Making Sense of the Business Environment with the Help of Intelligent Agents

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Abstract

The business environment needs to be watched constantly. More importantly, meanings of the trends and events recognized need to be understood in specific business context and their impacts on business operation be awared. The quality of environmental scanning in terms of objective-related and evaluated data is usually a more problematic issue than the quantity of information. In this paper we explore the use of intelligent software agents in monitoring and interpreting the accumulated environmental data. We examine the notion of interpretation and its process. We discuss the agent's role in data interpretation, analyze tasks for the interpreting agent and present the agent design.

Keywords: Environmental scanning and interpretation, intelligent agents

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1. Introduction

Strategic management gives real time response to environmental events, seeks the best match of opportunities and resources, and defines products and markets. The view that sees the external environment of an organization as one of the major determinants of its strategy is widely accepted. However, the tools to monitor and grasp this important determinant are less developed than demanded. Traditionally the managerial understanding of a business environment has often characterized by *intuitive and fragmented activities.* As the environment increases in scope, dynamics and complexity, the information to be digested explodes. The task of grasping environmental changes becomes increasingly demanding and threatens to exceed human capacity to bear cope with it. Often the data collected may contain rich information of strategic value while at the same time they may present incomplete, inaccurate and sometimes conflicting signals that have to be subjected to analysis and interpretation to figure out their real meaning and to understand their impact on business. While the present can be observed, the impact on the company and its future actions can only be inferred. The difficulties lie in the fact that the analysis and interpretation is greatly complicated by the enormous quantity of data. There is often the risk that too little time and too few skilled people are available to make a detailed analysis of the data and to make sense out of the data, or it is often too costly to follow up the new information manually and to ensure that the data are not outdated by the time someone gets around to analyzing them (Bayer and Harter, 1991; Rangaswamy et al, 1991). With large data storage like data warehouses, the data interpretation task becomes an extremely time-consuming, labor-intensive and knowledge-intensive process. To derive answers to important questions from a data warehouse can sometimes be very demanding for end users. The task of identifying all interesting events and giving explanations as to why those events occurred will be even more enormous. There is certainly a need for automated data analysis and interpretation tools.

There have been earlier efforts in automated data analysis and sense-making systems. CoverStory is an example of an automated news-finding system using expert systems technology (Schmitz et al, 1990). It extracts data from large scanner databases and automates the creation of summary marketing memoranda which describe the key events that are reflected in the data (Schmitz et al, 1990). Similarly, the INFER system by Rangaswamy et al (1991) automates interpretation of marketing data by employing a knowledge base of simple data interpretation techniques often used by analysts, and generates summary reports atomatically. Another example is SCAN*EXPERT (Bayer and Harter, 1991), which searches through scanner databases, figures out who are the key competitors (thosing having similar products, service, market share) in the market, find events in the data which are of interest to managers and analysts, and then find possible causes for the events by using a hypothesis-driven analysis strategy to find key factors in the data associated with interesting events. These earlier studies have been limited to the analysis of well structured quantitative data items to serve marketing needs, employing state-of-the-art technologies.

Today, computers are no longer devices used exclusively to perform calculations; they are more also a medium to represent actions in which humans can participate. Software agent systems are typical of such applications. Software agents are computational programs or entities that act to accomplish delegated, specialized tasks on behalf of users (Maes, 1994; Wooldridge and Jennings, 1995). Agents participate actively in accomplishing specific missions by taking the initiative autonomously and acting with the aim of reaching certain user-specified or automatically generated goals. While computing programs traditionally depend on users to use them, agents make it possible for the programs to work independently of the users' presence and instructions, and to deliver only customized, user-wanted information and service. While conventional programs usually remain dormant until specifically called by user instructions, agents are always "alive" and ready for action and do not rely on the users' explicit action to be activated. They work in the background and perform automatic actions at the user-level of abstraction (Maes, 1994; McKie, 1995). The benefits of using software agents include improved speed, productivity, customized service, proactive support.

The software agent approach represents one of the most popularly exploited solutions in problems of automatic gathering, filtering and searching for information. However, little has been said about its application to the interpretation of the collected information. So, can managers benefit from an agent information service in interpreting large amounts of data? How can an agent help to ease the difficulties or improve the outcomes? These form the major concern of this paper. In the following sections, we will first look at the collection of business environment data and define potential strategic issues. We will then examine the interpretation process and its key elements to understand what interpretation should encompass. On the basis of the analysis we will examine the role that agents can play in making sense of the business environment, define the tasks that need to be done by the interpretation agent and present the agent design.

2. Environmental Data and Strategic Information

Environmental scanning often takes a holistic approach so as not to miss any signals. The general components of the environment usually include such key elements: *socio-cultural politico-legal, economic, technological, natural* *resources, demographic, industrial and competitive forces, local, regional and international conditions.* The significant aspects of the outside environment will vary depending upon the nature of the organization's business and the length of the time. So the identification of relevant environmental data on each of the environmental elements will also be industry- and time-specific.

Strategic information needs to be extracted from environmental data. Managers' information needs may range from being impossible to articulate to the highly specific. Often the precise set of strategic information can not be known before the information is known (Neubauer and Solomon, 1977). Nevertheless, it is possible to identify the types of environmental data managers would like to have. According to Aguilar [1967], managers' environmental information needs are grouped into five areas: market tidings, technical tidings, broad issues, acquisition leads and others. *Market tidings* refer to information about current and likely future activities in the market and competitive field. *Technical tidings* refer to product and process information new and unknown to the company. *Broad issues* are events happening outside the industrial environment, for example government actions and policies, and the general economic situation. *Acquisition Leads* refer to leads for acquisitions, mergers and joint ventures involving competitors, new entrants as well as information concerning possibilities for the manager's own company.

It is also possible to identify a list of various issues of concern to top management and then try to recognize possible ternds and events related to each of them. As is widely known, top management is interested in long-term issues that may have a high impact on their business missions and operations. Issues can be revealed from data and each issue is related to a set of data items by business relationships. In Table 1, a starting list of environmental data and potential strategic issues is given. As the organizational context (for example, its experience related to the issue domain, its size, perceived capability or resources) always plays a crucial role in sense-making, internal issues are also listed, together with specifically defined business objectives and performance indicators.

Table 1. A List of Environmental Data and Strategic Issues

(Source: Aguilar, 1967; Ansoff, 1984; Anthony, 1965)

Environmental Data	Major Groups of Potential Issues
1. Macroenvironment in countries Significant to own business **Social-cultural:** major social vlaues and	**1. Environmental Issues** **Broad Issues:** Trends in global market place (protectionism vs free trade);

norms that will affect business operation. **Political:** political climate that may affect business. **Regulatory and Legislative:** regulations and laws in employment, production safety, pollution control, safety and health, advertising, contracts; government actions, policies, government decisions affecting the industry; trade and monetary regulations and legislations. **Economic:** the general state of economic conditions at the national, regional and local level, for instance interest rates, GNP, unemployment rates, inflation, consumer index, commodity prices, exchange rate. **Demographic:** statistical information about population, data such as mean age, income, family size. **Natural resources:** accessibility to natural resources, regulations on their use. **2. Industrial and competitive environment** **The Industry:** news and policies, structural changes such as mergers, acquisitions and joint ventures involving big players and competitors, as well as information concerning the possibility of own company; new entrants into the industry. **Product and Market:** product life cycle, market capacity. **Technology:** fundamental technology breakthrough or evolving development in production technology, process technology, service technology; technology used by competitors; technological developments of substitutes; problems involving existing products, or	growth of government as a customer; business with socialist countries; economic and political trends in developing countries; competitions from developing countries; monetary trends; inflationary trends; emergency of multinational firms; emergence of new industries; government controls; union pressures; impact of society's concern with ecology; intra-European nationalism; conflict between multinational firms and national interest; changing work attitudes; pressures for employment maintenance; new government policies and changes in regulations and legislations; growth of the service sector. **Industry and Competition Issues:** Mergers, acquisitions involving big players and main competitors, as well as the possibility concerning own company; Actions of competitors and new entrants; trends in price, demand, supply and capacity development; Saturation of growth; Changes in market shares; Shrinking product life cycles; Emergence and development of new products, services, substitutes; changes in modes of generating products and services. **Technology Issues:** technology as competitive tool; technological breakthroughs; trends in process and service technology, solving the problems with existing and new products; technological developments of substitutes; Development of technologies in related fileds. **Customer Issues:** customer value and demand changes for existing products and services; political stimults in consumer nations; affluent consumers; changes in age distribution of customers; selling to reluctant consumers **Competitor Issues:** competition from developing countries; changes in major

new product development; technologies in related fileds shoule be reviewed to determine the applicability to own operations. **Labour market:** local and national labour market data such as unemployment rate, wage rates, skill distribution, educational level, labour market growth. **Customer:** customer value and demand; structural changes about current or near-potential customers, their markets, their problems, mergers and acquisitions involving them, political stimults in consumer nations. **Competitor:** direct and indirect competitors, their products, production, market share, stock performance, strategies, technology innovation, structural changes of current and potential competitors. **New entrants:** look at their products, services and strategies relative to our own; **Suppliers:** our realtionship with current suppliers and competing suppliers; key physical resources: (raw materials): the price, availability. **Distributors:** distributors and alternative distribution channels. Transportation network: truck and airlines.	competitor's strategy, Stock performance, market share; structural changes; technology innovation; service improvement. **Supply Issues:** price and availability of key physical resources; bottlenecks in procuring key physical resources such as raw materials, equipment, energy; relationships with key suppliers and competitive suppliers; purchasing considerations for current and potential products. **Labour Market Issues:** trends in labour market grwoth, unemployment rate, skill distribution, educational level, wagw rates **Distribution Issues:** bottlenecks in product distribution; price and availability of distribution channels; relationships with key distributors and competitive distributors. **2. Internal Issues** size, complexity, structure, communications, power structure, role definition, centralization/decentralization, values and norms, management style, management competence, logistic competence, capital intensity, technology intensity, production diversification, market diversification, technology diversification.
Performance Trends, Issues	
Business Objectives	

In our previous work we developed a software agent that continuously collects environmental data from multiple data sources and then organizes the data into a data warehouse structure (Liu, 1998; Olofsson, 1998). In the data warehouse, the data model is a collection of documents or articles, with fields such as document ID, source, search words, buffer, summary or comments.

Data are organized around the major subjects of the business environment: *SocioCultural, Political, Legislation, Economy, Demographics, NaturalResources, TheIndustry, ProductMarket, Technology, LabourMarket, Customer, Competitor, NewEntrants, Substitute, Supplier, Distributor,* and into different sets (layers): *current detail environmental data, lightly summarized environmental data and highly summarized environmental data.* Data at different levels of detail are linked together through summarizing rules, as is shown in Figure 1.

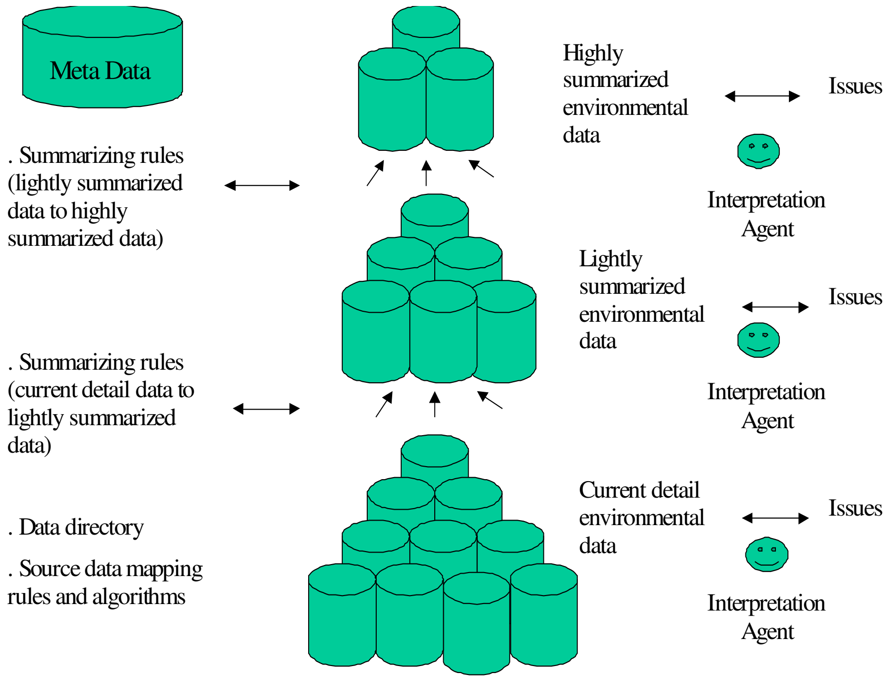


Figure 1. Data structure in the environmental data warehouse

The current detail data reflect the most recent happenings to the most detailed extent, for example daily industry news by region, monthly unemployment rate by region, technology development by market segment, monthly macroeconomic data by country, daily commodity price by grade, daily exchange rates, etc. Summarized data are the result of the aggregation of lower level data along both the attribute dimensions and time dimension. They are the attributes or combination of attributes that are more often queried, for example, at the lightly summarized level: weekly industry news by world region, quarterly unemployment rate by country, technology development by product group and region, weekly commodity price, weekly exchange rates; and at the highly summarized level: monthly industry news by world region, monthly unemployment rate by region, technology development as a whole, monthly commodity price, monthly exchange rates, etc. Summarized data are kept over a longer time span so trends can be established.

Issues can be drawn and detected from data at different levels, based on specified business relationships between issues, frames of reference for perceiving the issues, indicating signals, and the data. The business relationships are represented as cognitive maps, frames of reference as customizable templates, held by the interpretation agent. Issues can be better understood and discussed with the support of data at different levels. Search words are generated in association with the nodes of cognitive maps and the attributes of frames of reference so that supporting documents can be extracted when needed.

Meta data contain no data directly taken from the source environment. Rather, they tell us about the data warehouse as well as the data in the warehouse, and they follow up with changes that were made to the warehouse and the data [Gray, 1997; Inmon, 1992]. They maintain a data directory for the data warehouse, rules and algorithms used for mapping source data to the warehouse and for summarizing current detail data and lightly summarized data. The data directory defines the data in clear non-technical terms, describes business rules associated with the data, warns of out-of-date or incomplete data and gives signals for starting the aging process.

3. Interpreting the Business Environment

3.1 Understand the Interpretation Process

Scanning and interpretation are intertwined processes. While scanning concerns mainly seeing and perceiving the environment, interpretation concerns meaning construction, impact analysis, and conceptual scheme assembling. The aim of scanning is to capture what is going on in the environment and to recognize only those events that are relevant to our own business, as well as to classify the chaos of data into structures. Interpretation aims to understand the identified events, to bring meaning out of observations, to discover plausible relationships and structures (e.g. cause-impact maps), and to develop frames of reference or models for understanding (Daft and Weick, 1984). Scanning is collecting data. Interpretation is translating the data into understanding. It is a sense-making process in which people assign meanings to ongoing occurrences (Gioia and Chittipeddi, 1991). More specifically, the tasks of interpreting the business environment include:

(1) Identifying events and trends from data, recognizing them as meaningful issues, and formulating an issue-list.

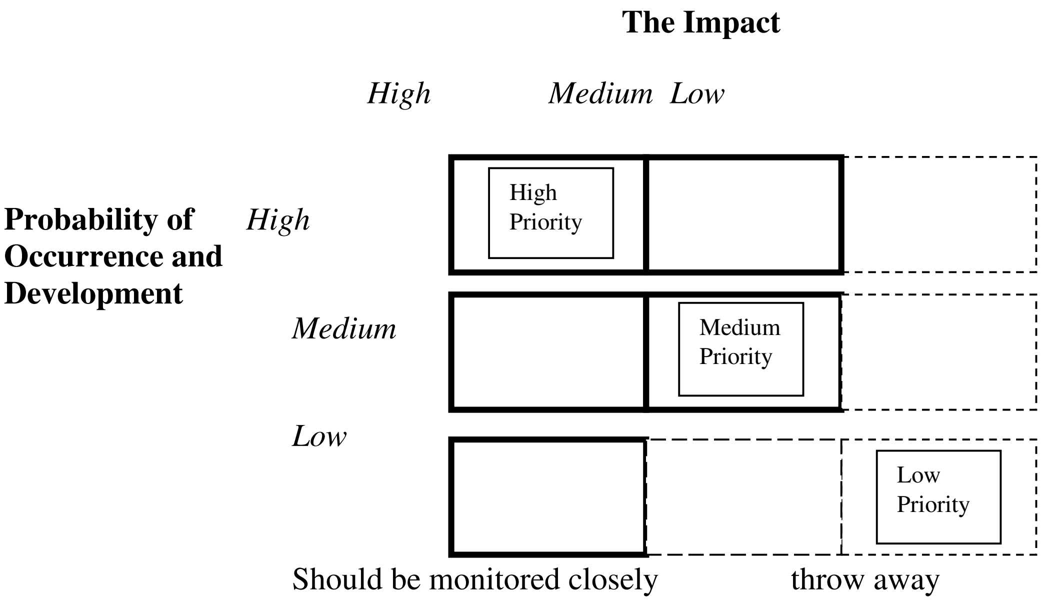
(2) Judgement is made to determine the probability of occurrence, the likely time of occurrence and the significance of each issue, to forecast their development in the long run; to investigate the causes of events and trends; to examine the interdependencies and cross-impact relationships between issues; to see if the occurrence of any events has an influence on the occurrence of others and the strength of the impact (totally determined, partially determined, have a common determinant, totally unrelated), for example, if the occurrence of event A enhances or inhibits the probability of event B occurring or has no effect, if event A is an essential prerequisite for event B to occur.

(3) Judgement is applied again to assess the impacts of major groups of issues on business (represented by selection criteria or performance indecis) and categorize issues as *crisis, threats, and opportunities.* Issues are evaluated in terms of whether they are emergent, evolving, or urgent, controllable or uncontrollable, their impacts positive or negative, bring potential gain or loss. The opportunity category implies a positive situation in which gain is likely (holding possibilities for future gain) and over which the company has a fair amount of control. Opportunities suggest chances of new markets or advantage to the company. The threat category implies a negative situation in which loss is likely (holding possibilities for future loss) and over which the company has relatively little control. Threats tend to hinder the performance of the business operation or keep the company from implementing its strategy and achieving its objectives. Threats increase the risk associated with implementing strategy, increase the resources required to implement a set of strategies, or suggest that one or more strategies may no longer be appropriate. A crisis needs urgent handling. It has an immediate and important impact on business operations. Issues that have zero impacts tend to stablize the company's current strategy and operations and are regarded as unimportant (Neubauer and Solomon, 1977; Dutton and Jackson, 1987; Jackson and Dutton, 1988; Schneider and Meyer, 1991).

(4) Rank and prioritize the issues and formulate a strategic issue agenda. Issues are examined again in terms of the extent of their impacts on business (high, medium, low), and the probability of their occurrence and development (high, medium, low), as is shown in Figure 2. Issues that have a high impact and high probability of occurrence have the highest priorities for managerial attention. Issues that have a low impact on business and low probabilities of occurrence have the lowest priority. Issues that have a high impact on business should be monitored closely; issues that have low impact will be discarded.

(5) Propose action/reaction strategies. Issues that are urgent by nature and have a high impact need to be acted on immediately. Issues that have a high impact but are emergent by nature will be acted on later. Unimportant issues will call for no action.

Three strategies are usually employed in analyzing and interpreting data: (1) Data-driven strategy. The interpreter performs a broad-based search, actively looks for interesting and important events as well as patterns in the environment data. (2) Goal-driven strategy. The interpreter develops hypothetic issues, seeks data support for the hypotheses, or, if a specific issue is known exist, tries to find causes and reasons for the trends and events. (3) Mixed strategy: an integrated use of both data driven and goal driven strategies (Bayer and Harter, 1991).



Fingure 2. Prioritizing The Issues

3.2 Mental Models and Cognitive Maps in Sensemaking

Managers couple analysis and intuition in management (Mintzberg, 1989 - Mintzberg on management). Their thinking process is highly inferential and intuitive by nature. Managerial cognitive activities are characterised by cognitive simplification and selective perception guided by knowledge, experience and judgement.

A mental model is the representation of a cognitive structure, of belief and knowledge in the head, at the conceptual level. It is a mental map that describes an interconnected set of understandings and assumptions about the business elements and their relationships, as well as implicit views of what one's interests and concerns are, what is important, what demands action and what does not. Managers develop simplified mental models of reality using only a small part of the information available (approximate rationality), combined with prior knowledge, experience and premises (Isenberg, 1985; Durand et al, 1996). Mental models tend to be static during a certain period of time. However, changes in time and in business context may call for changes in the models.

Mental models relate to the way in which a person makes sense of and explains the world around him. In his interpretation process, mental models are employed to synthesize data, make sense out of data and perform well-learned behaviour patterns (Isenberg, 1985). They are the underlying assumptions that actually link environment to strategy, data items to issues. Mental models help in the understanding of the external environment, as new information is understood in the framework of existing mental beliefs and models. The key factors and links of the mental model affect the types of information used to evaluate the impacts or to interpret the information, which is also one of the reasons why interpretation may produce distorted reproduction of information. A new understanding of the environment may in turn trigger a change in existing mental models. How issues are interpreted and the quality of the interpretation always depend on the interpreter's knowledge, experience, mental models and creative thinking.

Cognitive maps are the explicit description and computing implementation of mental models. Cognitive maps consist of nodes generically called "concepts" about different aspects of the environment and the cause-and-effect relationship between these concepts (Eden, 1990; Durand et al, 1996). Cognitive maps provide a method for structuring multiple and conflicting aspects of argumentation, a designed scheme for addressing both the content of issues and the need for a recognition that people change organizations, a tool for capturing the views, knowledge and expertise surrounding issues, and for helping managers to focus on the important aspects of issues. It would be an appropriate intermediate between mental models and interpreting rules.

4. Interpretation Agent

4.1 Agent's Role in Data Interpretation

The concept of an agent has been used widely in computer science literature, though not always as an entity directly at the user's service. The role model of software agents is the human mind and human behaviour. In this sense, software agents are regarded as substitutes for human agents. Agents have many properties attractive to us: *purpose or goal-directed; take initiative autonomously; decide own course of action dynamically while responding to their environment; self-learn and learn from the user, and so on.* The very first idea of the agent approach suggests the delegation of tasks and responsibility. Such an approach allows users to move away from computing details while focusing on more conceptual constructs. It reduces complexity and increases efficiency. The delegation of functions supports user mobility [Etzioni and Weld, 1995, 1996; Maes, 1994].

Information access and management is an area of great activity for software agents. *Software information agents* can be used to locate information sources, to combine intelligently disparate streams of information from multiple distributed resources, to respond to a specific request from users with relevant, synthesized results. They are very useful for answering queries that require logical or heuristic deductions or induction, or that require numerical computation using algorithmic models, for discovering hidden patterns and relationships from large data set, for uncovering findings that could be missed by human experts. Such tasks would be very difficult or simply impossible for a human to carry out alone. Software agents, on the other hand, can remain active all the time in the computational environment, periodically visit the information sources, monitor information, look for trends, identify new information, fuse the information with other relevant data, extract implied information and distribute results to the user. Such a service increases the user's current awareness.

Warehouse data interpretation is also a process of information access management. To keep on exploring the data warehouse and summarizing detailed data in the warehouse all the time is no small task, let alone making sense out of huge amounts of data. The process is costly and sometimes also leads to manually made mistakes in information. In some other cases it may simply be too late when people get time to analyze the data. A software agent that can automatically attend to data, relate and interpret data would be an ideal alternative. However, there have always been risks associated with using computers for sensemaking and there have always been doubts about and critics of it. The main argument is that computers can follow instructions but they can not understand meanings (Wilson, 1970; Winograd and Flores, 1986). Man has emotions, needs, desires, values, judgement, intuition, a capacity for speculation, imagination and creativity - all play a certain role in sensemaking and understanding. Computers have none of these. Computers depend on man for creative thinking and performing.

On the other hand, man lacks computational effectiveness as a data-processing machine, although he does have irreplaceable roles to play. Computer systems, then, are abound with computational efficiency and effectiveness, which is actually the primary driving force for the development of all kinds of support tools. What distinguishes software agent systems from just any computer systems is that agent systems tend to acquire more autonomy from users in accomplishing the tasks, in an effort to reduce the user's workload, and so improve productivity. For example, managers often spend much time recognizing and resolving ambiguity presented by data. An agent can help a lot in identifing the conflicts and then bring it to managerial awareness. Managers can then focus on resolving the confusion and reach a correct understanding, rather than having to pay attention to identifying the conflicts in the first place. When able to communicate with other agents, a software agent may help in resolving any confusion in data, too. In agent systems, users have less responsibility than in interactive support systems because agent systems do not need the user's explicit instructions for doing their jobs. But this does not mean that agent systems do not care about the user's role in accomplishing the tasks. In fact, agent systems leave the choice for less or more interference in the process to users. Users have control over their agents. Users exert control and influence the agent's operating process by defining their personalized profiles or by the implicit learning capability of the agents. Developments in computing methods and technology have made it possible for computer systems to incorporate the managerial perspective into the system’s process, so it is possible for an agent system to incorporate a manager's needs, knowledge, creativity, perspectives into the interpretation process. The interpretation will then not just mirror what is said in the data but also include reality-invention or reality-construction (Durand et al, 1996). While aspects of issues perceived by managers often differ between managers, a personalized agent would be able to represent the special perspective of its owner. An agent-based interpretation system may also help managers to be creative by imposing new information on them and saving time for them to exercise their own unique abilities. Agents can be so designed that they would not follow the mistakes of users.

4.2. Tasks for the Interpretation Agent

The interpretation agent aims to make sense out of collected environmental data to serve information needs for strategic management. Its duties include:

(1) Periodically visiting the data warehouse, watching for new information, tracking key issue indicators and alerting users to important developments.

(2) Comparing and relating new information, recognizing and selecting significant events, trends, and peculiar signals.

(3) Reasoning and explaining about the possible causes for the events and trends based on cognitive maps that affect the subject of the event, forming hypothesized issues, examining interdependencies between issues.

(4) Identifying the major groups of issues and assessing their impacts, predicting the probability of occurrence, the development course and milestones.

(5) Ranking the issues according to the perceived impacts and probability of occurrence and development, selecting and forming a key strategic issue list. Those with a high probability of development and high impacts should be brought to managerial attention and be monitored closely. Those with low impacts can be ignored no matter whether there is a high probability of development or not.

(6) Generate a summary report of the interpretation result (Table 2); send notice to managers.

Table 2. Interpretation Report

<table>
<tr><td colspan="4">Date:

Reporter:

Context: (Company Profile, Business Objective, Performance Indicators, Internal Issues)</td></tr>
<tr><td rowspan="2">Key Strategic Issues

Supporting info:
. Probability of Gain/Loss
. Magnitude of Gain/Loss
. Probability of Occurrence
. Development Milestone
. Indicating signals
. Actions</td><th>Opportunities</th><th>Threats</th><th>Crisis</th></tr>
<tr><td>Positive issues in ranked order</td><td>Negative issues in ranked order</td><td>Urgent issues in ranked order</td></tr>
</table>

Signal Alerts (by subjects)	Socult	Politi	Legal	Econ	Demo	Natres	Indus	Tech	Custom	Com...
	List of signal alerts									

All Identified Issues (by subjects)	Broad	Indus	Tech	Custom	Compet	Supply	Distrib	Labor
	List of all the (new) issues identified by the agent							

4.3 Agent Architecture and Implementation Considerations

A software agent can be understood as having a brain, sensors and effectors, resembling human beings. These components can be implemented in a framework where *engines* (reasoning mechanism) and *library* function as the brain, *adapters* function as sensors and effectors [ABE Level 5 documentation, IBM, 1996]. Adopting this framework, architecture for the interpretation agent is shown in Figure 3. The user interface provides agent control as well as user-profile building mechanisms. *Agent control* offers a user the power to manipulate the agent, e.g. starting, stopping and monitoring agent activities. Agent operation can be both user-invoked and event-triggered. When the user is not present, a prespecified trigger activates an agent operation at specific timea or when changes occur in the data warehouse. *User profile* offers a user the possibility to customize the agent to his own changing preference, perspectives, and mental models. The user sets up the context of interpretation for the agent. He also supplies his mental models concerning issues and frames of reference for perceiving the issues as cognitive maps. The agent should have template mechanisms to enable the user to easily acquire and update cognitive maps, or even be capable of dynamically adapting to changes in the data environment. The interface also presents the interpretation report to the user.

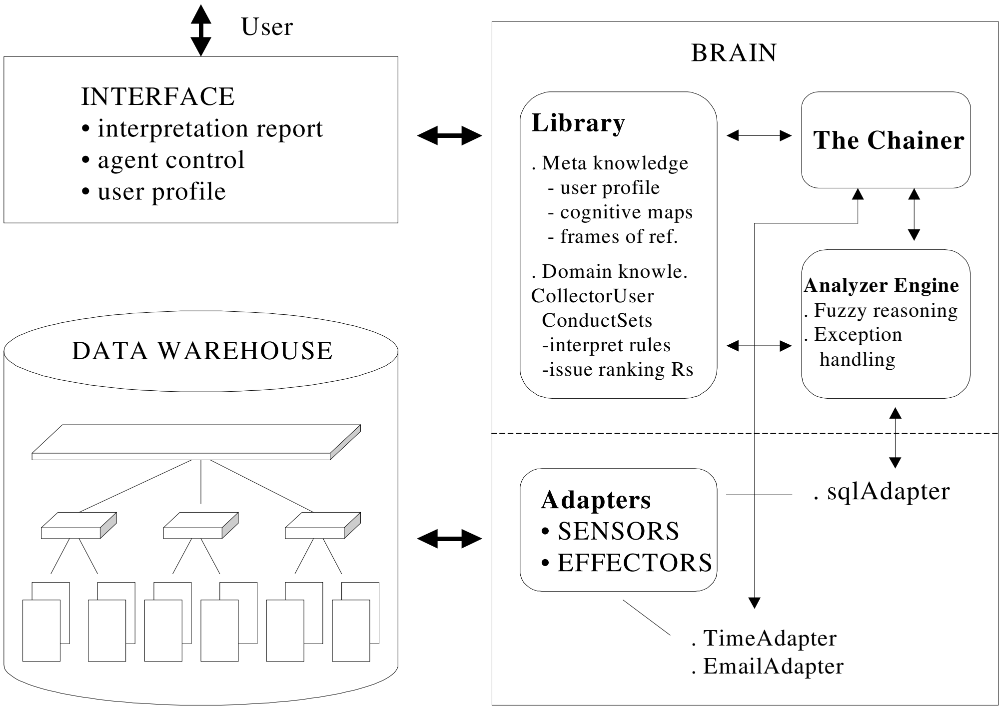


Figure 3. The Interpretation Agent Architecture

Adapters are intended to relate various real world applications to the agent. Each adapter deals with a particular application domain (e.g. adapters for mail applications, adapters for Internet and web applications, adapters for database applications), device type or protocol and performs three functions: *notifying events, sensing conditions and effecting actions.* An adapter watches for significant events in its domain and notifies the rest of the agent system when they occur. Should the engine need more information from any adapter in the course of its inference, it can request it through sensor calls. As a consequence of inference an engine might decide to take action in the application world. It then generates a request to the adapter through effector calls. Effector calls act on and change the agent environment and any change as a result of an effector call will be returned to the agent system as a new event. Adapters and engines relate to each other through events and attached procedures. Adapters are implemented as Java classes. For the interpretation agent to fulfill its responsibilities, in addition to standard adapters such as TimeAdapter, EmailAdapter, application-specific adapters need to be added, in this case a sqlAdapter. The sqlAdapter is responsible for opening a connection and querying the data warehouse, in order to track the issue indicators and support issue discussions. It also creates and maintains a database for client-side application.

The *library* manages the persistent storage and retrieval of objects that are needed for engine inferencing and are grouped as conduct sets. A conduct set is a set of rules and long-term facts used for inferencing on behalf of a particular client. The library contains domain knowledge: interpreting rules supporting data and issue analysis, hypotheses about causes of potential events. It also contains data about conduct sets – meta knowledge: user preferences, cognitive maps and frames of references surrounding issues and environmental subjects - in terms of predicates, sensors and effectors that are used in the rule set and the long-term fact set. At an even higher level, the library stores assumptions underlying cognitive maps and frames of reference. The decision as to what cognitive maps and interpreting rules the agent should use is based on values specified in rule atoms and can be modified through modifying profiles.

The Chainer engine is a standard construct. The analyzer engine needs to have reasoning mechanisms implementing multiple reasoning strategies: data-driven, goal-driven or mixed fuzzy reasoning. In addition, exception handling needs to be considered. Generalized rules will be defeated when information is available to indicate that the agent is dealing with an exception to the rule. Users may reject part of the interpretation result given by the system. In such cases, user feedback should be incorporated into the system to revise the result. The user can also contribute to exception handling and benefit from handling exceptions by constantly rethinking and updating his mental models.

At the client-side of the system (example: Figure 4), the user can easily get access to a summary report or strategic issue list (linking to supporting documents by clicking on active words in the list), signal alerts linked to specific issues, as well as all the new issues identified by the interpretation process. Using a multidimensional data model, the agent will be able to present the interpretation report in different styles (for example, key strategic issues by milestones, by impacts, by actions, by indicator signals, etc.) and put the information into multiple perspectives.

With AddComments, the user can add comments to issues and signal alerts which form his own perspectives. UserProfile helps the user to set up personal preferences and those issues that are of the most concern, and to create and update mental models as well as frames of reference. By attending to the captured signals and analyzed result, the user can modify cognitive maps guiding new interpretations. With AgentConfiguration, the user can define the interpretation context by describing company profiles, internal issues, business objectives and performance indicators.

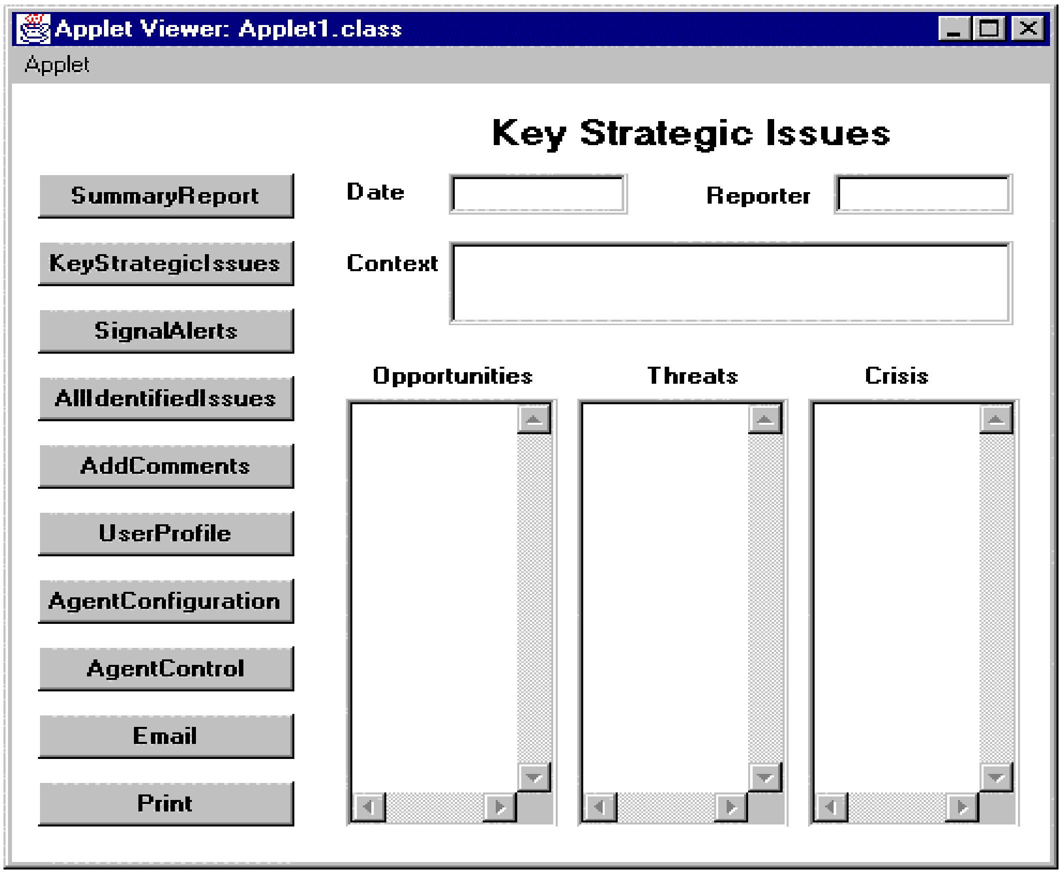


Figure 4. Agent Client

5. Discussion and Conclusions

Environmental scanning aims to supply managers with the right information from the right sources in the right form and at the right time. The technological tools to do the work are less developed than they are in demand. In this paper we explore the use of intelligent software agents to help managers to interpret the business environment. We examined the notion of interpretation and its process. We discussed the agent's role in data interpretation, analyzed tasks for the interpreting agent and presented the agent design.

Managers who need certain environmental information tend to establish channels that will automatically keep them informed (Mintzberg, 1975). The agent-based scanning and interpretation system actually provides a comprehensive information channel that continuously keeps managers informed of environmental events and their meanings for the business. It is a comprehensive channel as it does not exclude managers' familiar information channels. Rather, it can can accommodate different kinds of information channels, old and new, and has the ability to integrate and synthesize them. Merging brings synergy and even creativity.

The principal of DSS development has had two main foci: effort saving and decision quality enhancement. In the context of environmental scanning and interpretation, the emphasis will be on effort saving and information service quality improvement. While there are always trade-offs to make in designing, it seems that managers often tend to make little use of comprehensive tools that require much time to learn and much cognitive effort. They would like to ask the system to give them materials that are ready to use, data that are already analyzed. At the same time, they may also ask for instruments that they can use to question or confirm the presented information (Schmitz et al, 1990). They not only want to delegate work to the computer system, but are also interested in computers that bring new ideas and new structures to them. When managers deal with the issues on their strategic agenda, they perform a real-time learning activity: altering old mental models and coming up with new ways of doing things in the light of new knowledge and new understanding about the business environment.

An environmental scanning and early warning system always needs to be wide in coverage. Only with support technology like agents can organizations of today make 360° radar possible. With less effort, an interpreting agent can provide managers with an up-to-date summary report of data analysis, which would previously require time-consuming work by skilled analyst and managers.

A critical component to make the agent system a good information channel is its ability to learn from its own running process and to learn about the user. The next step in our work will need to test the use of adaptive user modelling approaches in the scanning and interpretation system.

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