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Agent Based Environmental Scanning System: Impacts on Managers and Their Strategic Scanning Activities

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Abstract

In this paper we propose a framework for analyzing the impacts of scanning support technologies. The framework is applied to examine the impacts of an agent-based environmental scanning system on managers, as users, and on their scanning process and outcomes. We develop speculations on the system's impacts and contrast them with empirical results.[1]

Introduction

Software agents are computational programs or entities situating in a computing environment and assisting users with computer based tasks. They act to accomplish specialized tasks on behalf of users and act towards reaching certain user-specified or automatically generated goals with certain degree of autonomy and flexibility (Maes, 1994; Wooldridge and Jennings, 1995; Jennings and Wooldridge, 1998). Computing programs traditionally depend on users to use them. Software agents make it possible for the programs to work independent of users' presence and instructions, and to deliver only customized, user-wanted information and service. They work in the background and perform automatic actions at the user-level of abstraction (Maes, 1994; McKie, 1995).

Agents have great potentiality in a broad range of applications and people do seem to like to use the agent concept and technology in more and more contexts. The vitalization of the agent-field is to a large extent attributed to the development of computational power. In one aspect, applications thought to be impossible to automate in the past are rapidly becoming a possibility; in another aspect, the widespread computer systems of today create new, extra tasks for people. Computers can do more to help people to exploit most from computerized systems, and they are also expected to do so because people need help to deal with the ever-increasing information overload and work overload.

Agent technology and applications are still in the early stage of development. Much of their effects and impacts remain to be explained. To address these concerns, in this paper we attempt to analyze the impacts of an agent-based environmental scanning system which we have developed to help managers in their strategic scanning activities. Leavitt's task-people-structure-technology framework (Leavitt, 1965) is used as the theoretical warranty. We shall first look at the properties of scanning process and outcome, and the performance indicators of scanning support technologies. This provides a framework for analyzing the impacts of agent-based scanning systems. Applying the framework, we then discuss the perceived effects of agent based scanning systems and contrast them with some primitive empirical results.

According to Leavitt, *task* (or work practice), *people* and *structure* constitute the organizational context in which applications of *technology* happens. The main argument is that technology and task, people, and structure are highly interdependent; changes in any of them are usually accompanied by changes in one or more of the others. For example, task (or work practice) must continually change to meet the challenges of the outside world. It determines the requirements for people and technology support while people and support technology must adapt to new work practice. The adoption of a technology tool may change work practices, affect people and transform the way people conduct work practices, because in designing tools ways of being are also designed (Leavitt, 1965; Alter, 1980). As current technology becomes more powerful, it encourages the development of even more powerful technologies.

Environmental scanning is the mechanism for organizations to secure the business intelligence needed in strategic management and to be constantly alert to threats and opportunities arising from environmental forces. Changes in the business world call for developments in the work practice of environmental scanning, which in turn calls for advances in scanning technologies, enabled by, e.g. information technology. In our research we have chosen to build a software agent-based scanning support system (Liu, 1998a, 1998b, 1998c; Olofsson, 1998).

Environmental Scannng: the Process and Outcome

The environmental scanning process is often evaluated by its efficiency, effectiveness and economics, characterized by a variety of features and attributes (Table 1).

The direct outcome of the scanning process is information. Information quality is one of the indicators for the effectiveness of the scanning activity. Information quality is always a multidimensional concept. It is often

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measured in terms of a set of characteristics (Table 2, Alter, 1980; Singh et al, 1994; Wang et al, 1995; Watson et al, 1995).

Table 1 Features and Attributes of a Scanning Process
(Source: Aguilar, 1967)

Features	. intuitive vs formalized, fragmented vs systematic, occasional vs continuous, rigid vs flexible (adapt to changing information needs) . personalizable . customizable
Rule of Efficiency	. instant feedback . time spent . good source accessibility . types and levels of scanning skills available in the organization
Rule of Effectiveness	. scope and magnitude . interests and values of the people who do the scanning . learning effects . results (good or poor): information quality
Rule of Economics	. cost: access to commercial information service, man-power expense (cost must be weighted against benefits)

Table 2 Information Quality Attributes

- *Value and Relevance:* related to the capacity of information for reducing uncertainty and resolving ambigurity.
- *Accuracy:* the degree to which the information portray what it is supposed to portray.
- *Reliability:* trustworth of the information, related with the credibility of its source.
- *Age (currentness), Timeliness* and *Time Span:* recent information is often more trusted and valued than older information. On the other hand it is possible for old information to be timely and new information not to be timely. What is important is that accurate information is available at the moment it is needed.
- *Completeness* or *Sufficiency:* related with scope of coverage and level of detail or level of summarization. The scope and coverage of subject matter is important to data quality. A lack of understanding of the mental models of executives translates into inadequate information coverage.
- *Consistency:* conformity among information
- *Integrity:* consistency of the same information; single truth of the same fact.
- *Format:* media and layout, variety in presentation
- *Understandability:* information presented and known in context.
- *Precision:* the fitness of detail of the portray.

The quality of the acquired information depends on the design and production process involved in generating the information. For example, the value, relevance, accuracy, reliability and consistency of information depends very much on the accessibility to good sources, availability of scanning skills, interests and values of the people who do the scanning. The completeness or sufficiency, age (currentness), timeliness and time span of information are determined by the scope and magnitue of scanning, time spent on scanning, scanning speed, which have dependence on whether the process is intuitive or formalized, fragmented or systematic, occasional or continuous, rigid or flexible. The consistency and integrity of information depend on careful cross-checking. The quality of information is also, of course, generally related to the cost of the scanning process. But high cost does not naturally guarantee good information quality.

Scanning Support Technologies: Performance Indicators

Decision/information support tools are often described in terms of a number of attributes (cf. Alter, 1980). For strategic scanning support systems, the charactersitics of most concern to us include the following:

- structures imposed on the scanning process and the tasks
- efficiency: the ratio of time and effort expenditure with the scanning result from the system
- effectiveness: the extent to which the system accomplishes the right goals
- instant feedback and follow up capability
- degree of ease of use and likelihood of operation errors (related with demanded cognitive effort and learning effort from users)
- reponse speed
- controllability: user's ability to immediately influence or change what a system does
- adaptability: user's ability to modify a system over time as business conditions or other requirements change
- cost of ownership (cost of implementing, operating and maintaining the system)

A scanning support system as the technology means supporting scanning activities impose certain structures on the scanning process and task. It may automate the task and replace people to accomplish the work. It may simply formalize the task by establishing and enforcing methods and procedures that maintain uniformity and efficiency. Or it may only try to facilitate the task by providing tools and information which can be used to perform the task more easily. In taking different approaches, the work practice gets structured and influenced to a varying extent. A system that automates most or all of the task exerts the greatest control over the process and the substance of work. As such, the system will bring effects on the efficiency and effectiveness of managerial scanning and to speed up instant feedback and follow up process. The cost of ownership for the system is directly related to the cost of scanning.

Managers' cognitive efforts and mental models are indispensable inputs to the scanning process. How data are collected and interpreted, as well as the quality of interpretation and understandings always have a dependence on manager's interest, value, scanning skills and mental models as well as the time and effort managers would like to commit to. Cognitive efforts refer to cognitive resource-expenditures, e.g. information processing effort, planning effort to determine what information to seek and watch, communicating effort,

learning effort, etc. The cognitive effort expenditure in accomplishing tasks is dependent on the approach used. For example, heuristics can save considerable effort compared to a normative approach (Johnson and Payne, 1985; Payne et al, 1988; Thorngate, 1980).

The use of support tools will also have a direct influence on managerial cognition. On the bright side, it may save user-effort in doing scanning and help users to build and maintain mental models through its effect on the scanning process. On the dark side, it may also present negative effects as support technology can bring potential threats and burdens to users (Ackoff, 1967; Alter, 1980; Norman, 1994).

First, although support systems are purported to improve decision/information quality and save decision/scanning effort, they can not guarantee that decisions/scanning be made/carried out at a lower level of cognitive cost than they would have without the system. In fact, when assisted with a support system, users' cognitive effort expenditure often get expanded because it consists of not only the effort to process information generated by the system but also effort to learn about the system and to use the system. Sometimes, the effort associated with using the tool might overburden the user and inhibit their additional information processing (Todd and Benbasat, 1992), such as in the case where a system is designed only to provide the user with a basket of tools and the user is left to decide if and how system capabilities should be employed.

Second, some negative impact of support tools on human cognition may come from underlying psychological effects. That is, support tools may make people diminish themselves and start to think of themselves as being like the computer (Lanier, 1996). People (will) start to limit themselves to the categories and procedures represented in the computer, thus losing their vision and creativity. It takes time for people to get used to working with the computer.

Third, automation offered by support systems tends to reduce peoples' skills because they become disengaged mentally when work is done automatically. *Fourth*, when a user is immersed in an information-rich or knowledge-rich environment, he may be oevrloaded with information and hence get a heavy cognitive load too. *Fifth*, where the system automates the task or its process is too complex and difficult to understand and control by the user, he may feel a sense of loss of control.

While effort saving and decision quality enhancement have been two main principals of DSS development, in the context of environmental scanning, the focal point will be on effort saving and information service quality improvement. While the traditional DSS literature has emphasized the importance of decision quality (Keen and Scott Morton, 1978), literature in behavioral decision theory has indicated that cognitive effort may be a more important overall consideration in many problem contexts. In many cases, managers tend to put high priority on effort saving (Todd ans Benbasat, 1992). So while there are always trade-offs to make in designing support systems, it seems that managers often tend to make little use of comprehensive tools that require much time to learn and much cognitive effort to work with.

Agent Based Strategic Scanning Support Systems: Perceived Impacts

Based on the above discussion of scanning process and scanning support technologies, some perceived impacts of agent-based scanning systems are presented in Table 3.

An agent based environmental scanning system tends to automate the scanning activities and ask for little real time user interference. When scanning is delegated to software agents, managerial perspectives can be incorporated into the process. So managers do not lose their personal views as a result of using software agents, as they may with human agents. An agent's scanning activities can be guided, trained and controlled according to the user's preferences perhaps easier than that of human agents. The scanning process is more formalized and is much faster than the human process. It would not have to sacrifice flexibility of the process, in terms of sources to be consulted, changing interests and concerns, and the natural mixture of searching, analysis and signal tracking procedures. As repetitive work by the system does not require much extra cost, constant and systematic search and monitoring effort as well as information recall would be easily conducted, which ensures that managers get their knowledge about the environment refreshed as frequently as needed. Due to the computing efficiency an agent system can have (Winograd and Flores, 1986), the speed of getting access to the limited, right information gets increased, and the range of environmental elements covered in the scanning can be greatly widened while manpower is saved. The benefits of an agent system would become more significant as the number of data sources increases and as the scope of scanning expands.

An agent based scanning system reduces greatly users' effort expenditures in scanning by offering a single integrated information channel and doing scanning for users. But the data it presents to managers need to be carefully controlled so that it will not use up managers' coognitive capacity. The system forms a medium for direct and flexible communication between managers and data sources, cuts down the need for many intermediaries acting as information filters and reduces the flow of documents in the organization. Because of the inherent limitation of computer systems (Winograd and Flores,

1986), when having access to the same data sources as people do, an agent system may not guarantee the same quality on value and relevance, accuracy, reliability, consistency and understandability, especially when it is at the beginning of its operation. However, it could out-perform human in timeliness, age, time span, completeness, and format of information. As the agent fulfills its responsibilities again and again, and it learns from its own running process and learns about the human scanning process, the information quality could be improved in terms of value and relevance, accuracy, reliability, consistency and understandability.

Table 3 Agent-Based Scanning Support Systems: Features and Perceived Effects

Features of Support Technology	Perceived Effects on Environmental Scanning	
	Scanning Process and Outcome	Software Agent Based Scanning
Decision Support Systems . structure imposed on work practice . degree of ease of use (related with demanded cognitive effort and learning effort from users) . flexibility . feedback and follow up capability . information processing capability . division of labour between people and the systems . cost for system development, operation and maintenance *Software Agents* . initiative and autonomy (impose high structure on work practice) . easy to learn and use (little user training) . reduced operating and maintenance cost . personalizable and customizable (user profile) . adaptability to changing information needs . proactive support . repetitive tasks . fast feedback and easy follow up	*Scanning process* . intuitive vs formalized . fragmented vs systematic . occasional vs continuous . rigid vs flexible . feedback speed . personalizabity and customizability . types and levels of scanning skills available . interests and values of the people who do the scanning . time spent, speed . follow-up . information recall . scope and magnitude of scanning . good source accessibility . learning effects . **cost**: access to commercial information service, manpower expenses *Information Quality* . value and relevance . accuracy . reliability . age, timeliness, time span . completeness or sufficiency . consistency . format . understandability . precision	*Scanning Process with Agents* . formalized . systematic . continuous . flexible . instant feedback . easily personalizable and customizable . consistency and gradually improving scanning skills . always perform at best possible level . can incorporate changing interests and values of people . faster than human process alone . follow up much easier . information recall accurate and easy . broad coverage in scanning . does not guarantee good source accessibility, but can access to more sources . fast process and fast feedback result in more frequent learning effect, but there is the risk of incorrect learning. . reduced manpower expenses . when access to same sources as human process, it may not guarantee the same quality on value and relevance, accuracy, reliability, consistency, understandability. But it can out-perform human in timeliness, age, time span, completeness, and format of information.

Empirical Results of A Pilot Study

A pilot study to investigate the practical functioning of the system was conducted at AG, a Finnish company in the alcoholic drink industry and producing Vodka.

In recent years, the environment of the alcoholic drink industry has experienced significant changes. It is no longer a stable and predictable world, but rather a dynamic and uncertain one holding surprises and discontinuities. In the global Vodka market, there often come new production limitations and consumer regulations. In order to develop its sustainable strategic positions, the senior management of AG started building their industry foresight. They realized the need to develop insights into what new types of customer benefit they should seek to provide, what new competencies they will need to build or acquire in order to offer benefits to customers, and how they will need to reconfigure the customer interface over the next several years. They were in need of good information systems technology solutions to help them to create, to maintain (to modify and to update) a reliable, good quality foresight. More specifically, these IT/IS solutions should help them to quickly access and scan data sources and build a synthesis of the information obtained. It should support their work in such a way that they are more productive and effective when working on foresight reports (Memorandum, Industry Foresight Research Group, IAMSR, Åbo Akademi University, 1997).

ScanAgent: A Business Environment Scanner

ScanAgent is built as a solution for AG. It is used to collect environmental information, especially product information, market information, competitor and customer information, and legislation information, from selected data sources available through the Web (Memorandum, Industry Foresight Research Group, IAMSR, Åbo Akademi University, 1997; Walden et al, 2000). It does the following things:

- it periodically visits selected web sites and reads their page content or watches these sites for changes;
- according to the users' specific interests, it filters the accessed information to focused data sets that reflects market tidings, technical tidings, acquisition leads or broad issues concerning a specific business segment;
- it compares, relates and integrates information from different sources, watches out for significant events that call for special attention and sends e-mail messages to its user to inform and alert him or her about the changes, and presents the results to the user's homepage.
- it also stores interesting data in a data warehouse. It builds meta-data on retrieved data to follow up on retrieval. Data are sorted based on dates, content and profiles.

Users work with an agent client to get access (browse or search) to the scanned information. For example, a manager can choose a search profile by simply clicking the "Groups" button and selecting the interested subjects and segments. For instance, there are groups for competitor information (competitors Diageo, Allied Domecq, Absolut, etc.), for the drinking habits of actual and potential customers, for legislation in liquor consumption and distribution, and for various alcoholic products. The result of the search is displayed within the client application.

The agent client also offers report-making functions and retrieval control functions. A user can add the materials retrieved by the agent to a report, add comments, or distribute the material through email. He/she can also use "logical keys" to add classification attributes which help to control the storing and retrieval material for later use.

Test with the scanner agent showed that it retrieved data very fast and efficiently and saved time for the user. It makes faster use of data sources than human users. Repeated tests showed that the quality of retrieved material improves as the search profiles became more focused and better defined (Walden et al, 2000).

The Empirical Study

The ScanAgent system was developed during 1997-98. At the time of data collection, it has been in regular use by a market analyst for eight months, about 6 hours per week. The system has covered business data banks important to the company and the market analyst uses the system to follow up the data sources for the environment information the company needs. He has at the same time some other information sources available.

For data collection we have used a questionnaire survey. The participation was limited to the market analyst. The questionnaire survey method was used in order to facilitate comparison with future follow up studies, and also in consideration that with an interview method we will not necessarily get more information. The questionnaire includes three sections: quantitative questions, qualitative questions, and general comments, directed towards obtaining the user's opinions on the applicability, practical functioning and impacts of the system.

The survey results show that the user has found the system very useful and is satisfied with its performance. The system is found easy to use, requiring little learning effort, and is easy to control. The system saves manpower. The benefits of the system gets much more significant as the number of data sources increases and as the scope of scanning expands.

The system facilitates fast feedback and follow up in the scanning process. It makes the scanning process much faster and more systematic. It saves time and effort spent on scanning, searching for information, processing information, and determining what information to look for. It facilitates good source accessibility, personalization of scanning (scanning adaptable to changing needs of the user) and the customization of scanning (scanning adaptable to a changing context), though its customization is still regarded as not so easy and needs improvement. It reduces the cost of scanning activities (access to commercial information service, manpower expenses). It brings positive effects on the cost/benefit ratio, the interest and the value of the people who do the scanning, as well as learning through scanning.

The system has a significant positive effect on the reliability, age (currentness) and time span of information. It also has a positive effect on the value and relevance of information, the accuracy of information, the timeliness of information, the consistency or conformity among subsets of information, the scope and magnitude of scanning, the completeness or sufficiency of information (levels of details of information), and the precision of information. The information provided by the system is very up-to-date and very systematic. About 20% of the information provided by the system is found useful. About 50% of the needed information can be obtained from the system, and about 50% of the information provided by the system is irrelevant. Still, the user feels that the system helps reduce the overload of information. The user does not always get access to needed information faster than those who do not have access to the scanning system, which means that there are other sources of information that is not incorporated into the system yet and probably they would prefer them to stay

out of the system. The user often checks the information provided by the system with other good sources available, which is found to be consistent with each other. Information provided by the system supplements information from other sources.

The user did not find that the system tends to overload his capability to absorb new information or to reduce his role in information analysis. This is attributed to good data source selection and good search words setting. The user does not think that the system exerts constraints on his work. *"I do not feel that I am limited to the categories and procedures represented in the scanning system". "The system does not hinder my creativity in scanning. I do not lose my vision and creativity in scanning when using the system. I can influence the system's performance with my experience. The system helps me to look at the same information from different perspectives, to better synthesize data and to better make sense of data, to accumulate new knowledge quickly"*.

The survey results mostly give support to the speculations in the previous sections. At the same time, many of the system impacts are still unknown or can not be sure yet. For example, whether the system has big improvements in adapting to user's changing needs and concerns, whether the scanning process is flexible or rigid, whether the operating cost and maintaining cost of the system is reduced, whether it improves instant feedback in scanning, whether it helps to develop types and levels of scanning skills, to put pieces of information into a general picture, or to explore new cause-effect relationships, or to clarify ambiguous relationships. This tells that the system function is still relatively weak in helping data interpretation and in mental model learning. Finally, it is not sure whether the use of the system makes the user feel belittled.

Summary

In this paper we analyzed the impacts of an agent-based scanning support system on users and the environmental scanning process and outcomes. A scanning process is characterized by its efficiency, effectiveness and economics. It is also characterised by a number of features: intuitive vs formalized, fragmented vs systematic, occasional vs continuous, rigid vs flexible, personalizability and customizability. Information quality, as the measurement of the outcome, is measured in terms of its value and relevance, accuracy, reliability, age (currentness), timeliness and time span, completeness or sufficiency, consistency, integrity, format, understandability, precision. A support technology is described by its degree of ease of use and likelihood of operation errors, reponse speed, controllability, adaptability, cost of ownership, its effect on task efficiency, effectiveness, instant feedback and follow up capability.

Perceived effects of agent-based scanning systems include that: *the scanning process becomes more formalized and much faster than the human process; the speed of getting access to the limited, right information gets increased, and the range of environmental elements covered in scanning can be greatly widened while manpower is saved.* The benefits of an agent system would become more significant as the number of data sources increases and as the scope of scanning expands. As a personal representative, the system forms a medium for direct and flexible communication between managers and data sources, cuts down the need for many intermediaries acting as information filters (while it does not exclude human communication channels from managers). When having access to the same data sources as people do, an agent system may not guarantee the same quality on value and relevance, accuracy, reliability, consistency and understandability, especially when it is at the beginning of its operation. However, it could out-perform a human in timeliness, age, time span, completeness, and format of information.

The primitive empirical results mostly confirm the above speculations. In addition, it is also found that, the system is very useful and the user is satisfied with its performance. The system is found easy to use, requiring little learning effort, is easy to control, and saves manpower. The benefits of the system gets much more significant as the number of data sources increases and as the scope of scanning expands. The system seems not to overload the user's capability to absorb new information or reduce his role in information analysis. The user does not think that the system exerts constraints on his work. The system does not hinder creativity and user experience in scanning. The system helps to look at the same information from different perspectives, to better synthesize data and to better make sense of data, to accumulate new knowledge quickly.

It must be pointed out that the results are based on a pilot study of a weak market test nature. The impacts of the system are far from proven. In fact, many of the system impacts are still unknown or can not be certified yet. Currently the agent system is under implementation in a number of Finnish companies of several industries. In time, it will allow more comprehensive cases and stronger market tests to study, for example, whether users are willing to apply the system in their duties, whether the system has become widely adopted by companies, whether those using it systematically have produced better financial results than those who are not using it, how the organizational structure is affected, etc.

The user involved in the study is a market analyst instead of a senior manager. Nonetheless, the system has proven to be very easy to use and supportive to the user, and this will not change with managers as the users. A manager's knowledge and experience may make some difference in rating the relevance and percentage of

usefulness of information provided by the system. And the effects of the system on cognitive elements may also differ. But in other dimensions we expect that a manager-user will have similar experience with an analyst-user.

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