

Revitalising Executive Information Systems Design and Development

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Abstract

This paper reviews the conventional studies of Executive Information Systems (EIS) and related research areas. It is found that conventional EIS studies contribute little insights to the success development and adoption on EIS. Notably, there is a need for revitalising EIS design and development. A focus group study is conducted to explore and identify challenges faced by current managers' information processing activities, and to obtain managers' perceptions on agent-based solutions for supporting executive information processing. The findings have challenged the conventional EIS design guidelines or framework to a greater extent. This paper provides implications on the uncertainty of executive information and executives' information processing activities. The implications suggest a three-levels agent-based EIS design model for supporting executive's information processing activities.

Keywords: *executive information systems, executive information, executive information processing activities, software agents, information acquisition, information synthesis*

Introduction

Executives Information Systems (EIS) have not been advanced to a great extent in both research and practice since its prevalent in the 1990's. In the late 1980's and early 1990's, EIS research focuses widely on the concept of EIS and executive information sources and requirements (Jones & McLeod, 1986; Wetherbe 1991; Watson et al., 1991; Millet & Mawhinney, 1992; Warmouth & Yen, 1992; Watson & Frolick, 1993; Jordan,

1993; Jones et al., 1993). From the mid 1990's to late 1990's, the adoption and keys to EIS success are the research emphasis in EIS study and practice (Rainer & Watson, 1995; Nord & Nord, 1995; Young & Watson, 1995; Nandhakumar, 1996; Rai & Bajwa, 1997; Bajwa et al., 1998; Pervan, 1998; Koh & Watson, 1998). Since then, little insights and guidelines for revitalising EIS design and development have been provided.

Conventional EIS Studies

Conventionally, the design of EIS focuses on office support applications, planning and control process, and improved analytic and modelling capabilities (Rockart & De Long 1988). Key functions of earlier EIS design are mainly standard office automation packages and management reporting facilities on company's KPI (Key Performance Indicators) and CSF (Critical Success Factors) (Rockart & Treacy 1982). The improved analytic and modelling capabilities are mainly developed to provide status and trends of internal and historical information (Millet & Mawhinney 1992). Hence, it is rather a management control and planning system with performance measures based on critical success factors. EIS studies indicate that most EIS are used predominantly for performance monitoring and control (Vandenbosch & Huff 1997; Edwards & Peppard 1993). On top of that, most EIS are designed with the assumption that the critical deficiency is the lack of relevant information, as a result, executives are supplied with information more than they can possibly absorb.

Conventional studies on EIS study also focus mostly on executive's information attributes (sources, types and contents) and executive's information needs. Researches believe that the identification of executive's information attributes, and the determining of executive's information needs or requirements would contribute to the successful design and development of EIS (McLeod et al. 1984; Watson & Frolick 1993; Jordan 1993; Watson et al. 1997).

Conventional views on EIS design also imply that value added presentation of data via user-friendly interface such as graphical, tabular, and/or textual information presentation is essential in EIS design. Data should be processed (i.e. summarised, aggregated, analysed), prepared and reported to executives using friendly and colourful interface (Watson et al. 1991; Nord and Nord 1995; Young & Watson 1995).

Recent EIS study implies that an ideal EIS should include scanning, filtering and reporting function in order to collect and synthesise information from multiple sources and proactively report brief and aggregated information to executives (Vandenbosch & Huff 1997; Xu & Kaye 1995, 1997; Liu 1998b).

The Need For Revitalising EIS Design and Development

Many EIS failures have been reported from the study of the adoption of EIS and keys to EIS success (Rainer & Watson, 1995; Nord & Nord, 1995; Young & Watson, 1995; Nandhakumar, 1996; Rai & Bajwa, 1997; Bajwa et al., 1998; Pervan, 1998; Koh & Watson, 1998). Conventional EIS's data extraction is usually based on existing databases and predefined information needs. Information provided is internal and historical orientated due to the internal database focused and the inflexibility in data extraction

(Liu, 1998a,b; Chen, 1995). Besides, information provided from EIS is often already existed in other forms (Koh and Watson, 1998). Information processing is reactive, whereby executives need to initiate information search. For instance, competitors information monitoring cannot be initiated automatically. Information can easily become stale in a conventional EIS due to the limited and static presentation of data (Watson et. al, 1995). Despite the over emphasis on easy of use, friendly interface and wireless access features, the usefulness of the information contents is often neglected (Nord and Nord, 1994; Xu, et al, 2003). Conventional EIS is also inflexible enough to adapt and meet changing information needs (Young and Watson, 1995; Bajwa, et al., 1998; Salmeron, 2002). High costs in developing and maintaining EIS and long time consumption due to the long process of development and training (Bussen and Myres, 1997) are other failure factors. Despite the integration of data manipulation and decision support tools into current managerial support systems, the key deficiency is the lack of intelligent functionality (Liu, 1998a,b; Montgomery and Weinberg, 1998). For instance, systems are lack of the function in continuously scan business environment, automatically filter irrelevant data and information, and proactively provide signals or alerts of potential opportunities or threats.

Research Background

A focus group study is used in this research as an explorative approach to (1) identify challenges faced by current managers' information processing activities, and (2) to obtain managers' perceptions on agent-based solutions for supporting executive information processing activities. The findings will be useful to examine the validity of the conventional EIS design guidelines or framework in the changing environment, and to identify the desired properties for an intelligent agent-based EIS.

Four focus groups discussion were conducted with a total of 41 middle towards top-level managers, who attended the Executive MBA (part time) Luton Business School. The size of the focus group is about 10 persons per group. Each session begins with a brief statement on the purpose of the focus group, the confidentiality and ground rules for the discussion, i.e. one participant talks at a time. The discussion questions, the related concepts and the use of agent-based software are also introduced prior to the discussion. Each focus group session took between 45 minutes to one hour to complete. All the discussions were tape recorded and transcribed verbatim for late analysis. Analysing raw data follows two steps: firstly, organising raw data into structured, meaningful themes according predefined or newly emerging themes and categories (Dey, 1993). Secondly, using thematic qualitative analysis (TQA) (Nicholas and Anderson, 2003) to conduct a detailed interpretive conceptual analysis and mapping. Meanings were sought from the transcripts to identify consensus, dilemmas, and contradictions. More research findings and discussions can be found in the previous papers (Ong et al., 2004, 2005).

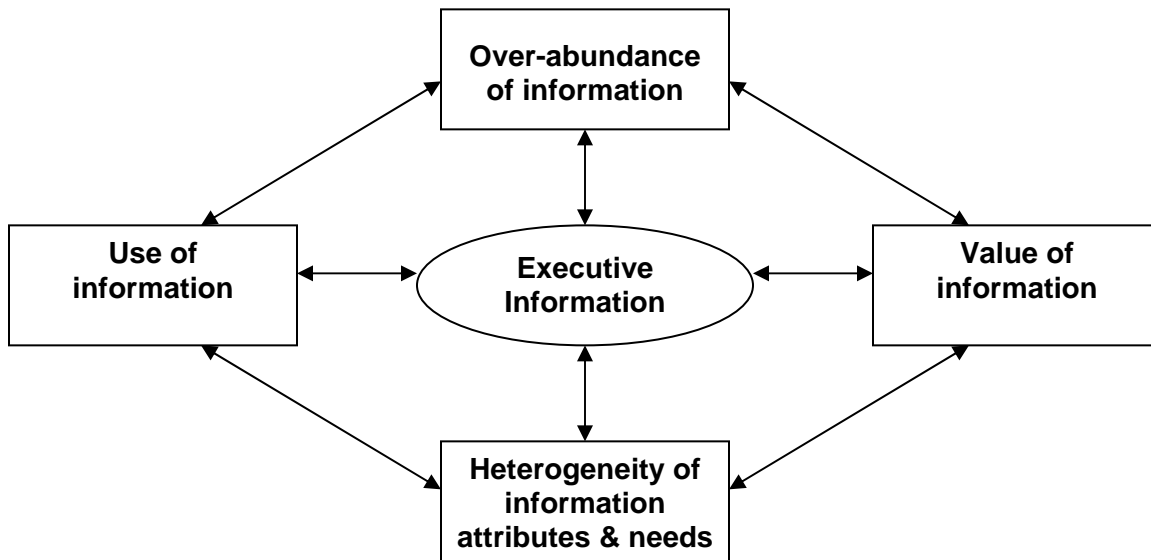
Discussions and Implications

The Uncertainty of Executive Information

The nature of executive information environment has not been taken into deep consideration in the study of EIS field. If information is defined in terms of its ability to

reduce uncertainty (Daft & Macintosh 1981), insights on characteristics contribute to that uncertainty will be useful for developing value-added information systems. One of the main purposes of the focus group study is to explore challenges faced by executives in their current information processing activities. The findings of this study suggest implications on characteristics that contribute to the uncertainty of executive information, as depicted in Figure 1.

Figure 1 Characteristics contribute to the uncertainty of executive information



a) Over-abundance of information

The findings confirm that executives are suffering from the over-abundance of information. Executives receive both internal and external information, from both informal and formal sources. Most EIS are designed with the assumption that the critical deficiency is the lack of relevant information, as a result, executives are supplied with information more than they can possibly absorb. Ackoff (1967) has foreseen this dilemma since the introduction of management information systems (MIS). He strongly believes that the emphasis of a manager support system should shift from supplying relevant information to eliminating irrelevant information. He argues, “*Unless the information overload to which managers are subjected is reduced, any additional information made available by an MIS cannot be expected to be used effectively*” (Ackoff 1967, p. 148). The duplication of information sources also causes the excess of information. With the increasing amount of distributed information and heterogeneous information sources, executives are pressurised to spend more time and effort to cope with these challenges. Hence, effective data management is often cited as a key to success of EIS development (Koh & Watson 1998). One of the major concerns is the ability to combine data from multiple sources.

Implication: the need to reduce redundant and irrelevant information to a reasonable amount for executives to process and digest.

b) Heterogeneity of information attributes and needs

Conventional studies on executive information focus mostly on executive's information attributes (sources, types and contents) and executive's information needs. Information system developers are expected to understand and identify executive's information needs, information sources and types. The findings, however, suggest that the nature of executive information is diverse, dynamic and heterogeneous. This means that executive's information attributes and needs are changing rapidly over time. Often, by the time useful information is acquired and reported, the strategic issues facing the executive have changed. Though a generic pattern is possible to identify, it's unlikely for information system developers to identify an exclusive list of executive information types and sources, as well as exclusive pattern of executive needs or requirements for individual executive. Notably, without the understanding of the individual executive information, how can the EIS developers design an effective EIS for executives? Jones & McLeod (1986) find that executives can manage information to some extent by controlling their information sources and types. This allows them to achieve control over the manageable volume of information and potential value of information.

Implication: the need for individual executives to define, modify and control their respective information attributes and needs.

c) Value of information

The findings suggest that the credibility and reliability of information are key values to executives. The credibility of information refers to the provision of relevant, meaningful and understandable information. The reliability of information refers to the consistent provision of trustworthy information. The availability and scalability of information are also perceived as important. Conventional studies of executive information mainly look into the preference sources and types of information rather on the value of information (Daft et al. 1987; McLeod et al. 1984). However, the underlying problem is that the value of information cannot be assessed until the information arrives. Unexpected and unpopular sources and types can generate high value information. In addition, the perceived value of a specific set of information may vary for different executives according to individual differences. Nevertheless, the findings suggest that the value of information is associated with the provision of semantic and contextual support on information acquired. Executives believe that the semantic support on natural languages and contextual support on information content would enhance their information processing activities.

Implication: the need to provide semantic and contextual support to the information acquired in order to increase its credibility and reliability.

d) Use of information

Executives use information for different purposes. Information use involves the selection of information from a larger content of information in order to attend to or to act on, for examples, to make sense of a situation (enlightenment), understand a problem (problem solving), make a decision (instrumental), determine facts (factual), verify another piece of information (conformational), predict possible outcomes or trends (projective), initiate or sustain personal involvement on a particular course of

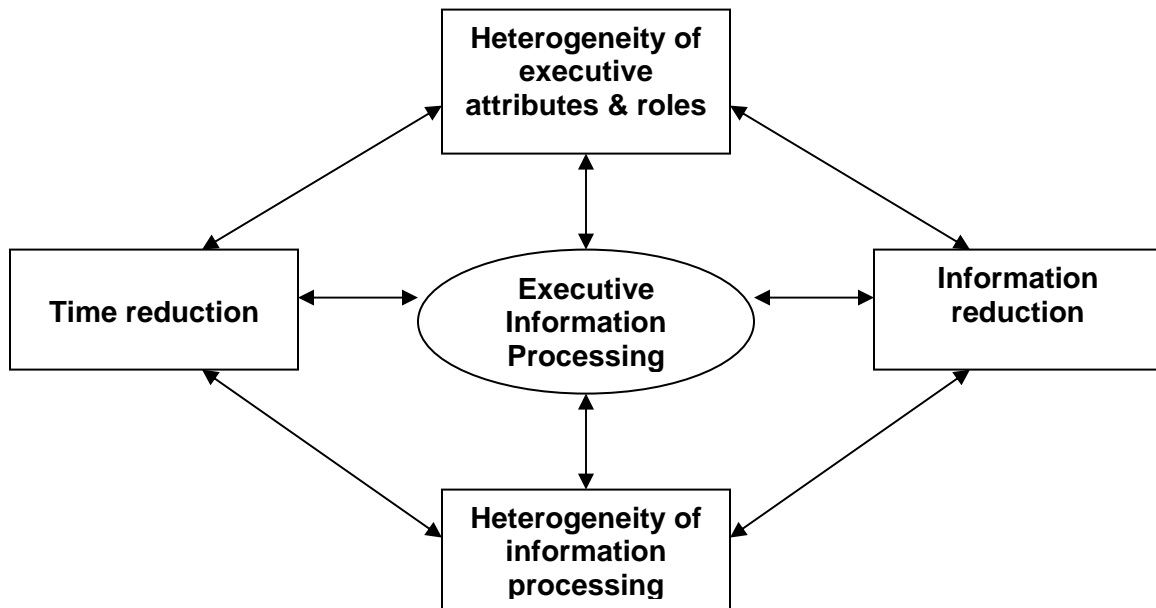
action (motivational), or develop relationships (personal/ political) (Taylor 1986; Choo 1998). The findings suggest little insights on the above uses, instead executives are more concerned on the way the information is selected and stored for future references, and the way the information is disseminated and reported. Besides determining how managers use needed information, Ackoff (1967) postulates that it is necessary to determine how well managers can use needed information. And if managers are unable to use it well, they should be provided with either data manipulation tools and decision support tools. The manipulation tools and decision support tools will help, especially 'weak managers' to gather and process information for decision making.

Implication: the need to provide data manipulation tools and decision support tools to improve executive's information use.

The Uncertainty of Executive Information Processing Behaviour

The concept of information behaviour refers to "those activities a person may engage in when identifying his or her own needs for information, searching for such information in any way, and using or transferring that information" (Wilson 1999, p. 249). Many models of information behaviour have been produced, for examples, Wilson (1999)'s problem-solving model of information seeking and searching process, Choo (1998)'s model of information use, Ellis et al. (1989a,b, 1993)'s and Marchionini (1995)'s process-oriented model, Rasmussen et al. (1994)'s and Ingwersen (1996)'s cognitive model, Dervin (1992)'s sense-making framework, Kuhlthau (1991, 1993)'s affective model, and Taylor (1986, 1991)'s situational model. This study, however, focuses on information processing behaviour. It refers to those activities an executive may engage in searching, scanning, filtering, refining, interpreting and presenting information for decision making. It is found that most of the studies conducted on executive information processing behaviour focus on information acquisition and scanning behaviour (Daft et al. 1988; Jones et al. 1993; Auster & Choo 1994; Wang & Chan, 1995; El Sawy 1995; Vandenbosch & Huff 1997; Liu 1998a,b; Sawyerr et al. 2000; Hough & White 2004), mostly adopted from Aguilar (1967)'s concept of environmental scanning. Virtually no study is done on executive's information filtering behaviour. However, a few studies are attempted on executive's information interpretation behaviour (Liu 1998a,b). One of the main purposes of the focus group study is to explore challenges faced by executives in their current information processing activities. The findings of this study suggest implications on characteristics that contribute to the uncertainty of executive information processing behaviour, as depicted in Figure 2.

Figure 2 Characteristics contribute to the uncertainty of executive information processing behaviour



a) Heterogeneity of executive attributes and roles

The findings confirm that executives are individuals who perform different roles with different agendas, cognitive styles and mental models (Mintzberg 1973; Kotter 1982, 1999; McKenney & Keen 1974; Isenberg 1984). Conventional studies of EIS mainly look into Mintzberg’s managerial roles, few have actually look into the implicit factors, such as executive’s agendas, cognitive styles and mental models. Mintzberg (1973) identified ten managerial roles, which he grouped into three groups: interpersonal, informational and decisional. Clearly, some executives may engage more in certain roles than the others. According to Kotter (1982, 1999), the informational and interpersonal roles allow them to build networks of people and set agenda for their decisional roles. In the process of gathering information and evaluating information, executives can either exhibit preceptive or receptive approach, systematic or intuitive approach (McKenney & Keen 1974). In addition, executives often work with combined thinking with acting, linking agendas and mental models in their work (Isenberg 1984). The findings also confirm that executives comprise novice users and expert users of executive support system (Hung 2003), and some are considered leaders or laggards in executive information gathering and processing (Xu & Kaye 1995). Hence, it is unlikely to design a common EIS for executives with heterogeneous attributes and roles. System developers must be conscious of, not only the executive roles, but also the implicit agendas, cognitive and mental models in developing EIS.

Implication: the need of using an end-user centred approach to develop specific EIS for specific individual executives.

b) Heterogeneity of executive information processing behaviour

Due to the above heterogeneity of executive attributes and works, executive information processing behaviour is, therefore, complex, dynamic and heterogeneous. Executive information processing behaviours can be characterised as: apparently fractionated and opportunistic but strategically linked; highly inferential and intuitive; highly interpersonal; using action as experimental probes to aid understanding; and 'off-line' idea generation (Young 1987). The findings reveal that executives exhibit different information gathering and processing behaviours over different occasions and time. Hence, it is unlikely to determine the specific behaviour of gathering and processing strategic information, especially when they are continuously and rapidly confronted with changing and diverse information. This challenges conventional EIS studies that believe a common EIS can be developed to provide executive information based on the understanding of executive's information needs and their behaviour in acquiring information. This includes ascertaining executives' information sources, information type, information storage, process of interpretation and sense making, and information dissemination (Jones et al. 1993; Xu et al. 2003). The findings imply that EIS should be personalised to fit individual user's profile and preferences, and should be coached to mimic individual user's information processing behaviours. Centre to this approach is EIS usability and adaptability. Mintzberg (1973) used to suggest that certain important information processing and strategy making tend to be centralised in the hands of the one man in each organisation who heads it. As a result, manager will operate the systems in man-machine or manager-analyst systems. A logical argument following this speculation is that the focus of EIS design needs to shift from developing a common EIS to developing an EIS environment or platform on which executives can develop, control and coach the EIS for their particular needs at particular events. Hopefully, an adaptive EIS will progressively understand and mimic some of the executive's information processing behaviours.

Implication: the need to design a personalised and adaptable EIS that fits user profiles and mimics user behaviours, and eventually capable of assisting user in some of the information gathering and processing activities.

c) Time reduction

Time reduction refers to reduce the time and effort an executive needs to gather and process information. The executives usually have time constraint issues with frequent interruption yet concern on a wide range of internal and external business environment issues (Kotter 1982, 1999). The over-abundance of information and the multiplication of information sources demand substantial time and effort to process. The findings show that executives are very concerned with the amount of time spent on information gathering and processing. Executives will resist using EIS if it demands more time and effort to learn and use the system than using other means to gather and process information. Hence, executives often rely on external information providers or their knowledge workers who search, gather and process information on behalf of them.

Implication: the design of EIS must be of ease of use, requiring little effort and time to learn and know how to use and control the system.

d) Information reduction

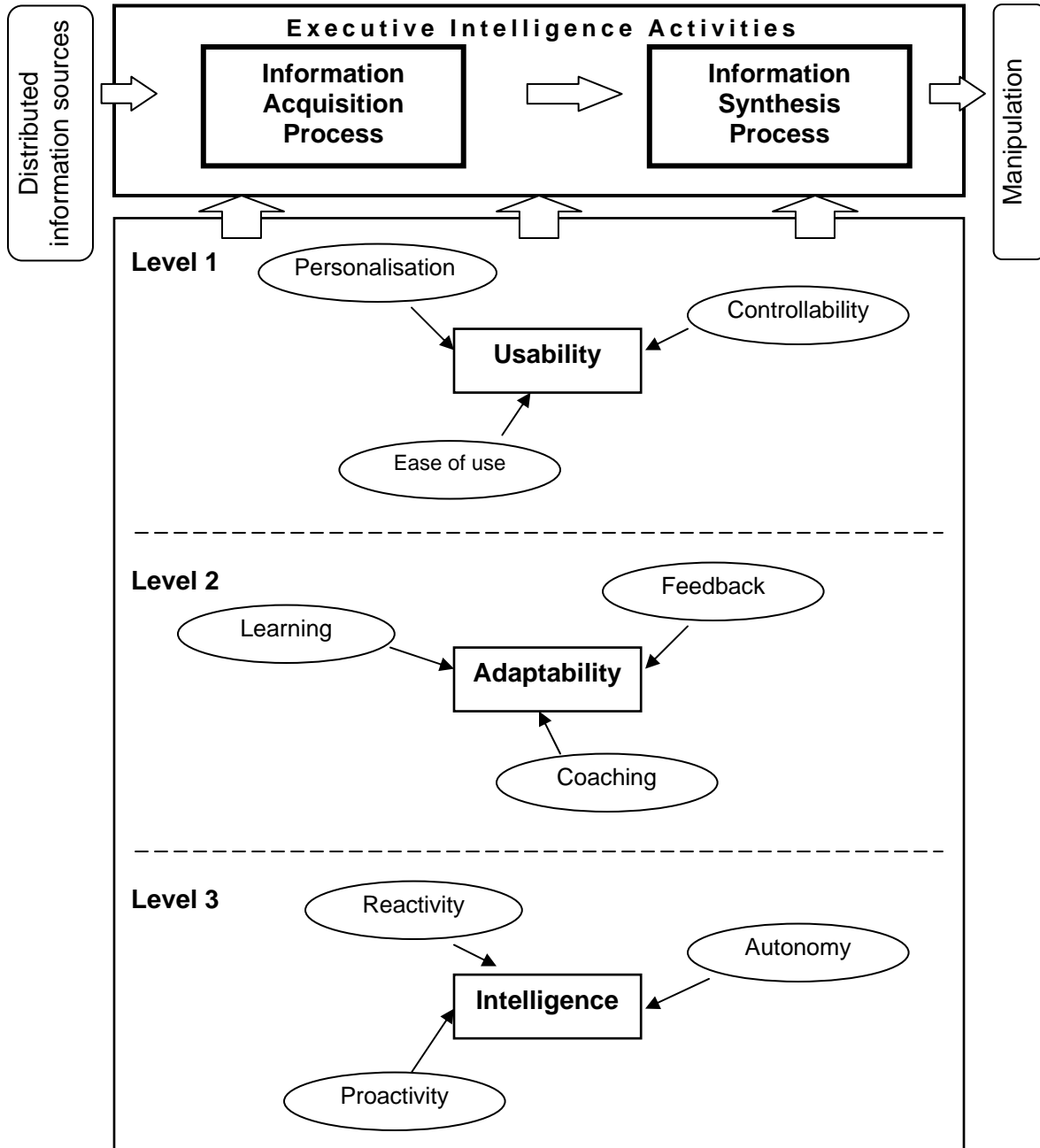
Due to the time constraints and the over-abundance of information, the reduction of information is critical in the design of EIS. The findings suggest that executives can only digest a manageable amount of information. However, there is a dilemma in the process of reducing information, in which, potentially valuable information may be accidentally screened out. Taylor (1986)'s '*noise reduction*' criteria in the value-added processes of information suggests three processes of information reduction: the process of *exclusion*, or withholding information, the process of *inclusion*, or supplying information within some boundaries, and the process of *precision*, which has to do with focus and specific information. The idea of exclusion is to restrict or to contain the amount of information presented, excluding information that is not relevant and useful. The intent of inclusion is to assure that nothing of conceivable value is omitted. The intent of precision is to assure that only the feasibly defined information is presented (Taylor 1986). Hence, EIS with its emphasis on supplying information will not help this process without a basic change in the filtration (or evaluation) and condensation (or filtering) of information, as Ackoff (1967) suggested. Simon (1971) states it clearly that, "*It is conventional to begin designing an Information Processing System by considering the information it will supply. In an information-rich world, however, this is doing things backwards. The crucial question is how much information it will allow to be withheld from the attention of other parts of the system*" (Simon 1971, p.43).

Implication: the need to filter irrelevant information without omitting potentially relevant information.

An Agent-based EIS Design Model

From the above findings and discussions, an agent-based EIS design model for supporting executive's information processing activities is proposed. This model provides a framework for supporting executive's information processing activities in a three-levels model (see Figure 3).

Figure 3 An agent-based EIS design model



The information acquisition process is responsible for scanning and searching information from the heterogeneous and geographically distributed information environment, as well as managing information contents, sources and types or formats. The information synthesis process is responsible for screening out irrelevant information and refining information acquired for further manipulation and utilisation. Both processes can happen concurrently as searching and filtering are carried out at the same time. For example, the user defines his search criteria as well as his filter criteria. The system

would search and scan the information needed, while refine the information and filter the irrelevant information. Both processes are supported by three levels of agent-based functions: usability, adaptability and intelligence. Based on executives' choices and perceptions, Level 1's usability function is perceived as the most critical and immediate need in agent-based EIS development, followed by Level 2's adaptability function, and finally Level 3's intelligence function.

Usability refers to the extent to which a system can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (based on ISO 9241-11). Usability is highly critical in managing the uncertainty of executive information processing behaviour. Every senior executive is unique individual working in specific business context with specific information needs. Usability function aims to provide a user-centred EIS, rather a developer-centred EIS. From the focus group findings and discussions, value-added attributes contributing to usability function are ease of use, personalisation and controllability. Ease of use aims to reduce the difficulty of using the system via relevant interface in order to increase the accessibility of information. Executives are impatient users due to daily time constraints, thus, unlikely to devote much time in computer-based information support systems. Personalisation is the capability to manage and customise information for specified executives for specified purposes based on individual executives' profiles and interests. Personalisation of information acquisition and synthesis helps to search and scan information with potential value for executive needs, as well as screens out the irrelevant information based on user preferences (Foltz & Dumais 1992). Controllability is the capability to exhibit control over executive work profiles and information profiles. Ackoff (1967) stresses that, "No system should ever be installed unless the managers for whom it is intended are trained to evaluate and hence control it rather than be controlled by it" (Ackoff 1967, p.153). It is important that executives are given the right to alter their information needs and preferences, as well as their information domain without depending on system developers. The usability function is the first step to assure the executives that the system is tailored designed and developed for not only executives, but individual executives.

Adaptability refers to the extent to which the system fits the specified and right context of work and information, with the ability to strengthen the responsiveness of system for coping the uncertainty of executive information. This is akin to Taylor's (1986) definition of adaptability in his value-added model. The adaptability function aims to increase the level of relevance and contextualisation of information, with the appropriate semantic and contextual support. From the focus group's findings and discussions, value added attributes contributing to adaptability function are learning, coaching, and feedback mechanisms. Learning is the capability of the system to improve its information processing activities by observing executive's information processing behaviours and information preferences. This is similar to the implicit relevance feedback approach (Morita & Shinoda 1994; Fasli & Kruschwitz 2001). Coaching, however, allows executives to train the system in order to increase its robustness, thus, to support the user in successfully achieving their objectives in the work domain and information domain. This is achieved by gradually building individual user profiles that contain executive's work domain and information domain. Feedback mechanism is the capability to increase

the relevance of information through executives' explicit evaluation and feedback on the information acquired. This is akin to the explicit relevance feedback approach in the study of information retrieval (Rocchio 1971 and Salton & Buckley 1990). Notably, the adaptability function requires user participation implicitly and explicitly to increase its relevance and contextualisation. As the system becomes more adaptable, executives are more likely to adopt the next level of intelligence function.

Intelligence refers to the extent to which the system exhibits self-determined activities that performs a specific task on behalf of an executive, with no or very little executive interaction. With the emergent of agent technology (Sycara et al.1996; Jennings & Wooldridge 1998; Klusch 2001), software agents or information agents are potential for building an agent-based EIS. The representation and processing of ontological knowledge and semantic metadata, user profiles and natural language input, translation of data formats as well as the application of machine learning techniques enable software agents to acquire and maintain knowledge on itself and its environment, thus, achieve appropriate intelligence functions (Klusch 2001). The intelligence function aims to autonomously, reactively and proactively manage information on behalf of executives or other agents, preferably on the online basis. From the focus group's findings and discussions, preliminary value added attributes contributing to intelligence function are identified as autonomy, proactivity and reactivity. Autonomy is the capability to operate without the direct intervention of users. The agents have control over their own actions and their own internal state. For example, executive allows the system to process information continuously in the background, identifying information that might interest the executive and bringing up to executive's attention that is seemed appropriate. Reactivity refers to the capability to perceive user's information environment and act timely in response to the changes in the environment without user's intervention. The notification of change presented by the system involves no user interaction. For instance, once the system perceives changes in executive information environment, either information needs or information attributes, the system would adjust and adapt to meet those changes. Proactivity is the capability to exhibit goal-directed behaviour by taking the initiative where appropriate without user's intervention. For example, the system is able to take appropriate decision and action in information process, manipulation and presentation, like rank the relevance and significance of information, recommend executives of new and relevant information and alert executives of information threats.

In summary, the findings make the purpose of using EIS more explicit, that is to enable executives gaining background knowledge, keeping up-to-date, and backup tacit knowledge (Bennett III, 1998). More emphasis is put on using EIS to enhance information processing and learning than to support direct decision-making. A fundamental conception of an agent-based EIS is that the system should be treated as a complimentary tool in supporting executive information processing activities, mainly on information acquisition and synthesis, followed by first level interpretation.

Conclusion

The paper has challenged some of the conventional views of EIS design and development. Conventional studies of EIS have neglected the characteristics contribute to the uncertainty of executive information and executive's information processing activities. The nature of executive information is unique, yet different for specific executives. Similarly, executive's information processing behaviour is complex, dynamic and heterogeneous. This uncertainty implies that a generic EIS model is impractical for individual executives. A three-levels agent-based EIS design model is proposed that comprise three essential functionalities: usability, adaptability and intelligence. This allows a user-centred, adaptable and preferably intelligent EIS to be developed. Future study can be followed in these directions, firstly to continue to examine executive's information domain and processing behaviour in order to cope with the uncertainty; secondly, to identify and develop agent-based solutions for supporting usability, adaptability and intelligence in EIS; and lastly, to explore suitable ways of interaction and learning between the executives and agents.

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