Inspector: An Expert System for Monitoring Worldwide Trading Activities in Foreign Exchange

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Inspector, an expert system, was implemented to assist foreign exchange management in the monitoring of trader activity and the compliance of risk management policies. The knowledge of senior foreign exchange managers, traders, controllers, and auditors is contained in an expert system shell, Nexpert Object. The foreign exchange deals from all Manufacturer's Hanover Trust (MHT) branches are recorded every day in a relational database, Oracle. Combining these systems with local area networks (LANS), global communications, and resident C programs provides a daily review of all worldwide MHT foreign exchange activity. The success of Inspector is directly attributable to the successful combination of traditional technologies, worldwide coverage, and a robust knowledge base. This success demonstrates that expert system technology, coupled with traditional technologies, can be effective in monitoring transaction-oriented financial activities.

A Risky Business

Several billion dollars of foreign exchange deals are executed each day by 23 MHT locations around the world, amounting to thousands of trades, with the typical deal being between 5 and 10 million dollars. In this high-stakes, high-volume international business, the ability to closely monitor trader activity and enforce risk management policies is a serious concern. A single unauthorized or fraudulent trade can damage the bank's profitability.

Like other large financial institutions, MHT has many safeguards in place to minimize over-enthusiastic trading, policy violations, and outright fraud. These safeguards include, for example, dollar limits on various dealing activities, back office verification of trade details, daily management information reports, and periodic audits. Despite these high-quality controls, a few bad deals occasionally occur.

The problems of poor judgment and fraud have always been difficult to control, in part because the instances are few and far between and in part because there has been no practical means of examining every recorded trade—the proverbial needle in the haystack problem. Inspector, an expert system application developed at MHT, is designed to solve this problem.

Finding the Needle

Although the sheer volume of deals to be examined is one obstacle, scarcity of expertise is the more significant barrier. Extensive knowledge of foreign exchange trading procedures, operational controls, and accounting practices is required to spot bad deals. Also required are the memory of a history professor, the perseverance of an auditor, and the insight of a sleuth. Finally, even if people with these skills could be found, few would accept such a tedious task.

Expert system technology presents an innovative solution to this serious and especially perplexing problem. Through the use of expert system technology, MHT is able to capture, combine, and represent the knowledge of its senior foreign exchange managers, traders, controllers, and auditors. Today, this knowledge is applied to every recorded deal in every MHT branch, every day.

The Whole Is Greater Than the Sum of the Parts

Inspector's success is not attributable to expert system technology alone. Instead, the system's success results from merging expert systems with traditional technologies, such as relational databases, third-

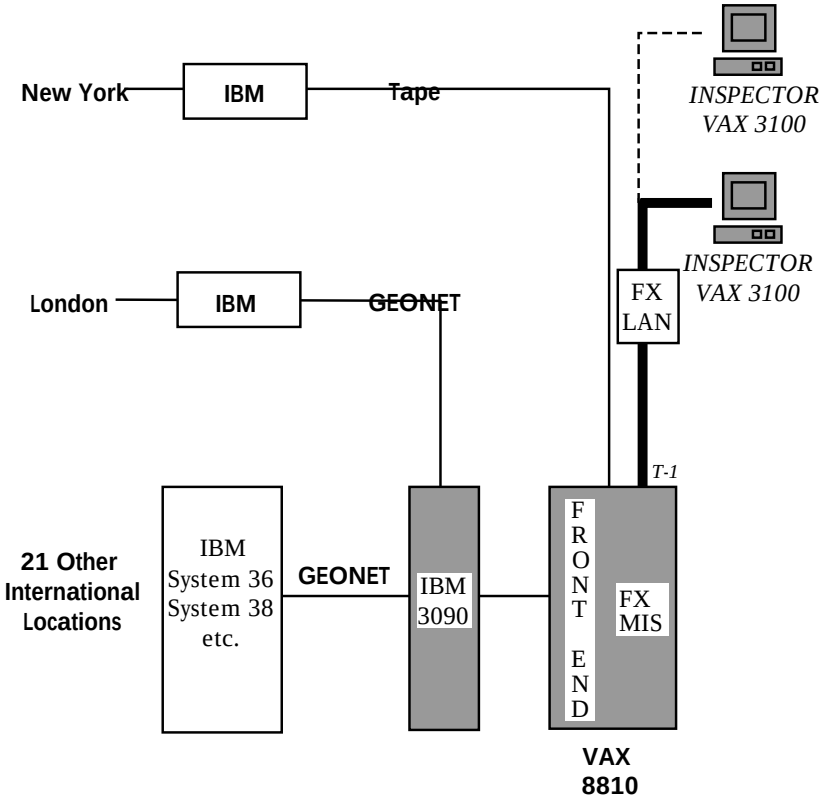

Figure 1. Inspector's System Configuration and Flow.

generation languages, LANS, and global telecommunications. Inspector is a technology melting pot, with several technologies contributing to the overall solution but no single technology able to effectively solve the problem on its own.

Several practical business requirements drove this multitechnology design. First, because trader fraud can occur anywhere, anytime, Inspector must examine every deal, preferably within 24 hours of booking the transaction. For Inspector, this time frame means data for each business day are analyzed as soon as they are received. Second, knowing that fraudulent trades rarely appear irregular at first glance, Inspector needs to perform extensive historical trend analysis and provide pattern-matching capabilities. Third, the management alert report generated by Inspector must be accurate, concise, and timely. Finally, the rules guiding the analysis must be easy to access and revise because as Inspector is being used, new knowledge will most likely surface.

As seen in figure 1, transmitting the data to Inspector involves considerable telecommunications support. Every 24 hours, data originating in 23 international locations are processed by several record-keeping systems running on IBM mainframes. These systems send the data to New York across MHT's global telecommunications network, Geonet. The data arrive at one of MHT's IBM data centers and pass through a system network architecture gateway to a Digital Equipment Corporation (DEC) data center, where they are loaded onto another mainframe. Here, the data are normalized by a C application written for the foreign exchange management information system (FX-MIS). Just prior to loading the data into FX-MIS, another C application copies the normalized data and transmits it five miles through Manhattan over T-1 transport lines to 270 Park Avenue, MHT's foreign exchange headquarters. At this point, it is about 2:00 A.M. eastern standard time.

The data arrive on a LAN and are passed to Inspector, which resides on a DEC Vaxstation 3100 with 16 megabytes of memory and 638 megabytes of disk space. The arrival of the data automatically activates a C program. This program loads the data into an Oracle database. Here, descriptive statistics are computed, and historical trends are revised. After the database is updated, the expert system, written in Nexpert Object, begins to run. By 8:30 A.M., Inspector has evaluated thousands of transactions and produced a management alert report summarizing any unusual findings.

The Oracle database, built in parallel with the knowledge base, serves as Inspector's long-term memory, statistical resource, and file cabinet. This design enables the expert system to flag a slightly suspicious deal; check with the database to see if any other similar deals were flagged; and, based on this historical query, determine whether to perform additional analyses or file the transaction in an alert log in the database. There is a high degree of interaction between the expert system and the relational database.

Currently, Inspector communicates its results through printed reports containing alerts, transaction details, and explanations. This paper medium has worked well, but it is not ideal. To be even more helpful, Inspector needs an interactive user interface. For example, a senior manager reviewing the hard-copy report for a particular branch might see something unusual and want to pursue a more in-depth investigation. This investigation might require a query to the database, the firing of more rules, and the ability to graph attributes of the resulting transactions. To facilitate this type of investigation, an interactive graphic user interface was developed for Inspector and deployed in September 1990.

Inspector is not a stand-alone system, nor is it a wholly embedded expert system. It is a stand-alone system in the sense that it currently runs

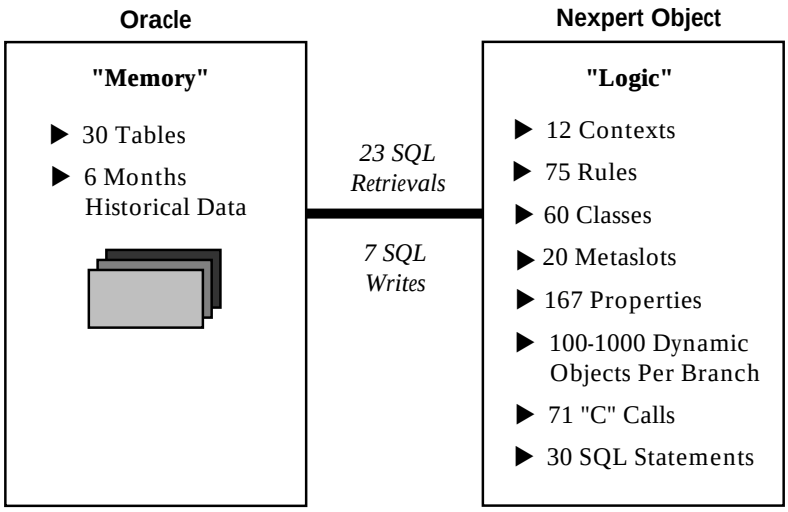

Figure 2. Inspector's Architecture.

on a workstation. However, if the expert system were isolated from its communications networks or relational database, Inspector would become inefficient and untimely. Inspector is probably best described as a multitechnology application because the expert system enhances several traditional technologies.

Design of the Knowledge Base

Three objectives drove the initial design of Inspector's knowledge base: accuracy, performance, and long-term maintainability. The first of these objectives, knowledge accuracy, is obvious, yet accomplishing the obvious is not always simple and straightforward, especially when performance and maintenance must also be considered.

The business requires that each day's information from more than 35 units (in 23 locations) be examined in a timely fashion so that management can have a report early the following business day. Fortunately, the general rules that are applied to each branch are similar; only the individual parameters and thresholds change. Consequently, Inspector makes significant use of Nexpert's knowledge representation features and inference strategies, especially contexts, rules, classes, metaslots, properties, embeddable standard query language (SQL)

statements, backward chaining, and knowledge islands. Currently, the knowledge base uses about 12 contexts, 75 rules, 60 classes, 20 metaslots, and 167 properties (figure 2). For each branch, 100 to 1000 objects can dynamically be created during run time. In addition, the rules contain calls to 71 external C routines and 30 SQL statements, 23 SQL retrievals, and 7 SQL writes.

Initially, Inspector's overnight execution time exceeded eight hours, which was clearly unacceptable. To improve performance, two major modifications were implemented. First, the scope of the daily report was reduced, and a second, in-depth report was produced. The in-depth report is now generated weekly and on an as-needed basis. Second, portions of the Nexpert analysis were reimplemented in C. As a result of these changes, execution time is now less than four hours for the daily analysis and five hours for the in-depth analysis.

To facilitate long-term maintenance, branch-specific information, such as thresholds, is kept in Oracle. Hence, Inspector's knowledge base is almost completely generic and contains only 75 rules. In fact, SQL embedded within the rules contains parameters to provide generic access to the database. Without the link to Oracle, the number of rules would have been vastly greater. A change in one rule might have required more than 35 changes (one for each unit) in a nongeneric knowledge base. This amount of change would have been a maintenance nightmare. Oracle also acts as the knowledge base's long- term memory, keeping records of minor, routine, and major alerts over time so that historical patterns can be identified by the expert system and further investigated by management through ad hoc queries to the database.

Judging Inspector's Innovativeness

Is Inspector innovative? From the perspective of MHT and the financial services industry, the answer is, clearly, yes. Expert systems offer a practical, cost-effective, and powerful solution to the age-old problems of monitoring high-volume, high-risk businesses. More systems of this type are certain to follow, both at MHT and other financial institutions.

For the AI field, Inspector's contribution is more subtle but equally significant. All too often, expert systems are stand-alone systems, causing many people to question the technology's fit with existing technologies. Inspector has shown that AI not only fits but adds an important dimension-—the ability to produce powerful applications that reason and think like human beings.

MHT built and delivered Inspector on a standard hardware platform, using proven technologies and a C-based expert system shell.

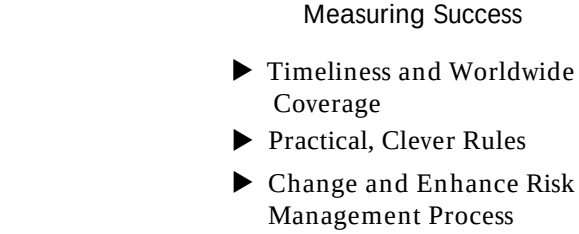

Figure 3. Critical Success Factors.

Consequently, nearly seamless integration with existing applications was achieved. By leveraging these applications and their experienced system support staff, Inspector was designed, developed, and initially deployed in less than 10 months. Furthermore, the system is more easily understood and maintained by non-AI specialists. Because understanding promotes acceptance, the AI–management information system partnership at MHT was strengthened.

Measuring Success

At the beginning of the Inspector project, three major critical success criteria (figure 3) were stated: worldwide coverage; a knowledge base of practical, as well as clever, rules; and, perhaps most importantly, a positive impact on the audit and control procedures of the foreign exchange department.

The first of these criteria dealt with the scope and timeliness of the completed system. Inspector had to access every deal from every branch every day; otherwise, the safety net created by the system would contain risky holes. Remembering that one bad deal can damage profitability, thorough coverage was an essential success feature.

The second criterion, building a knowledge base of practical, as well as clever, rules, underscored the significance of the expert system portion of the project. Trader fraud can happen in many imaginable and unimaginable ways. Rules to handle the imaginable are based on current risk management policies and controls and augmented by the practical knowledge and experience of our traders, chief dealers, senior managers, controllers, and auditors. Handling the unimaginable was a trickier knowledge-acquisition task. To capture this knowledge, our experts had to consider situations that have never and should never happen, but were they to occur would cause alarm.

The final success criterion, unlike the two previously discussed, was not technical in nature but, rather, dealt with people and change. For

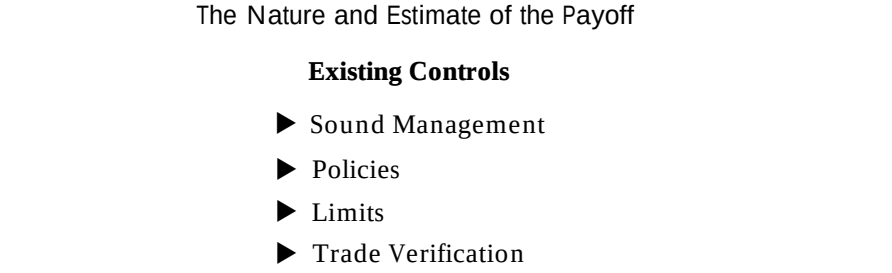

Figure 4. Inspector Provides a Safety Net.

Inspector to be a complete success, its advice had to become integral with the managers in foreign exchange. For Inspector's advice to become integral, the alert reports generated must be routinely reviewed, and when appropriate, follow-up action must be taken.

Senior management has taken several steps to ensure review and follow-up. First, a new staff position was created and filled by an experienced foreign exchange person, who reviews the daily reports and, when necessary, investigates the alerts. Second, regional and branch managers around the world receive the reports by electronic mail.

Today, Inspector is being formally woven into the audit and control procedures of the foreign exchange department. The positive response of senior management is clear—Inspector is a powerful system that has an important role at MHT.

The Nature and Estimate of the Payoff

Inspector is akin to a large safety net, ready to catch problems that might otherwise fall through the cracks. It is important to understand that the management and audit controls that were in place at MHT prior to Inspector and that remain in active use today are considered good by industry standards. Inspector allows MHT to leap beyond these standards and provides a totally new level of analysis, one that is part control and part management information (figure 4).

Given the dollars involved in the average foreign exchange deal, if Inspector helps identify even one fraudulent or unauthorized trade, the system will have paid for itself many times over. This benefit is an obvious one for MHT. A less obvious but equally significant payoff comes from Inspector's value as a deterrent. MHT's currency traders now know that all transactions are being reviewed daily by management. This "big brother" effect is a powerful defensive weapon against fraud.

These risk control benefits were planned; the management informa-

tion was a pleasant surprise. In the process of building Inspector, a large relational database was built to house, summarize, and maintain transaction information, including alerts generated by the expert system. Never before had such quick, easy access to these data been available. As a result, Inspector now produces several standard management reports and frequently provides ad hoc reports.

Development and Deployment

The decision to build Inspector was made in December 1988, and development began in mid-January 1989. A preliminary system was designed and built in about six months. This development period might have been shorter, but the team was new to VMS, Nexpert, and Oracle. The subsequent four months were devoted to connecting Inspector to the mainframe, running test reports, and revising the knowledge base and database (figure 5).

Inspector's development team was small, consisting of four people: a foreign exchange expert, a knowledge engineer, an expert system programmer, and a database programmer. (Both programmers also knew C.) The expert system programmer worked on the project full time, but the time commitment of the others ranged from one-quarter to one-half time. In all, the project required approximately two person-years.

The system was officially deployed in late September 1989, although the alert reports were being used earlier by a small group of managers. At this time, a second DEC 3100 workstation was purchased to separate the deployment and development environments. As with most systems of this kind, modifications and improvements are ongoing, particularly with respect to the rules guiding the investigation and search process.

In New York, deployment practically occurred overnight because those using the system were located in New York and actively participated in the design and development. For the overseas managers, another three months were required to inform, educate, and prepare them for the additional information and responsibility.

As mentioned earlier, a graphic user interface was developed under DECwindows to allow senior New York managers to work interactively with the expert system and the relational database. Whether they are following up on a suspicious set of deals or simply trying to better understand the complex business they manage, they need an easy, friendly and fast way to get their questions answered. We could say that the graphic user interface is the "icing on the cake," but at the moment, there seems to be no end to the potential applications unearthed by this novel, multitechnology system.

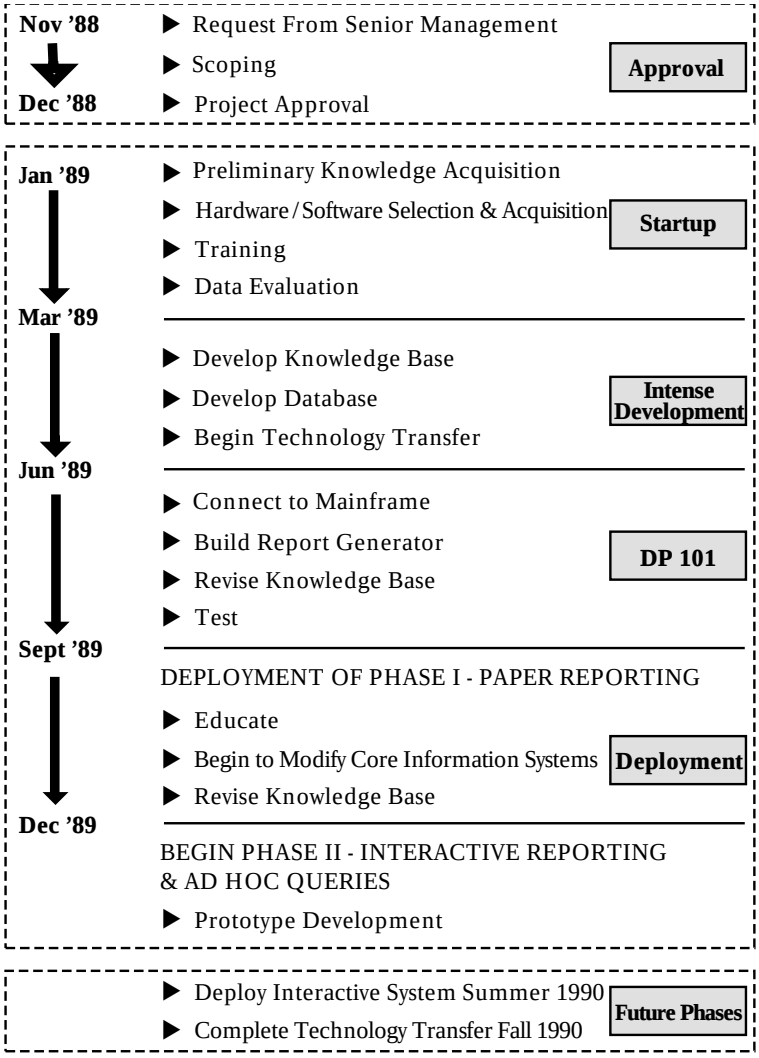

Figure 5. Development and Deployment Milestones.

Conclusion

Although Inspector is among the first systems of its kind in the financial industry, it will not be the last. For MHT, Inspector has added a new level of control and information that was not previously available. By being innovative and applying new technologies, the bank has added a strategic weapon against fraud.