewhat rationalize knowledge by making the decision making process more consistent and more explicit. However, we believe that Planet also amplifies the decision making process by enabling the auditor to plan the audit at a more detailed level, thereby freeing his/her time to focus on the most complex and important issues facing his/her client. In addition, Planet reduces the audit planner's need to rely on support staff. Because it is a very user-friendly system, and because an audit plan can be produced in a relatively short time (average 2 hours) there is a reduced need for word processors (secretaries) and paraprofessionals to prepare audit plans and programs.

Our belief that Planet will amplify the knowledge of the audit planner suggests, under the theories put forth by Hirschhorn and Farquhar, that the risk of user resistance is lowered. Nonetheless, it would be foolish not to take further steps to encourage acceptance. Because resistance to knowledge rationalization could mitigate the potential benefits of Planet, features were included to
help ensure the auditor will feel in control of the process. For example, although Planet has a standard order for the question and answer dialog, the auditor can alter the order in which the questions are asked. In addition, the auditor is given the opportunity to add "custom" risks and procedures to Planet which helps increase the auditor's feeling of ownership of the audit plan. Finally, because of the nature of auditing -- which many say is more of an art than a science -- the auditor must exercise his/her professional judgment simply to answer the questions. In other words, the rationalization has not been taken so far as to make the audit planning process a mundane or unskilled task.

**Cultural Values**

Auditing decisions are based largely on professional judgment. Even though guided by their education and training within the firm, auditors develop unique decision making styles. In addition, even if decisions are subsequently reviewed, auditors are accustomed to making relatively autonomous decisions. Since Planet rationalizes and amplifies this decision making process, it could potentially conflict with the traditional cultural values of the firm.

The structure of the knowledge in Planet, and the explanation trails available, were designed to minimize the risk of violating the cultural values of the firm. For example, the audit risk model is traditionally represented in multiplicative form. That is, \( AR = IR \times CR \times DR \) (audit risk equals inherent risk times control risk times detection risk), with each of the elements of this equation represented by percentages. It is extremely difficult to multiply several percentages together without an electronic aid (or at least a pencil and paper!). Thus, rather than show the risks as percentages, we express the risks as integers that are the logarithm to the base 0.9. As a result, the scores appear additive to the auditor, rather than multiplicative, and the auditors can easily understand and even verify the mathematics being performed by the system.

In addition to the features built into the system, the training and manuals which accompany Planet further enforce the idea that Planet is a tool -- not a replacement -- for the auditor. Great emphasis is placed on the judgments exercised by the auditor to use the tool well. This message is important, not only because it is true, but also because it re-enforces the cultural values intrinsic to the firm and the profession.

**Job Content**

Before the introduction of Planet, audit planning at Price Waterhouse was carried out as a two-step process: Strategic Planning and Detailed Planning. Strategic Planning, performed with the involvement of the audit partner, included risk assessment and a development of a high level expected audit approach for each major financial statement component. Detailed Planning, traditionally performed by audit seniors (sometimes with the assistance of more junior staff), included the selection of audit procedures within the guidelines specified by the Strategic Plan. The partner and manager then reviewed and approved the detailed plan before the commencement of the audit work.

Planet, in contrast, provides a "one-pass" audit planning process, eliminating the need for intermediate reviews. Thus, the job content of most levels of audit staff will be affected to some extent. These changes are congruent with other behavioral changes that are currently being implemented in the firm, notably an increased emphasis on team work. The one-pass planning aspect of Planet, as well as the interactive nature of the question and answer process, is conducive to this behavioral change. The early implementers of Planet have been encouraged to answer the questions in Planet as a team -- involving at least the audit manager, and preferably the partner as well.

Thus, in terms of job content, the technology is not the primary driver of the changes, but does complement the desired behavior. Change integration techniques are being used to ease the introduction of these new working arrangements.
Skills and Training

One possible outcome of the implementation of an expert system is the de-skilling of a process. Some have hypothesized that the introduction of expert systems will hamper learning because the "computer does it for you." Although this is a recognized risk, we believe that the opposite will be true for Planet. Because of the knowledge rationalization, the planning decision processes will be more explicit. In this way, we believe that Planet will help rather than hamper the development of good audit judgment. In fact, it is envisioned that Planet will be used to teach auditing to new auditors.

Many of the early implementers of Planet have made comments such as, "It made me think about my client in more detail" and "It helped me understand how the entire plan fits together." Comments such as these are taken as encouragement that Planet will enhance auditors' understanding of the audit process -- rather than remove their need to understand it at all.

Current Status

Version 1.0 of Planet is being used by Price Waterhouse auditors in several countries around the world, largely in Australia and Europe. Version 1.2 will be released for broader use in May 1996.

Early users were not selected based on any particular affinity for technology or for a perceived receptivity toward new ideas. Nevertheless, they have been very enthusiastic about the system. When the pilot testing was conducted in 1994, 97% of the pilot testers were supportive of the software. This is perhaps the most enthusiastic response we have ever had to a new audit tool. This leads us to believe that our efforts to overcome the resistance problems have been successful.

COMET

Background

The evaluation of internal control systems is a very complex process. Control weaknesses often arise from interactions among many details which, when taken individually, are very simple. However, in modern accounting systems, determining the interactions between all the simple details can be complicated. To handle the complexity, auditors and others use a variety of tools such as flowcharts, verbal descriptions of systems, and/or checklists describing "typical" controls in a "typical" system. However, even given those tools, it is up to the human to mentally extract all the important results and recognize the weaknesses and redundancies in the system.

Comet is a model-based analysis tool for analyzing business processes and internal control systems. Potential applications of this technology include not only internal controls evaluation, but also re-engineering, systems development and audit planning. Potential users include internal and external auditors as well as designers of new business systems. Comet provides Price Waterhouse and its clients with a facility to build hierarchical, structured, textually annotated models of a system and to analyze the system based on that model. While the model building facilities alone are superior to the flowcharting tools presently available to the auditor, the real power of Comet is that it automatically provides the user with an evaluation of the system and its internal controls.

Model-Based Approach

Comet uses a branch of artificial intelligence called model-based reasoning for its analysis. A model, in this context, refers to a structured representation of a specific business system.

Model-based analysis has traditionally been applied largely in engineering, rather than financial, domains. The original premise for Comet was based on the notion that a computer information system (CIS), like any other process, can produce failures for which hypotheses can be constructed to suggest the cause of the failures. In fact, this is one strategy that auditors already use.
to investigate errors discovered in financial systems — formulating and testing various hypotheses about the cause of errors. Walter Hamscher, the lead researcher on Comet, had previously done work on model-based systems diagnosing faults in electronic circuit boards. He suggested that these same principles could be used to cover other types of complex systems, such as accounting systems.

A model-based approach was considered a good match to the problem of internal controls evaluation because the number of combinations of "typical" controls which might be present in a complex CIS is so large that any attempt to create a generic yet robust listing of the possible combinations quickly becomes ineffective. Comet assists auditors in answering questions like, "How many controls are adequate?", "Which controls are crucial?" and "Are any controls redundant?". While methodologies exist (both within the firm and in the profession at large) to answer questions like this in abstract terms, the application of these methodologies becomes highly subjective when applied to a specific system. As a result, the expertise required to analyze a complex accounting system is considerable and the quality of the outcome is highly variable. Comet’s aim is to enhance the decision making ability of the experts and introduce some level of consistency in the decision making process.

Development of Comet

Accounting systems process accounting data through activities that create, use, alter, and store that data. While the variety of processes to perform these activities is perhaps infinite, each process can be broken down into a set of primitive processes or verbs. Comet’s model building tools include a set of verbs which can be used describe how the data is created, used, altered and stored.

Planet and Comet exploit artificial intelligence techniques in very different ways. In Planet, most of the intelligence is hard-coded into the knowledge base and the “inference engine” (that is, how the system reaches decisions) is fairly simple. In contrast, the intelligence of Comet is incumbent on having a robust list of primitives which the auditor can use to accurately describe an accounting system, and the inference engine is quite complex. Thus, Comet’s development was somewhat less dependent on knowledge acquisition and more dependent on building a user interface which could convey the results of the complex reasoning process in a way in which the auditors could understand.

Because of its reduced emphasis on knowledge acquisition, an early prototype of Comet was developed with little input from domain experts. Once this prototype was used to prove the concept, a partner and senior manager who are experts in analyzing complex computer systems were asked to use the prototype on some of their engagements. Their involvement resulted in a great expansion of the list of primitive verbs, common activities, and controls included in Comet. They, and other members of the Information Systems Risk Management (ISRM) practice used a succession of Comet prototypes on a wide variety of engagements ranging from relatively simple systems to highly complex ones in the financial services industry. The models created by these early implementers were sent back to the developers and used to refine and improve the modeling and analysis process.

The Modeling Process

Auditors can use traditional off-the-shelf flowcharting software to document the activities included in an accounting system. At first glance, Comet resembles off-the-shelf flowcharting software. There is a crucial difference, however, between traditional flowcharting software and Comet. Traditional flowcharting software produces only a picture. The documentation, if any, of what happens inside each activity is just text. It is up to the person examining the diagram to interpret the significance of how records are processed and to make conclusions about weaknesses in the system. In contrast, Comet uses the description of the processing steps to perform the analysis without further human intervention.
To build a Comet model, the user begins by drawing a diagram of the various business activities in the system and the relationships between them -- much like traditional flowcharting. While diagramming the activities in Comet, the user describes each process using a predefined set of verbs such as transfer, copy, create, merge, find, compare, compute, and assign. To facilitate the modeling of complex accounting systems, some common activities such as maintain standing data, and data entry, have been pre-defined for inclusion in a model. The user also includes controls in the descriptions of the activities. Again, these controls are described using a set of pre-defined verbs such as authorize, match and reconcile. The user can further describe each control by answering a set of three to seven yes/no questions about it. The answers to these questions help to assess the relative effectiveness of the controls.

Above is a snapshot of a portion of a Comet model. Processes are shown by rectangles. The dashed lines beside the rectangles indicate that the process can be expanded into further levels of detail.

There are many review and syntax checking tools included in Comet. These help to ensure that the model of the system is accurate and complete. For example, there are checks to ensure that every output described is created by a process in the model. In addition, the system checks that the types of inputs and outputs from a given process are consistent with the activity or verb used to describe the process.

Analysis of a Model

Once the system is described, Comet automatically determines a complete list of everything which could go wrong. Thus, the auditor need not hypothesize about possible problems -- Comet does that for him/her. Things that could go wrong are referred to as failures. The list of all failures is further refined to show only those failures which are significant. In the current version of Comet, which is being used by CIS auditors in an external audit context, a failure is considered significant if its downstream effects could cause an error in the financial statements. The system can also detect failures that generate operational type errors for an internal audit context.

Comet continues its analysis by determining the probability that each of the failures will be detected by the controls in the system. The auditor can input an allowable risk level to which the
probability of detection is compared. Once the analysis is complete, the user can review, for each significant failure, a list of the controls that could detect it. Conversely, the auditor can, for each control, see a list of all the failures that it detects. Comet also produces, for each control, a list of all the failures that could defeat it (render it ineffective). For example, failures in the activities that relate to maintaining a password file can defeat any controls that rely on the integrity of the password file.

Having produced these lists, Comet can analyze the overall control system in a variety of ways:

- It can find the critical controls -- those controls most capable of detecting some significant failure, or the only ones capable of detecting a failure that defeats other critical controls.
- It can find control weaknesses -- any significant failure that is not detected by any strong control. For example, assume that a purchases and payables system does not compare the amount specified on a purchase order with the amount appearing on the invoice. A consequence of this weakness is that mistakes in computing the amount on the invoice would not be detected.
- It can find redundant controls -- controls, which, if not performed, would not significantly change the set of failures and their effects.
- It can generate a list of incompatible activities to support segregation of duties evaluations, based on the notion that the same person must not be allowed to perform both an action and the control that is supposed to detect failures in that action.

Below is an example of one of the results of a Comet analysis -- the Failures Matrix. This shows a list of failures that affect the account chosen at the top right-hand corner of the screen. For each of the failures, the analysis indicates whether the risk of the failure occurring has been sufficiently reduced given the controls described in the model. In addition, the impact of each failure on the financial statement assertions is shown -- e.g., Genuine, Proper Amount, Recorded, and Operational.

**Figure 3**

Failure Matrix from Comet
Benefits

The analysis performed by Comet can be extremely powerful. Many system control weaknesses are difficult for a human to recognize as they arise from the interaction of numerous individually simple details. Some CIS may be too complex for a single human to mentally extract all the important results. It would be a rare human indeed who could provide anything like the guarantee of logical correctness that Comet provides.

The main effect of a model-based approach to evaluating controls is that it can reduce uncertainties associated with relying on controls. These uncertainties can lead to either over-auditing or under-auditing. Comet and its associated methodology have the potential to favorably impact the audit practice in terms of audit efficiency, effectiveness, and client service. As is the case with Planet, though, the benefits of Comet will only be realized if the tool is broadly accepted within our practice.

Impact and Acceptance

Knowledge Rationalization and Amplification

The use of Comet will undoubtedly rationalize the internal control evaluation process. In fact, it will make the process explicit to a level not previously thought possible. Thus, unless the auditors using it believe that it considerably amplifies their knowledge, it may meet with resistance. To date, none of the potential resistance surfaced. In fact, quite the opposite has occurred. Early users are emphatic about their support for the software. Some initially disliked the rigor required to break each process down into primitive verb sets, but they eventually came to prefer the Comet approach because the act of building the model contributed to their understanding of the CIS. This fits in with Hirschhorn and Farquhar's theories. While Comet rationalizes the decision making process, it also greatly amplifies it, thereby making the decision makers more confident in their decisions.

While we have yet to prove with certainty that Comet helps auditors make decisions more quickly (because a considerable investment is required in order to build a Comet model), it seems clear that the decisions made are much better reasoned and supported than those which can be made without the aid of the tool. Because internal control evaluations often result in making recommendations for change, having a detailed rationale, or "proof" for the necessity of the change greatly increases the credibility of these recommendations. This, too, can be seen as an amplification of knowledge.

Cultural Values and Job Content

Peer reviews of our (and other firms') audit work frequently suggest that CIS auditing is underutilized. Despite numerous academic theories and research which show that reliance on systems of internal controls is an effective and efficient means of providing audit assurance, it appears that many practitioners still believe that substantive testing and analytical review techniques are better. Some auditors claim that their clients place little value on recommendations to improve CIS controls when their own eyes and business acumen (i.e., management and independent controls) suggest that system outputs are correct. As CIS become increasingly complex, it may also be the case that financial auditors do not completely understand the work performed by their computer audit counterparts and are uncomfortable relying on that work. Because Comet will greatly rationalize the internal control evaluation process, it should make it easier for computer auditors to explain results to general auditors and clients. This may raise the perceived value of their work and facilitate greater acceptance of CIS auditing.

Skills and Training

The skills required to analyze a complex CIS without Comet are considerable. The introduction of the software has not changed this. Early implementers of Comet required significant
training, as the quality of the analysis performed by the software is dependent on the accuracy and quality of the model the auditor has described. We expect that the amount of training required to use Comet will ultimately be the same as or less than the training required by ISRM auditors not using the tool. However, the focus will shift more toward accurately describing systems, less toward analyzing them for weaknesses or redundancies in controls.

This raises another important issue. Widespread use of Comet by ISRM staff may change the desired skill set of individuals recruited into and attracted to this area of the practice. There may be a greater need for logical and systematic thinkers, rather than on traditionally trained auditors. This change in skill sets, and in the type of individual attracted to this area, is congruent with other changes being made in Price Waterhouse -- particularly in the European firm, where Comet is most widely used. In the European practice, a clear separation of career paths is being defined between Systems Assurance (SA) auditors and Business Analysis (BA) auditors. SA auditors need not be professional accountants, and need not be on an “up or out” career path toward partnership. Thus, new recruits into the ISRM practice will more often have a background in computer science than accounting or auditing. This is congruent with the skill set required to use Comet effectively.

Current Status

To date, nearly half of the staff of the European ISRM practice has been trained in the use of Comet and are using it on dozens of client engagements. The remainder of the European ISRM practice will be trained in 1996. Comet is also being evaluated for use by the other large Price Waterhouse firms around the world.

SUMMARY

Planet and Comet represent a new generation of audit tools that leverage advanced technology and focus on audit-specific issues. They hold out the promise for dramatic increases in both auditor effectiveness and efficiency. Because these tools affect the way in which our professional staff make decisions, careful consideration of the behavioral impacts has been made. By recognizing and managing these risks, we believe that we have minimized resistance to the tools, thereby maximizing the benefits.
REFERENCES


