Executives' Perceptions on Intelligent Agent System For Information Scanning, Filtering and Interpretation

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ABSTRACT

Using intelligent agent systems to support information processing for executives has not been significantly advanced in both theory and practice. With increasing information resources available to executives, it becomes important to explore the potential and the challenges of using intelligent agent for executive information processing. This study examines UK executives' perceptions on intelligent agent-based system for information scanning, filtering, interpretation and alerting. The study follows a deductive research design, i.e. hypothesis formulation and test. Qualitative methods comprising of focus group study and interviews are used to test the hypotheses. It found that executives perceive the usefulness of intelligent agent-based system for systemic information scanning and semantic filtering, but expressed great concern over automatic interpretation of information and the possible impact of an intelligent system on managerial work. The study reveals the extent of developing intelligent systems in support managerial information processing.

Keywords: information processing, information scanning, information filtering, information interpretation, intelligent agent, vigilant system, executive information system

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1. Introduction

The need for intelligent system to support executive information processing is driven by executive's limited time to process all possible information, the increasing data overload problem, and the dynamism and complexity of external environment which creates strategic signals that needs executives' attention (Daft et al., 1988; Auster and Choo, 1994; Kumar and Palvia, 2001). Time is regarded as a scarce resource for many executives (Singh et al., 2002). An individual executive has limited time and capacity to notice and process all possible information emerged from the external environments and internal systems. With the increasing availability of electronically distributed information and the use of social networking tools, the volume and forms of information accessible from online and wireless devices are increasing at an astonishing speed, which exacerbates managers' information overload problem. Executives are facing challenges in making sense of potentially relevant information from over abundance of irrelevant information. Acquiring external information for strategic decision is more challenging than accessing internal information, since strategically important external information is usually scattered in various locations and are not readily available (Xu and Kaye, 1995; Singh et al., 2002). Executives are unable to attend all information because they perform multiple roles and activities, which are characterized by brevity, variety and discontinuity (Mintzberg, 1973). As a result, most executives have bounded awareness, which cause them to ignore critical information when making decision, and fail to bring the right information into their conscious awareness at the right time (Bazerman and Chugh, 2006). Rajaniemi (2007) assert that executives should employ experts and information technology to scan the business environment for them. Choo (1998) suggests that one of the solutions to extend executives' scanning coverage is to automate the searching process. According to Liu (1998a), intelligent agent approach represents one of the most

popularly exploited solutions where problems are encountered in automatic information gathering, filtering and searching.

Intelligent agents are "software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in doing so, employ some knowledge or representation of the user's goals or desires" (Maes, 1994, p. 31). An agent works according to encapsulated knowledge of rules, assumptions, and samples that are either pre-defined by systems developers, users or learnt by the agent. In artificial intelligence research, agent-based systems technology has been hailed as a new paradigm for conceptualising, designing, and implementing software systems. Intelligent agent technology has contributed to intelligent systems development (Klusch, 2001), and been applied to many business areas. One of the emerging areas is to develop intelligent information agent to advance information gathering, processing, and disseminating. Examples are: a conceptual framework of DIEIS - Distributed Intelligent Executive Information Systems (Chi and Turban, 1995); a multi-agent architecture framework that incorporate an information discovery agent and an information filtering agent (Moukas and Maes, 1997); an agent-based framework for strategic scanning and interpretation (Liu, 1998c); an agent-based architecture for intelligent information retrieval (Shaw, et al. 2002); and ENIRAF – Enhanced Information Retrieval and Filtering for Analytical Systems (Wecel, 2007). Despite the great advances in ICT technologies, most of the intelligent systems, as reported, are either conceptual models (Chi and Turban, 1995; Shaw et al., 2002), prototypes (Liu, 1998c), or under development in laboratories (Liebermann et al., 2001; Moukas and Maes, 1998; Li, 2006). In practice, there are no robust intelligent agent-based systems available to continuously scan the business environment, automatically filter out irrelevant information, make sense of information and

proactively provide signals or alert of impending opportunities and threats, particularly in the context of executive information processing. Thus, this study aims to examine the potential of intelligent agent to executive information processing, and executives' perceptions on developing and using such systems.

The paper is organised as follows: section two is a critical review of literature of the potential of intelligent agent that could advance executive information processing, this serves the purpose of formulating the research hypotheses. Section three is research design with details of the approaches used for data collection and data analysis. The main findings and evidences are reported in section four with discussion of hypotheses results and the implications. The last section draws conclusion and addresses the limitations of the study.

2. Literature review and the research hypotheses

2.1 Information scanning

Information scanning refers to continuous and systemic scanning information from many sources through advanced information retrieval techniques (Klusch, 2001). The term is often used interchangeably as environment scanning. The first pioneer study of environmental scanning was carried out by Aguilar (1967, p7), which is concerned with "scanning for information about events and relationships in a company's outside environment, the knowledge of which would assist top management in its task of charting the company's future course of action". The environmental scanning effort is directed toward strategic decisions and strategic planning. As the external environment becomes more volatile and unpredictable, environmental scanning becomes more critical to strategic decision making. Hambrick (1982) regards environmental scanning as the managerial activity of learning about events and trends

in the organisation's environment, and conceives it as the first step in the ongoing chain of perceptions and actions leading to an organisation's adaptation to its environment. Stoffels (1994) views environmental scanning as a methodology that copes with external competitive, social, economic and technical issues that may be difficult to observe or diagnose but that cannot be ignored. The degree of information scanning, according to Aguilar's (1967), depends on three rules which comprise of different variables. Firstly, the issue-related rule, which looks into (1) the scope or magnitude of the issue; (2) the urgency or timeliness of the issue; (3) the extent to which an issue constitutes a problem; (4) the extent of readily definable issue; and (5) the relationship of the issue to long term plans. Secondly, the information-related rule, which refers to (1) the adequacy of existing information; (2) the availability of additional data; and (3) the predictability or regularity of information appear. For instance, an informal search would be appropriate for executive who would not know the information sources nor the availability of information. Lastly, the capacity-related rule, which deals with (1) the time, energy and other resources devoted by executives; (2) the number and nature of important issues; (3) the types and levels of scanning skills available; and (4) the interests and values of individual towards scanning. Information scanning can be in "reactive" or "proactive" mode (El Sawy & Pauchant, 1988; Choo, 2001). In reactive mode, also refers to problematic or decision-oriented search, information is acquired to solve a specific problem (Choudhury & Sampler 1997). In proactive mode, also referred to sensing or surveillance, the purpose is to explore and to detect potential threats and opportunities (Choudhury & Sampler 1997). Information scanning can potentially serve as a "corporate radar" that sweeps the total environmental horizon widely, captures early warning signals and identifies areas that require managerial attention (Xu, etal. 2003).

The potential of an intelligent information scanning agent is that it can act as a useful information assistant to search information for executives, particularly when they are busy with other managerial work. Chi and Turban (1995) suggests that knowledge creating and collecting agent are appropriate for information acquisition as they can scan and search information from internal and external environment. The information discovery agents, as proposed by Mouksa and Maes (1997), can perform information acquisition task by scanning and searching distributed information sources. Budzik et al. (2002) extend Watson's information agent to conceptualise an intelligent system that can proactively and automatically retrieve potentially useful information from online repositories. An information scanning agent is often perceived to be working with other agents. Liu (1998a) developed an agent-based support framework that can perform three types of activities: locating and choosing information sources, scanning and interpreting relevant information, diagnosing strategic issues. Three types of agents are identified as the information resource agent (IRA), the field intelligent agent (FIA), and the strategic issue attendant (SIA). The IRA is responsible for managing the sources of information, ensuring a match between user's information needs and the available sources. The FIA is responsible for domain-specific scanning, analysing and interpretation of information. The SIA is responsible for capturing strategic issues, creating and maintaining sets of issue profiles, an issue repository, and a dynamic strategic issue agenda. Shaw and his team (2002) suggests a multi-agent information retrieval architecture, which comprises of five software agents, data sources, and a user profile base. The five software agents are intelligent user information agent (IUIA), query enhancing agent (QA), searching and routing agent (SRA), filtering agent (FA), and analysis and synthesis agent (ASA). The user profile base (UPB) is a knowledge base of user profiles so that the information retrieval is carried out in the right context. The benefits of agent-based

information scanning are to support continuous surveillance of the environment (Liu, 1998b). Strategically, it can enable "decision without blinders" (Bazerman and Chugh, 2006), and to effectively support "evidence-based management" (Pfeffer and Sutton, 2006) by providing strategically important information to executives.

In practice, most systems used by executives are not flexible enough to capture signals from the outside business world that indicate impending opportunities and problems (Liu, 1998a). This is evident from a survey on Executive Information Systems (EISs) application in Spain that external information is rarely included in EISs (Salmeron et al. 2002; Averweg and Roldán, 2007). Averweg and Roldán (2007) found that information appeared predominantly in many EIS has an internal focus. This implies that an automated scanning process could potentially assist executives by systematically monitoring the business environment to gain strategic information. This leads to the first hypothesis that:

H1: Executives perceive an intelligent information scanning agent highly useful to acquire strategic information.

2.2 Information filtering

Information filtering (IF) is a process of screening out irrelevant information from large volumes of dynamically generated information and to present users with information likely to satisfy their information interests (Belkin and Croft, 1992). Information filtering is particularly important for executives, because "unless the information overload to which managers are subjects is reduced, any additional information made available by an Management Information Systems cannot be expected to be used effectively" (Ackoff, 1967). According to Belkin and

Croft (1992), the process of information filtering begins with people (users) or group of users who have relatively periodic or long term goals or work tasks. The users have regular information interests that may change over time as new conditions, goals and knowledge occur or change. Such regular information interests will be converted into representation of texts, which then turned into profiles that can be put to the IF system. When incoming texts, events, or surrogates are scanned, they are compared to the profiles. The comparison results in some of the texts to be retrieved for users' attention, and some to be discarded. The retrieved texts are used and/ or evaluated based on how well they respond to the information interests, which lead to modification of the user profiles and information interests. The modified entities will be used in subsequent comparison or filtering process.

Identifying information interests and building representations of the user preferences (hereafter refers to user profiling) have been emphasised for effective information filtering by Belkin and Croft, (1992). This view is reenforced by Balabanovic and Shoham (1997, P68) who argue that "the construction of accurate profiles is a key task – the system's success will depend to a large extent on the ability of the learned profiles to represent the user's actual interest". User evaluation and feedback are often used to build and modify user profiling. Recent research (Kelly & Teevan 2003; White et al. 2006) has been working on gathering relevance feedback automatically and unobtrusively by monitoring user behaviour in information processing, e.g. user reading time, scrolling and interaction with documents. The learning function enables the agent to dynamically adapt to changes in user preferences and information needs by learning from the users' behaviour.

There is an apparent need for information filtering, as executives are coping with increasing massive information from the business environment and internal systems. Information filtering could potentially act as a "variety reducer" (Beers, 1979) by screening out irrelevant information, thus ease information overload problem of executives. Many current systems for executives are incapable to filter information. This leads to the second hypothesis that:

H2: Executives perceive information filtering agent highly useful to reduce information overload and to increase information relevancy.

2.3 Information interpretation

Information interpretation involves making sense of incoming messages and information received. It is often viewed as an individual level process wherein people attend to and make sense of incoming information (Thomas, et al. 1993). In the model of sense making developed by Weick (1995), organisations are loosely coupled systems in which individual managers have great latitude in interpreting equivocal information from the environmental change and establishing their own representations of external reality. Information interpretation includes the process of translating the searched events, developing models for understanding, bringing out of meaning, and assembling conceptual schemes (Liu, 1998a; Daft & Weick, 1984). Cognitive learning theory suggests that there is limitation in human cognitive capacities, hence, there is a need for explanation (Payne, et al. 1993; Gregor and Benbasat, 1999). Gregor and Benabasat's (1999) empirical studies conclude that explanations are important to users, in particular, when the user perceives an anomaly, when they want to learn, or when they need a specific piece of knowledge to participate properly in problem solving. Gregor (2001) found that benefit of information interpretation did arise from the use of explanations. For instance,

problem-solving performance increased with frequency of using an explanation function, particularly with problems that require collaboration between system and user.

Intelligent systems and knowledge-based systems are in principle capable of support explanation and reasoning. Budzik, et al. (2002) conceptualise that software agents, in the case of information processing, must be able to reason about the contents of a document in the right context in order to provide helpful recommendation. For examples, the meaning of the information, the reasons for advising a particular course of action, and the justification for a particular piece of information. The information agents envisioned by Liu (1998a) and Shaw, et al. (2002) has the functionality of synthesising and interpreting information. Agent-based information interpretation has the potential to reason about the contents of a document so as to provide helpful recommendation. Shneiderman, (1998) reports that many systems used by executives are insufficient tools for trying out all permutations of a problem and combining ideas. Systems used by executives exhibit very low level of functionality in explanations, justifications, and interpretation. This leads to the third hypothesis that:

H3: Executive perceive an information interpretation agent highly useful to make sense of information.

2.4 Vigilant alerting

There has been an increasing trend of using executive dashboards, scorecards to present synthesised information to senior management in recent Business Intelligence (BI) toolkits (Simons, 2008). Being vigilant has been seen an important feature of an information system for executives (Walls, et al., 1992; Houghton, et al., 2004). The notion of 'vigilance' refers to

the ability of the system to watchfully detect any weak signals and discontinuities in the business environment, and actively initiate further investigation based on such detection (Walls, et al., 1992). Houghton, et al. (2004) argue that in a tight and turbulent economy with a lean and high velocity supply chain environment, an effective way to improve an enterprise's sense-and-response capabilities is to have a vigilant information system. The key functionality of a vigilant system is the alert rules about whether an indicator is within preset allocable bounds. Alerts are displayed and accessed through executive dashboards or wireless devices. The benefit is to entail both sensing capabilities to detect changes and enhance managerial visibilities, and responding capabilities to enable corporate decisions and actions to be taken. Houghton, et al. (2004) conclude that the ability to link executive decision making with operations in real-time through dashboards has given the company a strategic edge as a responsive supply chain partner.

Business globalisation has significantly changed the working pattern of many managers. It seems to be a common phenomenon for business executives to be constantly on the move. Thus, proactively sending alerts of strategic information processed from the intelligent system can keep executives instantly informed. With the rapid development of wireless communication technologies, mobile operating systems, and innovative Smartphones, business executives on the move are able to receive information and alerts where they are. This leads to the forth hypothesis that

H4: Executives perceive an intelligent agent to send vigilant alert highly useful to keep them informed wherever they are.

3. Research Methodology

The research follows a deductive approach for hypothesis testing. Due to the nature of executive work, focus group discussion and interviews with executives are adopted to gauge their views on the proposed intelligent functionality. Thus, the data collected is primarily qualitative in nature, which is considered appropriate in the context of executive work. According to Krueger (1994), focus group method is essentially a qualitative data gathering method that allows participants to freely express their thoughts and perceptions on a defined scope of issues in a permissive, non-threatening environment. The group synergy also allows more issues to be uncovered (Hines, 2000). In order to facilitate executive's understanding of the concepts of an intelligent agent-based system, a visualisation prototype is designed to demonstrate the main attributes of the proposed intelligent functionality − executive information searching/scanning (in Figure 1), filtering (in Figure 2), interpretation and agent learning (in Figure 3). The visualisation prototype serves as a demonstration tool to enhance executives' understanding of the agent-based system, other than as a tool for technological implementation.

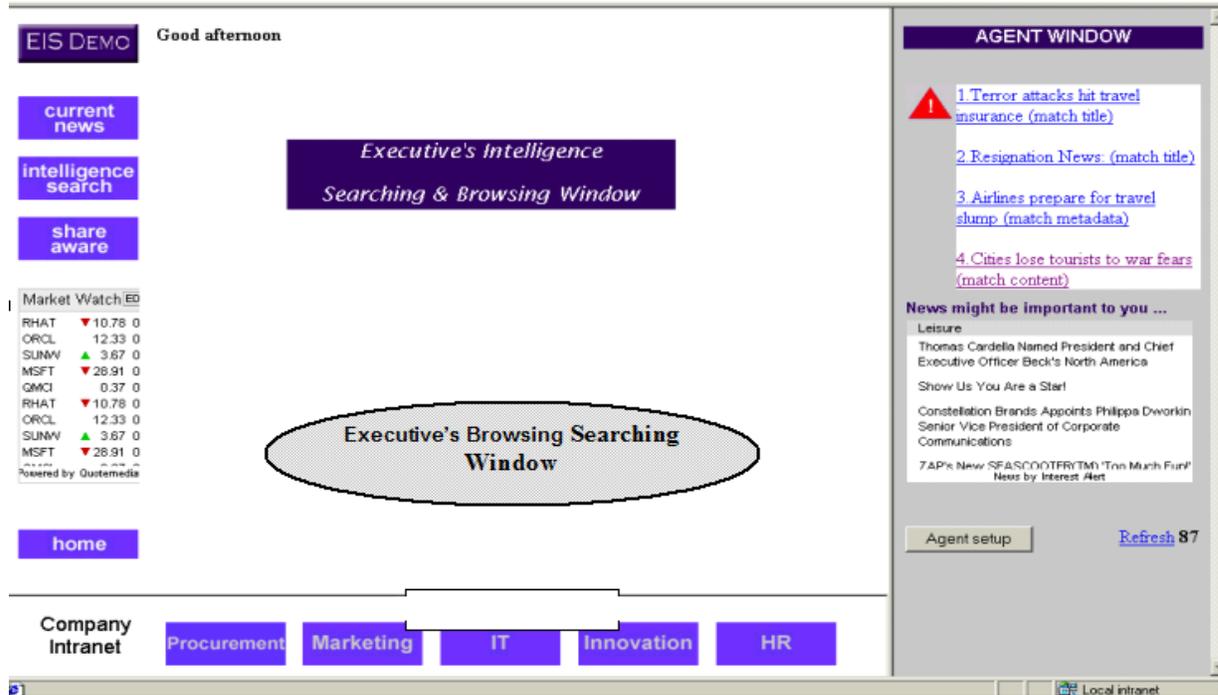Figure 1. Intelligent browsing, searching and alerting

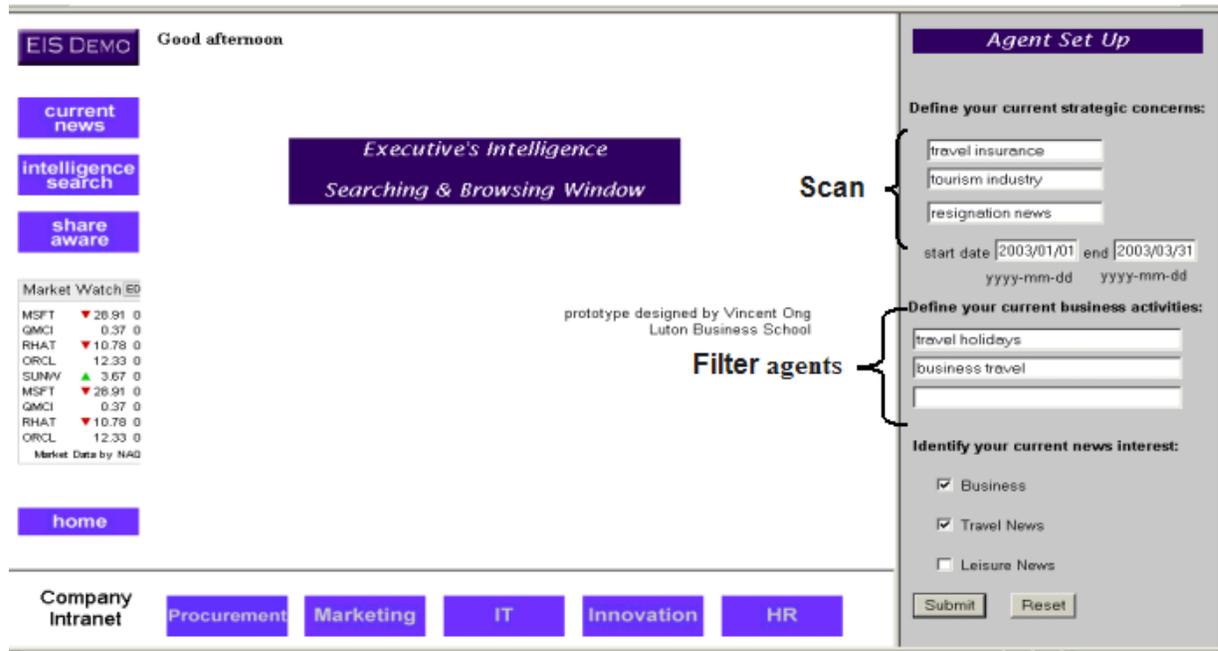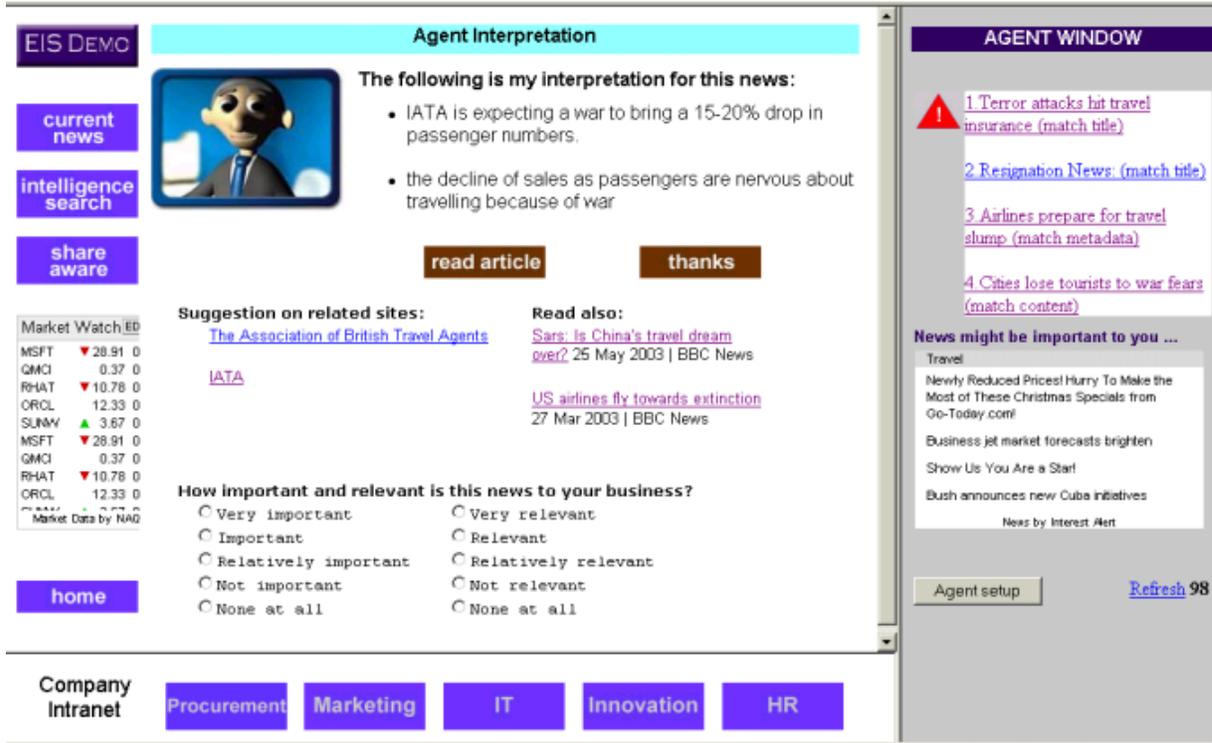Figure 2. Setting up agents for information scanning and filtering

Figure 3. Agent supported interpretation and agent learning

Three focus group sessions were conducted with a total of 31 middle and top-level executives.

Details of the focus group participants are given in Table 1.

Table 1. Focus group sample size and participant's profile

Focus Group	Sample Size (n)	Management Level			Organisation's Market			
		Strategic	Tactical	Operational	Regional	National	European	Global
A	7	4	2	1	2	-	-	5
B	8	6	-	2	2	2	-	4
C	16	5	10	1	4	5	1	6
Total	31	15	12	4	8	7	1	15
%		48%	39%	13%	25%	24%	3%	48%

Participants are from different industry backgrounds, most of them are at strategic and managerial level and involved in some forms of executive intelligence activities (48% at strategic level, and 39% at tactical level). Each session began with a brief statement on the

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rationale and objectives, the confidentiality and ground rules for the discussion (e.g. role of moderator, one participant talks at a time, and disagreement is welcomed), and the demonstration of the visualisation model. All focus group sessions took about an hour to complete. The method of thematic qualitative analysis (TQA) (Mason, 2002) was used to elicit related themes. This is followed by the categorisation process that identifies relationships between the themes and the meaning from the text in the transcripts. The focus group discussion was transcribed and compared with the field notes taken by a colleague who served as an observer to assure the validity of the focus group study. The reliability test, namely inter-rater reliability analysis (Morse, 1997), is achieved through the use of two research colleagues as separate interpreters with a view to reaching the inter-subjective agreement among interpreters.

To enhance the validity of using qualitative data to test hypotheses, a further one-to-one semi-structured interview with 25 executives are conducted. The selecting criteria is senior managers who participate in strategic intelligence activities. The sample is taken from the FAME (Financial Analysis Made Easy) online database with the SIC code of 65 – Financial Intermediation (except Insurance and Pension Funding); code 66 – Insurance and Pension Funding (except Compulsory Social Security); code 67 – Financial Auxiliary; code 63 – Travel; code 70 – Real Estate. These industries are selected due to the high reliance of information for strategic decision-making (Franke, 1987). The profile of the 25 participants is presented in Table 2.

Table 2 Participants in the semi-structured interview

No	Participant (nickname)	Position	IT Skills	Company Size (by employees)	Age
1	Adam	Deputy Managing Director	Proficient	250	55
2	Becky	Head of Corporate Governance	Proficient	12000	42
3	Chris	Director	-	100	53
4	David	Managing Director	-	400	-
5	Eve	Chief Operating Officer	Proficient	130 (UK)	39
6	Ford	Service Director	Proficient	-	38
7	Gary	Chief Information Officer	Proficient	-	46
8	Henry	Associate Director	Proficient	-	42
9	Ian	Strategic Planning Manager	Novice	150	33
10	John	Managing Director	Proficient	420	44
11	Ken	Deputy Director	Advanced	100	55
12	Larry	Head of CEO	Proficient	1200	45
13	Mark	Trading Director	Proficient	400	40
14	Nelson	Customer Centre Manager	Advanced	150	37
15	Oscar	Chief Executive Officer	Proficient	2600	53
16	Peter	Chief Operating Officer	Advanced	1000	36
17	Quin	Business Development Director	Proficient	76	45
18	Robert	Vice President	Advanced	1900	57
19	Smith	Chief Finance Officer	Proficient	-	41
20	Tim	Middle Manager	Advanced	150	30
21	Victor	General Manager of Group	Advanced	300	55
22	William	Operations & Systems Director	Expert	1500	43
23	Xandra	Head of IT Strategy	Proficient	30000	-
24	Yann	Director	Proficient	200	48
25	Zach	External Relations Director	-	4000	52

Over 80 percent of the participants are senior executives who are involved in strategic intelligence activities. Most of the participants worked in medium and large organizations in the City of London. Each interview lasted about 45 minutes to 75 minutes, and was conducted in the workplace of the interviewee. Interview contents were digitally recorded and transcribed verbatim for analysis. Due to high volume of raw data obtained from the interviews, qualitative analysis software - NVivo was employed to analyse the data. A sample transcript of interview is provided in Appendix 1.

4. Findings and Discussion

4.1 Hypothesis 1 - Autonomous information scanning

Most executives from the three focus groups are convinced that an automated information scanning agent could work continuously while executives are busy with other activities. The agent can save time and can reach information that is impossible for executives to search themselves. Evidences generated from the focus groups tend to support the hypothesis, which are as below:

"scanning keep you updated with information from external business environment that is spontaneous." "I think senior executives would use it (scanning) more as gaining background knowledge and keeping up-to-date."

"If you are sure and you know who your competitor is, I'm supposed what you can do is to tag into their information bases, and just keep checking and when some information changes, it pops up to you. And I'm supposed if you could set it with many fields, may be the natural news, the global news, something like that, you set them right and run them in the background. I mean as information is changing, it would pick it up and bring it to you."

"you set up to run (the agent-based system) overnight, or whatever, and when I come in the morning, there will be something to look at ..."; "... you could say to the system, 'get me half of page of view', it will then search all sources and present them in half a page."

The interview reveals that 14 out of 25 executives emphasize the needs for automated information scanning, as it gives the benefits of systematically searching for information on behalf of the executives, processing information continuously in the background, identifying

information that might be of interest to executives, and bringing up to executive's attention on what is seemed appropriate. It is evident from the following comments:

"I think continuous and autonomous is a good idea. I guess the things for senior management, that they spend majority of day away from their desk. They are not actually there to see news coming in ….They probably spend three quarter of their day in the meeting rooms, in different places around the building or outside with clients." (Tim, Middle Manager)

"It's not just a word search but the whole series of instructions that you can give, …like I am looking for this information, the search function on the browser is doing automatically, …scanning and searching that could happen without input probably, that would be far better than if I have to go and recreate. (John, Managing Director)

"I imagine I could come in to the office each day, and I could, if I choose, I turn on the tool and I say, 'today, I am particularly interested in finding about motor insurance', and I put some filters in and it goes away. And after a time, I might go back let's say two hours later and see what it discovers. (Larry, Head of CEO)

"And I think what you probably want is one set of criteria that is always there in the background, like keep an eye on what this company is doing, or report all news on this particular type of business". (Eve, Chief Operating Officer)

"The agents identify everything that could be critical in moving your business forward. I mean this way of identifying that as if nothing come as a surprise to you further down the line. So

you can know things very early in the cycle when people are beginning to act." (William, Operations & Systems Director)

"For example I am really focusing on the UK market in property outsourcing. However in the back of my mind I think that there maybe market in US. Maybe the agent could expand your queries into different source of information around US-based through specific criteria. The agent can actually suggest refinement or filters that I might like to apply ...the agent might find another source that might add another value for me." (Garry, Chief Information Officer)

It is noted that although scanning and alerting function are perceived useful by executives, the agents need to be controlled / coached somehow by executives. This will be discussed later.

4.2 Hypothesis 2 – Information filtering

Scanning without filtering could lead to over-abundance of irrelevant information that exacerbates the problem situation of data overload. One of the situations is scanning leads to the duplication of similar information that collated from multiple sources. Ten out of 25 executives interviewed (40%) recognized the problem of information overload problem and the needs to reduce information to a digestible, manageable level, which strongly support the hypothesis. Evidences are presented as below:

"There is an immediate need for this filtering mechanism because of the volume of the workload." "need more level of filter or more customisable filtering functions." "... to be made by the agent, who filters information for senior manager."

"I think the key to it (the system) is it does come out with relevant information, and it comes out with probably a digestible amount of relevant information. (William, Operations and Systems Director)

"We don't want too much. It has to deliver an appropriate amount of information at appropriate interval." (Tim, Middle Manager)

"As the volume of information is exploded on the internet, obviously we recognise we need to reduce to something manageable." (Peter, Chief Operating Officer)

According to participants, information needs to cut down to the appropriate amount for efficient use. Key points, headings, paragraphs and summary tend to be manageable and digestible.

"As I said earlier, the ability to produce an appropriate amount of information. So ideally, you want key points from an article on a subject, and then you want to be able to drill down into that if you find a particular area that is particularly useful or interesting. ...What I am looking for is to cut down to the bare minimum information I have to process." (William, Operations and Systems Director)

"I think it has to be simplified, it should be one set of information that allows a human to digest ..." (Robert, Vice President)

"If you want to make decisions very quickly, that's what tactical and strategic decision based information, you want minimum amount of information, readily processed, so that you can click on." (John, Managing Director)

"I think to set a criteria for any kind of system that one can really use it, you need only few key indices for decision making which means those information must be always readily available ...Information should be presented in very simplified form. Lots of time people present too many decision points in one set of information. (Robert, Vice President)

"On the average I think you don't want to be crowded more than a certain numbers handful of information, if too much then it's poor presentation even though you know you got good information." (Robert, Vice President)

The results of information filtering, as suggested by participants, can be in a number of ways including indexing, categorizing, ranking, etc. Some executives also require analytical tools to perform advanced modeling, forecasting, comparison, and strategic mapping. For example, the system should have

"... the ability to filter and rank the importance of information ... categorize the search results according to meaningful topics."

"As far as you know, every document could be important. I do not know how the system can get around it if the information just coming up without the classification. If the source of data can classify 1 is critical, 2 is important, 3 is not important, not mission critical something like that (Chris, Director)"

"...it should have different ways of organizing information, for example, information of the day before, information of the day after." "to predict and forecast as well, but that will be the next level"; "to provide recommendation based on the information provided."

"What would be useful for me is prioritization ... will save a lot of time, effort and energy (Ford, Service Director)" "some ability to priorities ...if you're not going to read anything else" (Adam, Deputy Managing Director)"; "priorities the information, ...that would save my time (Peter, Chief Operating Officer)".

The evidences support the hypothesis that filtering and synthesizing information are important functionality of the intelligent system. However, executives cautiously judge the functionality of an intelligent filter. One executive suggests there is a dilemma in filtering information, i.e. it can screen out potentially valuable information, which is evident below:

"There's a great possibility, very high risk, you are actually filtering out fringe of information that could be probably more beneficial to you than the initial information that you are looking for in the first place."

This could happen if the filter is not capable to recognize the contextual meaning of the incoming messages. This implies that the filter needs to be intelligent enough to understand, for example, the semantics and the context of the information. This has been echoed by some executives:

"It depends on whether they will actually tell you the context, justification of where about the information is coming from…""Software agents need to be knowledge-based in order to process and understand the level of importance …I think for me the way to improve is to understand the natural language."

Lack of knowledge in executive information system has been reported by Vandenbosh and Huff (1997), who suggest that one of the main problems is the absence of a predefined model with expert knowledge on how the data could and should be used. A possible way to improve filtering effectiveness is by embedding knowledge of the user (e.g. user's requirements and interests, profiling) into the agents, so that the agent is capable to recognize the context and the semantics of the information.

4.3 Hypothesis 3 - Interpretation and sense making

As evidence shown below, the findings do not appear to support the need for interpretation. Most participants tend to interpret data and to make sense of the data themselves. The concerns with automated interpretation are evident from the following comments:

"I have extreme concern about that interpretation function, …certainly for me, I interpret the data myself." "I feel more comfortable with the degree of relevance than interpretation for issue that is important to me." "I believe interpretation should be done by executive, and I think it has to be a low level interpretation first."

"I would just see it as a completely complementary. I would never see it replacing discussion with competitors in the market place, with competitors' customers, with their employees."

"One concern is decision making must be based on rules. You have a set of rules, and so and so, all depend on the credibility of the rules you set up. Secondly, I think instinct. A lot of decision making is intuitive"; "... you got the fact and then you make a decision from some instincts…that software doesn't have this intelligence instinct."

The findings support El Sawy and Pauchant's (1988) argument that executives do not and will not delegate their scanning and interpretation activities to software agents. However, the evidences are in contrast to the view that interpretation of data should be considered a unique and ideal feature for executive information systems (Young, 1987; Liu, 1998a,b). The rejection of the hypothesis of autonomous dada interpretation implies great challenges of developing intelligent function to mimic managerial judgement and interpretation.

4.4 Hypothesis 4 – Intelligent alerting

Intelligent scanning and alerting are vital to the realization of a vigilant system. The hypothesis is supported by the evidences generated from the focus groups and the interviews.

"Once the information comes in, ... the agent probably can give a flash, for example, about new information." "If the agent hasn't searched for a while, it could actually suggest to the user."

"You click on it, and it will actually suggest things to you on what you are trying to look for."
"I mean as information is changing, it would pick it up and bring it to you."

"You want to actually have the agent to be aware of that daily change. Today, priority for me is one thing. Tomorrow, it's something completely different. Now if I define within the agent, this is what I need now, tomorrow could be something completely different."

From the interview, 11 out of 25 participants expressed the needs for alerting functionality by means of automatically prompting, and recommending information. According to some executives,

"...the recommendation feature might be useful (Tim, Middle Manager)", "I'd say providing recommendation on the related articles (Smith, Chief Finance Officer)"

"Clearly, an agent that alerts the significant changes of information, particularly information that is new, and recognise which information that has been used or which information is regularly used and then it somehow remember that and update that, that obviously be a useful facility." (Larry, CEO)

"... any percentage that's changed you want to know about it. If the system could respond to the change, yes, it will be very useful." (Chris, Director)

"...the agent is going to prompt me with additional information that I might find useful, ...an agent which is actually working with you, not only giving you information but also telling you what the relevance of the information is and how you might use that." (Adam, Deputy Managing Director)

"...eventually the system will become an assistant to figure out options for you." (Yann, Director)

"...for example if you'd ask very specifically about the UK, but they may also say 'Well, you know there's an interesting article in relation to another European country is ...'" (Smith, Chief Finance Officer)

Although the information from alert function is perceived as useful, executives are unlikely to be triggered too frequently. One executive states that, *"I wouldn't want something flashing out on my screen every five minutes to say that the information is there and I wouldn't want to actually go looking for it myself. I think it would be something if you would notify on a minimal daily basis, maybe twice daily to see whether the system had updated (Mark, Trading Director)".*

"...a user should trigger and also be triggered by the information system... they will be triggered to tell them a change had happened ... now the system is going to react differently." (Robert, Vice President)

It is revealed from this study that the alerting function is closely related to the scanning function, i.e. executives expect the information agent to give alert and signal when new information arrives. This could be implemented in many ways online or wirelessly, e.g. a flash, a message alert.

4.5 Emerging issues and concerns over the adoption of the intelligent system

A key issue emerged from the focus group and the interview is that the intelligent system must be controlled by the user, and the system shall be capable to learn or being coached by executives in order to make scanning and filtering relevant and effective. This has been suggested by a number of executives, for example:

"it's the effort of coaching your agent, more effort needed to train the agent."

"...you still got to teach the agent what you need." "I think the object will be in the setting up of the agent. I think that's where the work would be, making sure the agent knows very clearly what it's that the executive is looking for and what structure or format he or she would like it."

"In terms of the profile of the agent, presumably it can retain some of your interests and thoughts of yesterday as well as what you're thoughts are today, may well then ask you to give you an option to act to this, or you want to get rid of others. So I reckon it must have a sort of flexibility within itself to retain as well as to develop."

"I think the fact is that both systems would have learning curve. One is actually the program itself, you wouldn't actually know what it's working on. And the people who are using it would actually go and say, 'oh, I did that last week and get the information or whatsoever'. From there, the system learns and how to turn and change."

Although most executives perceive the role of the intelligent system as a supplementary tool, a few executives expressed concerns that their managerial roles may be weakened or replaced by the agent-based system. For example, it is questioned that:

"would it replace executive when it learns too much?" or "...the redundancy of managers?" "...system can actually force to look at things that I don't want to look at."

Excessive usage and over-dependence on an agent-based system make some executives worry if their creative thinking and strategic vision may be weakened.

"I think you will be becoming more and more dependent on the software and not thinking for themselves." "...thus reducing creativity"; "...sitting in front of computer, limit the creativity, losing the skills"; "This system would actually limit the development of senior executives"; "...they become relying on this, they don't broaden their knowledge."

Even with agent learning and user coaching, some executives expressed concerns over the agents' capability to use human knowledge and to mimic human reasoning. For example,

"A personal assistant in a human form would know your personality, would have learned what to put for and what not to put for. A PA can make a judgment whether or not that piece of information is important to you. I am not sure the IT software can take, has the ability to take that information ... a simple form but not in a complex form".

"My other concern is does the software do the decision making? ... a lot of decision making is intuitive"; "you got the fact and then you make a decision from some instincts...that software doesn't have this intelligent instinct."

This concern reflects the most common, but the greatest challenge facing developing computer-based system for executives, because managerial decision making and the dynamic nature of executive work require human judgement that an intelligent agent may not be able to completely mimic.

The issues and concerns revealed fro this study highlight factors that could be critical to the development and implementation of the intelligent system.

5. Discussion and Implications

This study reveals that executives perceive the usefulness of an intelligent agent-based system in support autonomous information scanning, semantic filtering, analytical support and proactive alerting of information. This implies that there is an apparent need for using advanced intelligent technology to develop information scanning, filtering (refining) and alerting capabilities for executives who are confronted with over-abundance of information. The benefits are not confined to reduce information overload of executives, but also to enhance executives bounded awareness, and to increase the organization's sensibility-and-responsibilities to business opportunities and threats. The focus of developing the intelligent capabilities shall be: 1) identifying external environment sectors relevant to the company for scanning; 2) applying semantic and contextual information retrieval techniques in scanning and filtering; 3) extending business intelligence (BI) functionality to include alerting of strategic intelligence to executives; 4) embedding managerial knowledge within the information agents to enable effective scanning, filtering and alerting; 5) integrating external intelligence with internal key performance indicators and capacity to identify possible actions. The value of gaining strategic information through the intelligent system shall not be

overstated, strategic intelligence shall lead actionable, i.e. it should lead to appropriate and prompt action that is ahead of major competitors. There are many challenges to develop the intelligent information processing agents. As revealed from this study, the following needs to be addressed:

5.1 Executives' intervention and control

One of the requirements to make scanning and filtering relevant to executives information needs is to enable executives to easily control the agents and set criteria for the agents. For example, executives build a user profile with information interests and preferences, or specify specific search topics, examples, criteria, level and format of synthesized/summarized results. As executives' information needs and interests change over time, user control on the information agents makes the system more acceptable to the specific needs of executives. This is akin to end user programming - a PBE (Programming By Example) that allows user to manipulate information on the graphical user interface (GUI) level (Repenning & Perrone 2000). This approach allows customised personal information processing, but demands a lot of user efforts. In this case, the executives have to recognise opportunity for employing an agent, take initiatives to build the agent and endow it with explicit knowledge (Klusch 2001).

5.2 Developing machine (agent) learning capability

As revealed from this study, agent learning is vital for the intelligent system. A static agent cannot cope with the complexity and dynamism of executive information. Machine learning is a computational approach to make computer systems to learn from their experience. The five basic machine learning paradigms described by Langley and Simon (1995) are applicable to the development of intelligent information agent for executives, which are: neural networks

(focus on analogies to neurobiology), instance-based or case-based learning (focus on human memory), genetic algorithms (based on evolution), rule induction (focus on heuristic search) and analytic learning (focus on reasoning in formal logic). The implication of using one or more of the machine learning approaches in the context of executive information processing are in two folds: one is that executives and the system developers need to feed into the agent with cases, examples, business and reasoning logic, evaluation and feedback of quality and relevance of information received from the agent. The other is that the agent develops the ability to observe, monitor and remember executives' information behavior without executives' notice, e.g. what has been searched and read and from where, so that it can predict, search and report the information that executives may found relevant and useful. The agent can also seek clarification and confirmation from executives. This interactive process can lead to continuous updating and refining of executive profile that underpins agent's actions.

5.3 Developing a knowledge agent through knowledge engineering

One of the limitations of the intelligent system as perceived by executives is that interpretation and managerial decision making cannot be simply substituted by the intelligence agent, since the agent is lack of managerial knowledge and human intuition. It is not the assertion of this paper that an intelligent agent-based system is capable to deal with every aspect of executive information processing, however, an agent embedded with managerial knowledge is vital for intelligent scanning, filtering and analysing information. Scanning without filtering can exacerbate managers data overload problem, filtering without knowledge can screen out potentially important information. Thus, executives' knowledge needs to be captured, engineered into the agents. Knowledge engineering and ontology provide methods and tools relevant to build intelligent information agents. Knowledge engineering provides the backbone

for constructing structured and reusable knowledge models (Studer et al. 2003). The executive knowledge base and the reasoning rule base provide essential guidelines for the intelligent agents. The main challenge with knowledge engineering approach is that it requires substantial efforts from knowledge engineers to encode implicit control knowledge using complex algorithms. As a result, the agent has to be highly user-specific as well as domain-specific with relatively fixed representation of knowledge (Klusch 2001). Ontology is a formal, explicit specification of a shared conceptualisation (Studer et al. 2003). Ontology has become widespread in fields such as semantic web, intelligent information and reasoning services, natural language processing and knowledge representation. Ontology is particularly useful to develop the capability of the scanning and filtering agent in understanding the contextual meaning and semantics of incoming messages (Xu, et al. 2007; Espinasse, et al. 2009).

6. Conclusion

This paper examined the proposed functionality of an agent-based system for executive information scanning, filtering, interpreting and alerting. Evidences support the hypotheses that an intelligent agent-based system has been perceived useful, and the system can potentially enhance executives' information processing capability through automated scanning, semantic filtering, and being vigilant. However, agented-based information interpretation and sense making are not supported, due to the concern that the agent is lack of managerial knowledge and human intuition. The key characteristics and challenges of such an intelligent system are revealed including user control and intervention with the system; the learning capability of the agents; and the knowledge base of executive information processing. An effective filtering mechanism needs to be enriched with managerial knowledge and user

profiles by using knowledge engineering techniques and particularly machine learning approaches.

The study provides useful insight into the potential of how executive information processing can be improved by advanced intelligent technologies and the perceptions towards using intelligent information processing systems. As widely recognized that there is an increasing complexity and dynamism of strategic information in electronic and distributed environments, the development and implementation of the proposed intelligent system could improve quality of insight into strategic situations, reduce executives' blind-spots, which can lead to enhanced organizational sensibility and capability to deal with strategic opportunities and threats. It is particularly important that this study reveals executives' concerns on the possible impact of using an intelligent system, i.e. the fears of changing managerial roles, fears of limiting creativity and executive development, uncertainty about system capability of interpretation and using managerial knowledge. These concerns need to be addressed during implementation of the system, and shall be taken into consideration by system developers who design systems with a similar nature for executives.

Limitation of this study is noted, i.e. research sample used for this study is not industry specific, thus the results only reflect general perception of executives, not specific to certain industry. It is believed that different industry may face different environments, by which the level of uncertainty, and information intensity and needs may be different. Future study based on specific industry could determine the scope of scanning, and the knowledge base specific to the industry. It is also aware that the study only uses a visualization model, and relying on executives' knowledge about intelligent agents to gather their views. The study did not

implement and evaluate an agent-based system. It would be valuable to examine executives experience after having used intelligent system to carry out information scanning, filtering, analysing and alerting. Further research therefore can be carried out to develop and to evaluate a prototype, which could lead to new insight into more technological and organisational issues related to developing and implementing intelligent information systems for executives.

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Appendix 1: Sample of Interview Transcript

Interviewee: John (nickname), Managing Director, Airline Industry, UK

Q: In what ways and to what extent your current information gathering and processing activities can be improved?

I think we can systemise a lot more than what we did. I think what we did is an ad hoc basis. It is very much with what we want the strategic information but we do it from a tactical point of view. So we gather it here, we gather it there. But what we should be doing, if all of us look at the website everyday, we should be spent live. There is a big picture. What do we need to feed into that, what can be put into that, like a master database, which is a live document, or a live system that we can feed in, and can explain how the consequence to what I now know it here, is that X, Y, or Z. And if it get changed the input here, this is unlikely to be here. Somehow if we could find out what is happening in the market, a live basis that feed into our airport management systems, feed into our stand planning software, or to our administration work and operative engagement, that would be very helpful. Often, we have the situation we can't make decision because we don't have enough information. With a live piece of software, it will be able to give the outcome. I am not sure feasible yet, but in the business sense, to get all those tactical inputs, to look how it impacts the strategic direction of the company. It will be very useful. What we need is almost a simple process of managing our information and allows us to take out the emotion from decision making, which leave us pure answer or pure information from which people with more experience perhaps or people who can take more risks can act on that. Because what you tend to find people don't like to tell people bad news. Therefore, they would filter the bad news or they would condition somewhere and you can go down with that course of action because people don't like to tell people what the bad news is. And if you are going for a particular course of action, because of what people provide and because of the culture as well, we hope the culture isn't wrong here, you could end up with the wrong output based on the right input. How's going to be improved? Well, I think we can systemise our market intelligence in a better way. I think it is very much scanning newspapers, going through websites, or perhaps we can have an interrogation system on our web, on our host that went out scan, like I am looking for this information, the search function on the browser is doing automatically, collating from all different websites and to be present. It's not just a word search but the whole series of instructions that you can give, and perform the searches, takes out the rubbish, and present it to you for the course of action. That would be very useful. It shouldn't be something predictable. Donald Rumsfeld made a crazy statement that is absolutely right: "what we know we know, what we know we don't know, what we don't know we know, what we don't know we don't know." I think that "what we don't know we don't know" you could laugh at it, but actually what he said was absolutely right. Because the things you don't know about, that still come and hit you from that field, presumably they are there, you could take a completely different direction. If you could have some sort of intelligent systems hat filtering all the time from the Internet. You would know it, or you have a better chance to get it earlier. And that would be a way forward. But I guess the issue for an organisation is whether they could afford that, because I am sure that's concerning leading edge that we have to recognise first of all either the internal result, the risk profile we got. It is an extra optimal position from the predictable fashion of Internet rather than something which is perhaps not yet available commercial.

Q. In terms of scanning and searching capabilities, what would you consider to be useful?

I don't know how technology does it. What do I concern is the output. Three or four times a day, I would probably go onto the Web to just look for pieces of information. What I hope it would do, and that would be very useful, if the agent was able, for a short while, spot the trend of information I am picking up. So, it could almost predict what I was going to look for on a day or hourly basis. So, I will continue to present to you, a search, the same soft of thing. Because I think most people look for easy life. Most people want the ads taken out and the information presented to them in the clearest form, and therefore, scanning and searching that could happen without input probably, that would be far better than if I have to go and recreate. May be we have a whole series of … Monday look at one thing, Tuesday look at another thing, Wednesday or different hours during the day. It was recognised that, first in the morning, check market prices, or check airlines' news based on the day, check television on DVD, or check for industry coming out of the government, stuff like that. And it would go to a picture and store the information as well, so that I can go back. Because it is not very well having information life and then wonder what do I do with that later. To have some archives and all sorts of archive of intelligence.

Q. Imagining you have an ideal software agent that assists you in information scanning and searching, what would you consider to be useful?

I think we both are talking about the same thing. This is an agent that is proactive. It sits there. I think we shouldn't change that much, very similar. But I would say proactivity …taking the biggest problem is the volume of information out there and its relevance. So if it was an intelligent system, it knew what is wanted, and ideally, one would probably talk to the computer, and say 'find me information on". And more on a business tool rather than something which is, and the Web's intelligence basis are good, but it is just so huge, you know it keeps building. And therefore, scanning that was neat, efficient and targeted.

Q. In terms of filtering and refining capabilities, what would you consider to be useful?
It's all very well having this is 40 percent relevant, this is 60 percent relevant like current systems do. Sometimes because of the way, and this is about the user interfacing with it. We use terminology we know, we want, if it could be interpreted over the browser, it should interpret the way … one word in one language means one thing and another language means another thing. Let say US English and UK English. You might put a word in, and get hold on something totally different. You actually try to use the US word as well. The context of the word you expect, there are other words as well. So must know that, that word that you put in cannot mean all this rubbish because the other word you put in as well are related. I think that would make the intelligence tangible. The other thing is often, you know sometimes you put inverted comas on, it still comes out garbage. Or if you don't put the things in, you put the words you are looking for, you then got seventy, eighty pages. In actual, what you want is on page 9. The problem I got in terms of filtering, most people don't go beyond that … How do you get the system to recognise what you are really looking for is on page 7,8,9 or page 100? The way some organisations manage to get their sponsor pages or whatever to the top of the search profile and actually make your search slow down. Or may be you put the wrong word in and the supporting words you put in the advanced search. There is a mixed match. It will still give you the top one.

Q. Do you mean having some customisation in the system?
Ya, which you could refine. When you put certain words down, it knows what it means because it learns from you a number of times before. So again, it's rather a more efficient intelligent based system would be far better. I think if we look back in 50 years time, things will be seen very old fashion. And wonder how much would have come on. I think the future of MD could have a completely different conversation than they are having because the current filtering mechanism will be seen as too old fashion.

Q. Why the understanding of the meaning of the words is important?
Even in UK English vs American English, contextually, the word can mean different things. That's why, the filtering must recognise the context in the airport business. No point giving information on roads or rails or whatever. Let say, what 'passenger' means? Whole bunch of people or consumer. In my context, consumer means airline passengers. That's why, I hope the system would learn from … you have to train it somewhere. Even that should be minimised because it should learn from experience.

Q. In terms of refinement, what would be important to you?
The current ware of system is user-determined effectively, is not interactive. So you need to measure interactivity. For example, you say that, do you really mean what you just said? Do you really want to do that? That's intelligent system. The current system will do what it says. If the system could be interactive, and that refining process challenge you and also challenge the system. If that's intelligent one, it would say, and do it in such a way that adds value, rather just put a flag up, and saying here is the things you need to do. Refinement is very very much saying 'you say that, and I can get this or that, which you prefer?', giving options, such as 'don't show the screen again', or 'don't give that again unless I specify request for it' or something like that. Or research it, recognise the background. And if you almost anticipate what I am going to say because you persist to be agent recognise there is a connectivity here. You present this new information and there is a text cause of action.

Q. In terms of interpretation capabilities, what would you consider to be useful?
The biggest annoyance for any search is all the spam and flashing up. No matter how many controls you have, you still to get. We don't want that. What would be good if, first you could do is to take out all the websites that have the advertising on, forget the advertising, filters out. And in terms of how it shows it cleanly, keywords, rather than whole paragraph. You might not want the whole paragraph, you might just want a sentence, with the words saying 'aviation slumps by 25%'. In very simple blocks, not too cluttered. And at the bottom, you have more information on this or more information on other subjects related to this. I am very keen on seeing as little as possible, very clean approach rather a cluttered approach. I think current web is very cluttered, too busy. If you

want to make decisions very quickly, that's what tactical and strategic decision based information, you want minimum amount of information, readily processed, so that you can click on. If you want more information, you must have a box we can go and blow the screen up. So, I think clean, clear or clarity of information.

Q. How about the idea of giving alert or notification to the user?
I expect that to be automatic. I actually like the computer, if I am doing another applications, like Excel spreadsheet, almost like my children doing their messenger, they can hop in and hop out, something like that, it's important to that, and set the level of importance, can pop up and say 'do you such a such thing happens', that would be very useful. Sometimes you are in the meeting, talking about certain thing, something could pop up and change the whole way you do thing. The classic was we are doing our contract of negotiation with Easyjet, we got the news that two aeroplanes crashed into World Trade Centre. All that can give an impact in a minute, by far in the evening, the whole world change and so the way we run our business. So ya, alert, alarms, false true, so that when you are working on one project, or if you can say 'false true', something flash up saying 'do you know this is happening'. But again, it almost like alert phase, so if you get point five, you know what I mean, like the security indicator. So the system can have some alert phases, which are appropriate to your business, which you can set, but also the impact and marry the two.

Q. Earlier on you mentioned on information categorisation, would you like to explain more?
What did we do before we have email? There is a fundamental question. Now the question is that we have too much information. And because of too much information, and our brain takes thousand years too developed, although we are getting brighter, our brain can only process information the same speed 30, 40 years ago. But we are getting far more information. I think the average person living in 16th century, 17th century in England, for the one year of information you get, you can get it on the front page of newspaper in a day. And they travelled not more than five or six miles, and now we travel hundreds and thousands of miles. We have newspaper, we have the Web, we have telephone, we have PDA, we have all those things in place. How do you process it? How can you make it and therefore what this system should do is saying, 'I know the business surely, I know what is important, I will filter for you and I will get rid all the gross. But I know for you is gross, for you is not important, but for your organisation, it may be important to the organisation. I will make sure someone else will get it still.'

Q. How about the idea of providing relevance ranking or recommendation?
I think as I have said before, what you get on the Web today is substantial repetitiveness. It comes out 90 percent is actually not relevant. Relevance is important. I don't want to have many options, I want one, two, three really good points, something specific targeted. I like it to recognise sponsored Web site, therefore I will discounted because I know you are looking for.

Q. How about the idea of providing explanation or summary?
I think one line, or two lines. We tend to do that with our emails, you have the subject, or the first line, or the urgency. So I think that is important, but no more than one or two lines. When you get to BBC Website, for example, you have the information with picture layout, sometimes you click again across the top, you have information flashing in. It's like watching Bloomberg. You have the presenter there, you have option shares there, you have news clicks from the bottom. And you think, where do I look. Now, I used to be a traffic controller, I looked at radar screen, and I was always moving things, managing things. I find it difficult, how do the average, non-traffic controller, non-Bloomberg expert follow that. I think the Web if give you too much information, you can miss it. And if you slightly blind in one part of your eyes, whatever, you miss things. Therefore, less is more. Sometime you become word-blind. You see a sentence and the word 'NOT' is missed. You think is positive but in fact is negative. That's my personal point of view. I scan so quickly. I tend not read the whole sentences. …The key thing is to deliver, to crystallise the key issues or key attributes on what they want to tell you rather than the whole sentences. And if you want more things, yes, you can click on the options, but bang bang bang. It will be great actually, the words you are looking for are highlighted. That interpretation came useful, few words, bang bang bang.