IT-Enabled Strategic Management: Increasing Returns for the Organization

Bruce Walters
Louisiana Tech University, USA

Zaiyong Tang
Louisiana Tech University, USA

IDEA GROUP PUBLISHING

Hershey • London • Melbourne • Singapore

Acquisitions Editor: Michelle Potter
Development Editor: Kristin Roth
Senior Managing Editor: Amanda Appicello
Managing Editor: Jennifer Neidig
Copy Editor: Julie LaBlanc
Typesetter: Sara Reed
Cover Design: Lisa Tosheff
Printed at: Integrated Book Technology

Published in the United States of America by
Idea Group Publishing (an imprint of Idea Group Inc.)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@idea-group.com
Web site: <http://www.idea-group.com>

and in the United Kingdom by
Idea Group Publishing (an imprint of Idea Group Inc.)
3 Henrietta Street
Covent Garden
London WC2E 8LU
Tel: 44 20 7240 0856
Fax: 44 20 7379 0609
Web site: <http://www.eurospanonline.com>

Copyright © 2006 by Idea Group Inc. All rights reserved. No part of this book may be reproduced, stored or distributed in any form or by any means, electronic or mechanical, including photocopying, without written permission from the publisher.

Product or company names used in this book are for identification purposes only. Inclusion of the names of the products or companies does not indicate a claim of ownership by IGI of the trademark or registered trademark.

Library of Congress Cataloging-in-Publication Data

IT-enabled strategic management : increasing returns for the organization / Bruce A. Walters and Zaiyong Tang, editors.
p. cm.

Summary: "This book makes an effort to explore the interaction of information technology and strategic management and aims to encourage joint research efforts among IT and strategy scholars for common solutions"--Provided by publisher.

Includes bibliographical references.

ISBN 1-59140-908-X (hardcover) -- ISBN 1-59140-909-8 (softcover) -- ISBN 1-59140-910-1 (ebook)

1. Information technology--Management. 2. Strategic planning. I. Walters, Bruce A., 1961- II. Tang, Zaiyong, 1957-
HD30.2.I853 2006
004.068'4--dc22

2005032112

British Cataloguing in Publication Data

A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material. The views expressed in this book are those of the authors, but not necessarily of the publisher.

Chapter XI

Autonomous Environmental Scanning on the World Wide Web

Sören W. Scholz, Bielefeld University, Germany

Ralf Wagner, Bielefeld University, Germany

Abstract

Environmental scanning (ES) improves managerial decisions by linking the business environment with the organization's internal capabilities. This chapter provides an overview of current developments in ES, underscoring the link between the managerial decision-making process and the different modes of scanning both internal and external information sources, particularly the World Wide Web (WWW). The psychological foundations of human ES activities are scrutinized, and cutting-edge technologies that support monitoring or even scanning of autonomous information sources are discussed to integrate both aspects in a holistic perspective on ES. We identify the most serious challenge in ES to be the detection of relevant sources in vast information environments. Based on the Information Foraging Theory (IFT), we propose an innovative approach to assessing the information gain offered by digitally available sources.

Introduction

ES refers to the way in which managers study their relevant marketing environment. Scanning is a more challenging task than monitoring information sources, because a broad range of internal and external sources have to be exploited, data in different (often ill-specified) formats have to be combined, and the topics, as well as the information sources of interest, cannot be exhaustively described *a priori* but rather, emerge during the scanning activities. Aggravating this, managers typically have to limit their attention to very few data sources and, thus, exclude all other potentially relevant information sources. Consequently, there is constant competition for the manager's limited attention between different topics, information sources and fragments. Herbert A. Simon highlighted this interrelationship in the following way (quoted by Varian, 1995, p. 200): "What information consumes is rather obvious: It consumes the attention of its recipients. Hence, a wealth of information creates a poverty of attention and a need to allocate efficiently among the overabundance of information sources that might consume it."

The importance of ES activities to managerial planning processes is widely accepted and supported by empirical results. Several studies show a strong connection between ES efforts and business success (Analoui & Karami, 2000; Daft, Sormunen, & Parks, 1988; Dollinger, 1984; Miller & Friesen, 1977; Newgren, Rasher, & Laroe, 1984; Ngamkroeckjoti & Johri, 2003; Subramanian, Fernandes, & Harper, 1993; West, 1988). ES helps managers foresee favorable as well as unfavorable influences and initiate strategies that enable their organizations to adapt to their environments. Slaughter (1999) has noted that ES is an up-and-coming industry. ES should improve short- and long-term planning (Sutton, 1988), and should lead to a better understanding of external changes. At its best, ES is the first step in a well-organized chain of activities that lead to environmental adaptation (Walters, Jiang, & Klein, 2003); however, the actual managerial reality is found to be less structured and orderly (CIO Insight, 2003; Muralidharan, 1999). Meanwhile, the massive body of scholarly work (see Choo, Detlor, & Turnbull, 2001; Dishman, Fleisher, & Knip, 2003) for a detailed bibliography of scholarly contributions in the fields of competitive intelligence and ES, respectively) has not found a suitable impact on managerial practice (Wright, Pickton, & Callon, 2002), for various reasons. First and foremost, this might be attributed to the perception of managers that systematic ES is user unfriendly (because of its quantitative methods) and too complex (and thus simultaneously oversimplified, because of reducing scope to very few of the relevant variables) and, therefore, might make them lose ground (Day, 2002; Wind, 1997). Instead of systematically seeking for information on developments and changes, managers tend to reduce their cognitive load by restricting information gathering to exceptional events, such as preparation meetings devoted to strategic planning. In this case, the information-gathering task is commonly delegated to assistants or specialized market researchers and consultants (Chouldhury & Sampler, 1997; Lim & Klobas, 2000).

Previous research establishes that managements' cognitive inertia in responding to environmental changes increases the probability of mistakes in marketing planning (Daniels, Johnson, & De Chernatony, 2002; Reger & Palmer, 1996). But, even when this psychological obstacle is overcome, the manager faces serious difficulties in utilizing information from ES activities. Wright et al. (2002) report from an empirical investigation

that the lack of time to engage in systematic ES make the information and structure relevant, and ensuring that relevant information is opportunely available are commonly mentioned problems in United Kingdom (UK)-based organizations. Dishmann and Pearson (2003) argue that the ineffectiveness of many ES activities arising from these problems led to a downsizing of ES efforts in many United States (U.S.) firms. This problem becomes even more serious in the context of ES activities on the WWW, which provides—on the one hand—a massive information base covering new up-to-date information, but—on the other hand—does not provide this information in a well-structured and easily accessible manner. Professional tools for managing the ES process and systematizing these information sources are still not widespread in practice. Standard search engines, such as Google or Altavista, seem to be a great help in retrieving meaningful, relevant information at first glance, but do not organize search results in a serviceable manner (Tan, 2002). Thus, the manager may, at times, obtain excessive information and—as a consequence thereof—get drawn into a search process that could extend unreasonably. Considering these gaps between the claims of ES-related literature and managerial practice, this chapter aims to:

- Derive a system of scanning modes that fits practitioners' needs as well as covers the recent progress in ES by new Web technologies.
- Outline the linkage between ES in different modes and the stages of the managerial planning process.
- Provide an overview of current ES software tools' features.
- Outline a new approach for autonomous ES on the WWW.

To meet these goals, we outline how to keep up to date with ES activities from the practitioners' perspective, which is affected by limited resources and the need for timely information. We also explain how to choose the right scanning mode in different stages of the decision-making process. Researchers might benefit from the comparison of different frameworks in order to link their research approaches and results to the contemporary patchwork of scholarly knowledge. Moreover, both groups may take advantage of the description of currently available monitoring software and recent technological advances to support autonomous scanning activities on the WWW.

The remainder of this chapter is organized as follows. In the next section, we explain the concept of ES and delineate the relation to similar challenges, such as competitive intelligence and weak signal detection. Subsequently, a framework for ES is derived to explain the underlying structures and shortcomings resulting from the systems involved in ES and their interactions. Therefore, an alignment of the ES process to managerial decision-making is provided. Moreover, we discuss the state of practice in supporting software tools for ES in the context of this framework. In doing so, we return to a cognitive-driven approach derived from psychological insights in the field of information-seeking behavior, namely, the IFT (Decker, Wagner, & Scholz, 2005). The functionality of this autonomous ES approach is briefly outlined by means of a prototypical system in a proof-of-concept-test. Finally, managerial implications are drawn for both the use and development of autonomous systems supporting ES.

Ingredients and Targets of Environmental Scanning

Scopes of Environmental Scanning

A major issue in ES is balancing all of the drawbacks associated with grasping a very broad range of heterogeneous sources (which may lead to serious confusion due to irrelevant facts) with the disadvantages that emerge from ignoring or missing relevant facts by being restricted to very few or a set of homogeneous sources. Referring to Jauch and Glueck (1988), the external environment consists of the following six areas: (1) customers, (2) suppliers, (3) competition, (4) socioeconomic, (5) technological, and (6) governmental. A rather similar segmentation was introduced by Olsen, Murthy and Teare (1994), as well as by Goshal (1985), who differentiates the environment by competition, market, technology, resources, regulatory and global issues. Noticeably, all of these enumerations are restricted to external sources and, therefore, are useful for external ES only. In line with Frishammar (2002), we refer to external ES as follows:

Definition 1 (External ES): External ES is defined as both looking for and looking at information available in the six relevant areas: customers, suppliers, competition, socioeconomic, technological and governmental. These activities embrace all domains of gathering facts from external sources like competitive intelligence and market research, but take a more holistic, integrative perspective by considering consumers, competitors and technological developments in the same industry and different industries, as well.

Walters et al. (2003) provide an importance rating of various environmental sectors in the U.S. manufacturing industry matching our aforementioned definition, which is flexible with respect to the sources covered. Clearly, the focus of attention should be directed to sources related to areas considered as important in the individual business environment (Garg, Walters, & Priem, 2003). The WWW is found to be a commonly used information environment in this context. Choo, Detlor and Weibull (2000) identified the WWW as the second-most frequently used information source by CEOs in ES, dominated only by the use of mass-media information sources. In that study, consulting colleagues in the same department is the third-ranked source of information. Paradoxically, scanning internal information sources is less discussed in management literature and frequently skipped in business practice, although CEOs who match internal and external ES activities are found to perform significantly better (Walters & Priem, 1999). According to Davenport and Prusak (1998), internal knowledge can be seen as the most important source of information, as it is the only source that cannot be easily replicated by competitors and is, thus, a key factor of competitive advantage. The internal environment might be structured using Porter's (1998) value chain concept, organizational charts or the structure underlying organizations' management software systems and enterprise resource planning systems (e.g., PeopleSoft, Oracle, SAP).

In addition to the different sources to be considered, internal ES differentiates from external ES with respect to the “relevant areas,” as well. Two questions raised by Hambrick (1981) and Serpa (2000), namely “which sources” should be scanned and “which behavioral dimensions” make up the scanning process, are useful to structure the scanning issues for practitioners. The latter is targeting organizations’ culture, motivation and mood of employees as well as shifts in task-related interests; but also, hard facts, such as productivity, sales and some figures from controlling, might be of interest. Answering the first question is even more nebulous because of organizations’ heterogeneity. To give a few examples, mission and values statements, assessments of previous strategic plans, interviews with leaders of various departments, hiring policies, meeting protocols, and—of course—performance indicators as well as balanced score card evaluations can be used to find the answer to this question. Integrating the descriptions of Goodstein, Pfeiffer and Nolan (1991) and Garg et al. (2003), we define internal ES:

Definition 2 (Internal ES): Internal ES is defined as both looking for and looking at information available within an organization. Gathering information is not restricted to available indicators, but also covers informal and implicit knowledge. The activities are targeted towards already processed information concerning the organizational environment, as well as organizational resources linked with changes in the organizational environment.

The internal scanning process has a closer link to management activities, particularly to marketing planning, due to its target of organizational resources. Before an organization can cope with the task of concrete strategy formulation, it needs to gain a sound understanding not only of the external environment but also of its internal environment to match possible opportunities and threads identified in the external environment (Hough & White, 2004). Antecedents and consequences of different manners of matching organizations’ resource allocation to the contemporary external environment for creating competitive advantages have been discussed in detail by studies of the “resource-based view” of organizations (c.f. Hunt & Derozier (2004) for a recent compilation of related literature). A well-established result of these studies is the failure of business plans relying solely on external ES because implementation encounters resistance from inside the organizations. But, the question “how to gather” the relevant information appears to be a blind spot in literature, particularly in quantitative and model-related planning literature. Investigating the managerial practice, Walters and Priem (1999) found the preference for internal or external sources to be strongly linked to business strategy: CEOs of organizations committed to differentiation from competitors consider the external environment as more important than CEOs of firms pursuing a cost-leadership strategy. Xu and Kaye (1995) suggest that the balance between internal and external scanning should be 20:80. A recent study by Garg et al. (2003) provides new insights in the cohesion of environmental dynamism and successful allocation of internal and external scanning efforts in smaller manufacturing firms. Good advice to managers operating in stable environments is to emphasize internal and external environmental sectors associated with *efficiency*. In contrast, managers facing highly dynamic environ-

ments should emphasize their scanning tasks on internal and external sectors associated with *innovation*. The latter objective has received substantial attention in management literature because it makes up the interface of ES and weak signal detection (Decker et al., 2005). This interface is discussed next.

Environmental Scanning and Weak Signal Detection

The concept of weak signals as introduced by Ansoff (1975) has received substantial attention in strategic management literature. Ansoff called for a nexus between ES and weak signal detection by suggesting both scanning externally and internally for warnings.

Definition 3 (Weak Signal): Weak signals are emerging patterns of knowledge that are not explicit but rather subtle, implicit and dispersed in many sources. The separated information fragments are proximal cues for the likelihood of the same future events. Neither the direction nor the magnitude of impacts are deterministic, but might be sensitive to organizations' adaptations to changes in the business system.

When being communicated by at least one credible sender—for example, an expert of the relevant domain—the signal becomes strong. Since the strong signals are commonly received and adapted by all competitors in a market, only the identification of weak signals, before they become strong signals, offers the potential to create competitive advantages.

The environment is constantly emitting a countless number of signals revealing slight future trends and developments, and no individual or organization can pay attention to more than a small fraction of them. In the early stages, the signals are small, indistinctive marks that can hardly be separated from the background noise. But, the earlier the organization detects these weak signals, the more time it has to successfully align strategic decisions to emerging, forthcoming changes in the business environment. The central task of ES is to provide sound methodologies for the successful detection of relevant changes heralded in the information environment. Martino (2003) outlines the development of signals from poor to strong in the field of technological forecasting. Modern computer technologies can help identify the maturity of signals by means of data mining and bibliometric analysis of textual information sources. In particular, the WWW supports the timely, unfiltered provision of signals in the early stages; that is, while still fuzzy and weak in nature. These signals can be found in various white papers online of research institutes and newsgroups that discuss up-and-coming phenomena and possible future scenarios without caring too much about information quality or origin. Since information is often available on the WWW without even moderate censorship (such as typically exists in commercial/business journals and newspapers), signals heralding new developments at an early stage are more widespread than in traditional published information sources. Commercial newsvendors have to consider the impact of false information and, therefore, must be more cautious when offering information. This quality check takes time and often leads to substantial time lags in the publication

process. The most relevant characteristics of the information fragments available in the Internet are their vagueness and the absence of links to other information that would make a consistent and meaningful picture. Thus, linking information fragments from different sources is the main challenge for the identification of weak signals, according to Definition 3. While wide areas of the environment have to be scanned to detect crucial changes, the managers' information needs are often focused on a specific task, so they restrict themselves to few information sources thought to be the most relevant with respect to the task at hand. For instance, Nitse, Parker, and Dishman (2003) use multi-class interest profiles to dissect information needs according to the task environment of the managers. These profiles allow a segmentation of the information space in well-defined areas to facilitate a detailed search.

The concept of weak signal detection is frequently criticized as of limited use for practitioners because of the lack of generally accepted instructions on how to obtain the signals. However, Nikander's (2002) detailed investigation based on semi-structured interviews comes to the conclusion that weak signals exist, but the a priori identification is still challenging. Myers (1999) notes that text rich in weak signals exhibits variety and includes sources beyond those familiar to players in the immediate field of competition, and some sources may be considered illegitimate. Given different fragmented information spreading over various sources in diverse formats, both filtering of sources and combining of sources to firm up weak signals is needed. The practice of delegating these tasks to creativity or scenario workshops (e.g., Petersen, 1999) seems to be unsatisfactory for three reasons:

1. Since the participants should be experts in at least one domain, their statements are likely to be perceived as strong rather than as weak signals.
2. Due to the limitations of human information processing capabilities, the participants will previously filter with respect to their focus of interests before trying to combine information fragments in a second step (Ilomla, Aaltonen, & Autio, 2002).
3. Cutting-edge developments will be excluded because of this heuristic proceeding if the experts crowd out presumptive irrelevant information fragments in their specific domains before combining a consistent up-and-coming pattern with information fragments from other domains.

Thus, systematic ES activities might be the first step to answering practitioners' questions left open by scholarly work dealing with weak signal detection.

Integrating the Perspectives

Almost all scientific research in the area of ES is descriptive and utilities case studies (Aguilar, 1967; Correia & Wilson, 1997; Ebrahimi, 2000; Miller & Friesen, 1977; West, 1988). Despite the amount of empirical research that has been done, Choo et al. (2001) as well as Hough and White (2004) point out that the theoretical understanding of organizational ES is still limited. Xu and Kaye (1995) remark that despite all research

efforts in the field of ES, insights in the question of *how* information is actually processed into managerial decisions still remains hidden in a black box. The lack of generally accepted theories that combine the different aspects of temporal (e.g., how to gain future orientation instead of a retrograde perspective), methodological (e.g., which scanning modes should be followed) and thematic (e.g., which areas of the information environment are most important) issues in ES leads to the problem that the results of these studies are mostly restricted to interpretations in the context of a specific organization or industry. Due to this, an exhaustive generalization of these results still appears to be a blind spot in the literature (Hough & White, 2004).

Several reasons might account for these deficits, but two obstructions are rather obvious. First, the studies are constricted by their subject—for example, Business Intelligence (BI) or Competitive Intelligence (CI). Second, most of the studies are constricted by their perspectives, which cover either the combinations of signals from various sources, the information overload or human information processing. Figure 1 visualizes the relations between the aforementioned subjects and perspectives.

As we can see in Figure 1, internally available information is mostly accessible in BI, due to electronic records of consumer transactions that become standard with modern ERP and CRM software tools. In CI, the use of internal information is also an established business practice; for example, in terms of sales force reports and debriefing of new employees that have worked previously with competitors (Xu & Kaye, 1995).

Only a fraction of the relevant aspects of the external environment are typically existent

Figure 1. Subjects and perspectives in IS

in the internal environment. This information consists of prior aggregated information about the environment, such as historical data (e.g., marketing research reports) or previously developed future scenarios about developments to be reconsidered in the light of new emerging phenomena. According to Davenport and Prusak (1998), intranet technologies provide promising solutions for managing knowledge repositories and allow quick access to the sparse and distributed internal knowledge about the external environment.

Analogically, the Internet—in particular, the WWW—provides the manager with excellent external information. Trends in business, science, society and politics are digitally announced on the WWW long before their consequences are observed in the real world (Decker et al., 2005). McGoangle and Vella (1998) argue that 90% of all information needed by a company to make critical decisions is already public or can be systematically developed from public data. Due to the fact that the WWW is both a publishing medium and an indispensable element of daily communication, almost all up-and-coming real-world phenomena are discussed in the virtual reality of the WWW. Therefore, Choo et al. (2001) refer to the Internet as a “social information space.” Tan, Teo, Tan, and Wei (2000) argue that the WWW changes the traditional approach to ES in the following ways: It allows smaller organizations to overcome resource barriers. It changes the role of external consultants by shifting the focus from information acquisition to consultancy, and also provides organizations with quick, up-to-date information about competitors that was previously unavailable. However, due to the massive information supply—Google already indexes more than eight billion Web pages—efficiently searching this information space requires a considerable understanding of ways to manage the selection of information fragments, primarily because the WWW opens up a mind-blowing volume of ill-structured information. Search engines provide fundamental support in detecting relevant information, but are far from being sufficient tools for ES. The dynamic and largely unregulated nature of the WWW is making it increasingly difficult to locate relevant information at reasonable costs (Chen, Chau, & Zeng, 2002). Ding and Marchionini (1996) found the precision ratios of search engines to be rather poor. Testing three search services, they discover that less than 55% of the first 20 retrieved Web pages match the query. Moreover, Lawrence and Giles (1999) have estimated that search engines index only 16% of all information sources available on the Internet. This means that new information capturing weak signals is not linked with already established and indexed Web sites, so it is likely to be ignored. Building upon Stigler’s (1961) search theory, information foragers have to balance information quality with information price (e.g., search time) (Harrington, 2001). Noticeably, search engines do not provide any reference to the credibility of the information originators, such as humans are used to in assessing printed media. The only hints given by search engines are a few key words describing an information source and an assessment of congruity with the query (Nielsen, 2000). However, from a practitioner’s perspective, an integrated framework guiding and systematizing the ES process would be very beneficial in increasing efficiency as well as clarifying the information needs and, thus, triggering the ES process in a dynamic, volatile and unstructured environment such as the WWW.

An Integrative Framework for ES and Decision-Making

The scanning process is influenced by three constitutive subsystems: stages of the human decision-making process, modes of searching in this information environment and the design of the computer system support used to aid the scanning process. These subsystems and their interactions have a substantial impact on the overall quality of results (Slaughter, 1999). Next, we outline the subsystems and their main constraints influencing the ES process in detail.

Human Decision-Making

From the strategic perspective of a managerial decision-maker, the deliberative and rational decision-making progress is a sequence of five stages: (1) give attention to a problem or opportunity, (2) collect information, (3) develop a set of alternatives, (4) evaluate the alternatives by expected costs and benefits and, finally (5) choose the alternative offering the maximal utility (Frederickson, 1984; Mitchell & Beach, 1990). From the information-processing perspective, the unpredictable and dynamic environment forces managers to search for additional environmental information (Hough & White, 2004). Actually, the supportive activity of ES is mainly done in the first four stages of the decision-making process.

First Stage: Give Attention to a Problem or Opportunity

Empirical studies support the thesis that too much information negatively affects the quality of decisions as much as insufficient information does (Buchanan & Kock, 2001). Cognitive psychological research provides detailed information as to how human beings perceive stimuli (Anderson, 2000). It has been shown that human beings possess a screening mechanism for stimuli (Neisser, 1987); that is, when a stimuli reaches the brain it takes less than 5 seconds to decide whether or not it is interesting for the receiver. This implies a reduction of the real world's complexity through mental models for human information processing (Johnson-Laird, 1983). The accuracy of these mental models can vary as a result of personal traits and the state of expertise of the manager as well as the characteristics of the business environment that has to be modeled (Day & Nedungadi, 1994; Reger & Palmer, 1996). There is empirical evidence that managers' mental models also influence their decisions and firms' outcomes (Huff, 1990).

The constraints in human information processing strongly affect the decision-making process presented above. The manager can only scan and process a small fraction of the business environment at a time (Analoui & Karami, 2002). The manager's focus of attention and awareness of certain phenomena determine the problems and opportunities noticed in the business environment. According to Hamrefors (1998), the design of scanning activities has a major impact on the perception of environmental information.

Only if the person is in constant interaction with other persons or at least intelligent systems will that person be able to enrich the given information with new and varying perspectives to gain a satisfying picture of the real-world situation.

Second Stage: Collect Information

The mental model of the manager is a key driver of his or her actions in the second stage of the decision process, where information is gathered to expand the already existing knowledge. Mental models can help recognize and understand new phenomena apparent in the business environment, but can also lead to serious inertia, misinterpretations or even ignorance, because managers tend to maintain accustomed ways of thinking and interpretation (Nystrom & Starbuck, 1984; Rouse, 2002). Slaughter (1999) argues that the empirical scanning frame is inclined to overlook phenomena that do not respond to already established "ways of knowing." That is, the manager's cognitive representation leads his attention to well-known concepts and induces a prejudiced perception of the real world. Thus, it is important not only to avoid lapsing into familiar patterns, but also to be open-minded to new interpretations and environmental constellations that necessitate new concepts.

Third Stage: Develop a Set of Alternatives

Similar cognitive structures become operative in the third stage when sets of alternatives are evaluated. One of the key elements to solving a problem is to find a good way to represent the problem (Simon, 1973). Newell and Simon (1972) proposed that problem solving consists of a search in a given problem space. This space has an initial state, a goal state and a set of operators that can be applied to move the solver from one state to another. Bigger problems are usually characterized by a richer gamut of options at any point of the problem space. In contrast to formal decision theory, the problem solvers are not presumed to have the entire problem space represented in their mind when they are trying to solve the problem. In many situations, they will not be able to consider all possible problem states and will have to search the problem space to find the solution. Thus, one of the most important aspects of problem solving is searching for a path through the problem space that will lead to the goal state. Human problem solvers frequently use heuristics that allow them to move through a problem space (Krabuanrat & Phelps, 1998).

A different approach to problem solving claims that the crucial process is insight instead of search (Davidson, 1995). Thus, managers should scan for new, additional information from internal and external sources, but also take time to find new perspectives to the accessible organization's knowledge. This could imply the extensive use of executive information systems (EIS), which are especially helpful when applying exploration metaphors for discovery in warehouses, such as data cubes (Riedewald, Agrawal, El Abbadi, & Pajarola, 2000). Usually, internal sources are scanned first to identify a solution for the problem at hand. If this does not satisfy the information needs, external sources are taken into account.

Fourth Stage: Evaluate the Alternatives by Expected Costs and Benefits

The fourth stage is also affected by the characteristics of human mind. Humans have difficulties in the assessment of new information structures, but are rather good at recognizing already-assessed information structures (Rouse, 2002). This backward orientation means that mostly old and well-experienced cognitive models are used instead of building up new insights in the developments of the environment (Nystrom & Starbuck, 1984). Nastanski (2004) supports this thesis with his findings in a recent explorative study. The meaningful interpretation of changes and the communication of these insights to others are regarded as key issues in surveyed high-technology organizations. That is to say, information should be presented in familiar ways so other managers can grasp and evaluate the issues quickly and easily. Up to now, managers are trained in exploiting documents focusing on delimited and explicit phenomena rather than combinations of information fragments gathered from the WWW.

Fifth Stage: Choose the Alternative Offering the Maximal Utility

In the fifth phase, there is a shift in management intention. While in former stages information was processed to firm up the picture of the world, in this stage, information is used to argue the chosen decision. Referring to the “classical” marketing planning process, as illustrated, for instance, by McDonald (2000), this stage refers to the strategy formulation process. Often, well-known and established modes of representation, such as those contributed by marketing theory (e.g., Porter or BCG matrixes) are used in this phase. ES is used for confirmation or monitoring of already anticipated theoretical concepts—making up the managers’ mental models—as well as related observed phenomena.

In sum, the five stages of the managerial decision process are characterized by different qualities of previous knowledge and—as a consequence thereof—different information needs, which call for diverse strategies in obtaining new information. To avoid inefficiencies or—even worse—fall into the trap of ignorance, the information-seeking strategies should match the concerns of the decision maker’s mental model.

Modes of Searching in this Information Environment

Organizations have to cope with substantial interdependencies in their external environment. These interdependencies lead to three challenges organizations have to meet (Frishammar, 2002; Liu, 2001):

- Interdependencies call for a broad view of the external environment, since many factors can influence the existing and future business.
- Internal factors, particularly resource related, need to be evaluated.

- Due to the complexity and irreversibility of modern business strategies, an alignment to changes of these factors takes time.

In ES literature, different ways of gathering information are frequently described (Ebrahimi, 2000; Hough & White, 2004; Wilson, 1997). In his seminal work, Aguilar (1967) distinguishes four types of scanning behavior: (a) undirected viewing (which is executed without a particular purpose); (b) conditioned viewing (the individual is able to assess the value of the exposed information); (c) undirected search (as an unstructured search process); and (d) formal search (where the manager is actively searching for information or solutions to a specific problem).

Wilson (1997) proposes a different categorization. He labels the acquisition of information without purpose as passive attention (a), and passive search (b) as when new information is obtained during the search for information of a different kind. Active search (c) refers to the process of actively looking for certain information. Ongoing search (d) describes the process of searching for information when a basic comprehension of the search area already exists and the search should extend the available understanding of ideas, opinions, values and so forth.

While these classifications give a detailed description of how managers can obtain access to new information, we will present a separation of information-gathering behavior that refers to the state of the manager's mental model. The manager's mental model directly determines his information needs and, ultimately, affects his or her scanning behavior.

If the manager strives to extend the existing mental model, he will scan the environment to find new phenomena and concepts as yet unknown to him. A manager even may be exposed unexpectedly to information that might be of interest but is not already cognitively represented, thus perhaps discovering a new phenomenon or concept. This detection happens in an active, but random, manner, since no sophisticated concepts are available to guide or search for these new phenomena. Of course, the probability of detection is interlinked with the manager's disposition and exposition to the environment. Correspondingly, this mode of scanning behavior will be characterized as *discovery*. In the discovery mode, the identification of weak signals according to Definition 3 is one of the dominant challenges.

If the manager already possesses a fairly rough cognitive representation of an interesting phenomenon, it is useful to refine and amend the concepts with further information. New information sources are actively searched or passively exposed to improve basic understanding and interpretations. In doing so, the manager increases expertise in this particular area of the information environment. This mode of information seeking will be called *expansion*. If any weak signals have been discovered successfully in the previous stage, the managers have to engage external ES activities according to Definition 1 in this stage.

A manager who just wants to update an already well-developed mental model is searching for changes of certain constructs and interrelations between constructs in his model. He is able to easily specify the relevant areas and factors in the environment. By gathering information about the external environment, he monitors these determinants. Accord-

Table 1. Assignment of scanning modes to the stages of the managerial decision process

Managerial decision-making process	Scanning modes by Aguilar (1967)	Scanning modes by Wilson (1997)	Scanning modes presented in this chapter
1) Give attention to a problem or opportunity (e.g., weak signal identification)	(A) undirected viewing + (B) conditioned viewing	(a) passive attention + (b) passive search	Discovery
2) Collect information (mostly external ES)	(B) conditioned viewing + (C) informal search	(b) passive search + (c) active search	Expansion
3) Develop an array of options/alternatives (shifting to internal ES)	(D) formal search	(d) ongoing search	Monitoring
4) Assess and evaluate alternatives or options using expected costs and benefits (Combining information from internal and external ES)	(D) formal search	(d) ongoing search	Monitoring
5) Select alternative (Evaluating and utilizing already combined information from internal and external ES)	(D) formal search	(d) ongoing search	Monitoring

ingly, we refer to this information-gathering activity as *monitoring*. Since the organizations’ resources as well as previously processed knowledge and all experiences accumulated within the organization are relevant for the development of options and alternatives, a shift in attention from external to internal ES is recommended in this stage of the decision process.

These categories of scanning behavior can be correlated to each other and assigned to the five stages of the decision-making process discussed earlier:

Practitioners can use the category distribution illustrated in Table 1 to choose the corresponding scanning mode for a managerial decision problem at hand. Of course, this topology is not exclusive, but rather denotes the main modes of scanning behavior for each stage. Referring to the managerial decision-making process presented above, each stage is assigned to at least one stage of mental model development. Therefore, the managers’ mental models constitute a bridge between information searching and decision-making processes. The question of which scanning behavior is the best choice is strongly related with the perception of the environment as well as the already gained mental model of the relevant information environment. If substantial knowledge about a certain problem has already been obtained, *monitoring* turns out to be appropriate; if a rather new phenomenon is realized that cannot be consistently integrated or explained with the existing mental model, *expansion* seems to be the appropriate searching behavior. *Discovery* can be seen as augmenting the mental model with newly discovered

information that is not necessarily important for tasks at hand, but could turn out to be significant in future tasks.

Pawar and Sharda (1997) discuss the relationship between the aforementioned scanning modes and corresponding Internet utilities. When conducting discovery activities, lists, Web catalogs (such as those provided by Yahoo), newsgroups and search engines are helpful in supporting ES activities. In particular, the integration of advanced functions in commercial Web services like Google and Ask Jeeves, such as the automatic identification of similar sites, supports search processes in the Internet for up-and-coming weak signals. In the modes of expansion and monitoring, further Web utilities, such as FTP servers, are helpful extensions in information seeking. Moreover, the "outsourcing" of information collection activities by using commercial online databases such as Lexis-Nexis, Dow Jones or Dialog is found to be supportive in ES. Chen et al. (2002) assert that these online databases are among the main sources for CI professionals.

With increasing understanding of new phenomena in the business environment—which is a basic premise for expansion and, especially, monitoring—search engines have become more and more expedient support tools because search queries can be conducted and varied based on the already elaborated, existing mental model of the manager.

Computer Systems Used to Aid the Scanning Process

Even without the use of intelligent systems, CEOs search regularly for information on the WWW (Tan & Arnott, 1999). Nowadays, the Internet provides several billion documents (Long & Suel, 2003) largely designated for cost-free use. Boncella (2003) gives an overview of the search engines and their use in the context of competitive intelligence. These search engines have several drawbacks. A search engine only proposes simple links that have to be followed manually. Also, these search engines frequently provide too many irrelevant responses. Fine-tuning or the use of advanced search engines takes time and requires special knowledge. Information systems can absorb redundancies in the information space, structure the information search and filter the information available in the information environment (Myers, 1999). One aim of technical developments in ES systems is to develop sensitive and context-dependent reductions of the massive information overload that makes up the environment in which modern businesses must operate. ES systems have to pare away almost all of the theoretically available information. Xu and Kaye (1995) recommend that the transition from data-overloaded systems to intelligence-dominated systems could be achieved by conceptualizing human-computer-based information filtering and processing as an essential part of ES systems. Although many studies have investigated the effects of multimedia systems, their impact on managerial decision-making is not well understood (Huang, 2003). Recently, in information retrieval literature, there has been a shift from technology-centered to human-centered approaches in developing new support tools to find, extract, understand and use information available from electronic information environments (Kerne & Smith, 2004). Mental models not only facilitate the link between managerial decision making and ES, but are also helpful in describing the tasks and information needs of computer support in ES. The central task to all of these processes is the adequate assessment and classification of information available from different sources. Nodine,

Fowler, Ksiezyk, Taylor and Unruh (2000) indicate that the crucial process of information gathering is still done manually. They found that corresponding tools are used only 20% of the time to gather or analyze information.

Contrasting the limitations of the human mind and the complexity of modern business environments, computer systems are the most important utilities to supporting the ES process (Liu, 2001; Walters et al., 2003). However, especially in EIS, the support of ES activities is considered to be the least sophisticated part of decision support systems (Singh, Watson, & Watson, 2002). The inference and transfer of the user's information needs to software tools is often badly realized (Nitse et al., 2003). Seeley and Targett (1999) note that the introduction of new EIS frequently leads to reluctance in applying by chief executives. Since system developers assume that information needs can be easily elicited, the importance of developing and describing accurate information needs when designing EIS might be neglected. However, senior managers do not consider the identification of their information needs as their own responsibility. These obstacles are underscored in several studies that consistently identify the provision of timely, accurate and relevant information as the most critical problem for EIS (Rainer & Watson, 1995).

The framework developed herein explicitly addresses this main challenge. The interaction with the two other subsystems turns out to be useful in overcoming contemporary deficits in computer support systems. A successful system must strongly integrate concepts and limitations of managerial thinking and decision making that can be represented in mental models. A sound understanding of the user's way of thinking and the underlying information needs allows a customization that will increase the usability of the system. Again, empirical studies highlight these shortcomings. According to Wright et al. (2002), information overload and timely retrieval of information are stated as the most common problems in information gathering. Consequently, most of the existing software tools are still insufficient because of not fitting to the cognitive, structural and technological needs outlined in the framework above. To clarify these drawbacks, we will discuss two recent approaches to computer support for ES on the WWW—MasterScan and CI Spider. In line with the definitions of ES presented above, we separate ES software tools from standard CI software to facilitate a more complete and accurate comparison. Readers interested in a review of recent CI software tools are referred to Fuld and Company (2003). The two computer systems that claim to facilitate ES activities are described below. MasterScan, developed by Liu (1998), is a prototypic software agent that exemplarily executes scanning tasks for the pulp and paper industry. This system visits previously defined Web pages and gathers relevant information from these sources. The MasterScan is just able to extract information from pre-selected sources by comparing the content of these Web sites with the results from previous visits. Following the definition of scanning behavior suggested by Wilson (1997), the system only supports ongoing search activities. Therefore, it is primarily a *monitoring* tool unable to browse for new sources and detect information that is weak in the sense that basic ideas and concepts about this data have not yet been elaborated.

In a more recent approach, Chen et al. (2002) developed a tool for competitive intelligence on the Web that is also based on software agent technology. The CI Spider tries to avoid the principal shortcomings of classical search engines by generating its own structure for the retrieved documents and displaying them in a two-dimensional chart "on the fly."

The user has to specify a starting URL and the keywords used to evaluate the links and the documents found by the spider. Although the functionality of the CI Spider exceeds the well-known search engines, the user still must have a rather complete picture of the topics he or she wants to scan or monitor on the Web.

Although the development of appropriate tools is still in progress, some shortcomings can be outlined. Both of the aforementioned systems facilitate only the scanning modes of *monitoring* and—to some extent—*expansion*. The third mode of scanning behavior, *discovery*, is still not supported. This mode is crucial for detecting changes in the business environment and provides a trigger for the whole strategic decision-making process. While bad information quality can seriously harm the decision-making process, the total ignorance of future developments that are not even considered as problems (or opportunities) can lead to even more disastrous effects on business performance. The task of internal ES as introduced in Definition 2 is not supported at all by the aforementioned tools.

Undoubtedly, the task of discovering crucial developments in the external environment is challenging. The main reasons for the still missing link to *discovery* are rooted in the restricted understanding of human information-seeking processes and its appropriate transfer to mathematical models that can be implemented on computer systems. In the remainder of this chapter, we will present the IFT as a mathematical approach to model human information-seeking behavior and combine it with the detection of weak signals.

Information Foraging Theory

Basic Principles of IFT

To outline an approach that simultaneously deals with the three constitutive subsystems (stages of the human decision-making process, modes of searching in this information environment and computer systems used to aid the scanning process) as discussed, we draw on the IFT first introduced by Sandstrom (1994). IFT is a model that takes the characteristics of the virtual information environment into account, explicitly includes the limited information capacity of humans and facilitates a mathematical reproduction and handling of these problems in ES. Consequently, IFT is a suitable vehicle to overcome the obstacles emerging from the interdependence of the three subsystems and, thus, makes an ideal vehicle for autonomous ES on the WWW.

IFT models the forager's behavior while trying to deal with the constraints given in the information environment as well as its own limited capacity of information processing. The basic model of information foraging is based on the Patch and Prey Model of Optimal Foraging Theory, which assumes that information is structured in patches (describing the spatial neighborhood of information sources) and the forager has to decide which patches should be visited for which amount of time (Pirolli & Card, 1999; Stephens & Krebs, 1986). The forager has to cope with two basic decision problems: First, he or she is unable to access all information sources, so the forager has to select the most valuable

sources of information he or she is able to handle in a given time. In analogy to the Optimal Foraging Theory, Pirolli and Card (1999) refer to this selection as *information diet*. The basic principles of choosing this diet will be discussed later.

Second, the forager has to assess which information sources he or she wants to access. Imperfect information is used to decide which paths through the information environment should be followed; for example, which documents (information representations) should be selected. The forager uses proximal cues to assess profitability and the prevalence of information sources and their representations. This imperfect perception of the value, cost or access path of information is labeled as *information scent*.

The Model

The construction of the optimal *information diet* is modeled by the heuristic outlined in the following. IFT states that the behavior of information foragers follows the maximization of the rate of gain of valuable information per time unit cost (Pirolli & Card, 1999):

$$\max R = \frac{G}{B+T} \quad (1)$$

where R is the ratio between the total net amount of valuable information gained, G , and the total time spent on searching this information; for example, the cumulative time spent on switching from one information source to the next, B , and the total time spent on extracting and handling the relevant information from the information representations, T .

Assuming that a set of I information sources is available in the business environment that can be separated into two patches, $h=1, 2$, with $h=1$ referring to information sources (documents in the latter) in the external environment and $h=2$ denoting documents in the internal environment. The average ratio of gain of information from the information environment h can be considered as follows¹:

$$R(I_h) = \frac{\sum_{i=1}^{|I_h|} \lambda_h \cdot g_{hi}}{1 + \sum_{i=1}^{|I_h|} \lambda_h \cdot t_{hi}} \quad \forall h \quad \text{with} \quad T = \sum_{h=1}^H \sum_{i=1}^{|I_h|} t_{hi} \quad (2)$$

where g_{hi} is the gain of document $d_{hi} \in I_h$ extracted in time t_{hi} and $\lambda_h = 1/b_h$ is the encounter rate (e.g., prevalence) of relevant documents in environment h derived from the average time needed to encounter a document (with $B = \sum_{h=1}^2 \sum_{i=1}^{|I_h|} b_h$, in case of exploiting all documents in I). It should be noted that the gain of documents might differ between the

environments because the documents might differ with respect to length, structure and so forth, and last but not least, relevance. The profitability π_{hi} of document d_{hi} is given by:

$$\pi_{hi} = \frac{g_{hi}}{t_{hi}} \quad (h = 1, 2, \quad i = 1, \dots, I_h) \quad (3)$$

Construction of an Optimal Information Diet

The following algorithm can be used to determine the rate-maximizing subset of information sources given in information environments $h=1,2$ that should be selected and extracted by the forager (Pirolli & Card, 1999; Stephens & Krebs, 1986):

1. Rank the information sources by their information profitability. For simplicity of presentation, let the index i be ordered such that:

$$\pi_{hi} > \pi_{h(i+1)} \quad (h = 1, 2, \quad i = 1, \dots, I_h)$$

2. Add information sources to the diet until the rate of gain of information for a diet of the top n information sources is greater than the profitability of the $n + 1$ information source:

$$R(n) = \frac{\sum_{h=1}^2 \sum_{i=1}^{n_h} \lambda_{h'i} \cdot g_{h'i}}{1 + \sum_{h'=1}^2 \sum_{i=1}^n \lambda_{h'i} \cdot t_{h'i}} > \frac{g_{h(n+1)}}{t_{h(n+1)}} = \pi_{h(n+1)} \quad (h' = 1, 2), \text{ with } n = n_1 + n_2 \quad (4)$$

Equation 4 provides a criterion for the selection from an ongoing stream of information and, therefore, advises not only how to devote the limited attention to the external or internal environment scanning activities, but also gives clear advice on which documents or sources should be considered.

Accessing the Information Gain

The information gain of a document is appraised by means of its relevance in a given context. The relevance of information depends on the information needs directly connected to the manager's mental model. Referring to Rouse (2002), the value space of information is made up of the following three dimensions:

- **Usefulness:** the extent to which information represents the intentions of the user.
- **Usability:** the extent to which information can easily be assessed, digested and applied.
- **Urgency:** the extent to which information contributes to near-future aims of the user.

Due to the given information overload of the WWW, the relevance of a document is not evaluated by reading documents in their entirety, but rather by pre-estimating the value of a document through proximal cues. These proximal cues are singular language expressions, name of authors or location of the information source. Thus, we represent each document d_{hi} by means of an L -dimensional vector, where each dimension captures a language expression that occurs in the world. Fauconnier (1997) argues that a language expression does not have a meaning in itself, but rather has a meaning potential. The assessment of the *information scent* by means of language expressions that embody proximal cues is modeled by a spreading activation network.

According to Anderson (1990), the activation of a memory fed with a proximal cue should be the sum of the base-level activation for that stimulus plus the activation that spreads to it from elements in the current context. As a Bayesian prediction of the relevance of a language expression k , the following formula proposed by Anderson (1990) in the context of his well-known adaptive control of thought (ACT-R) theory is applied:

$$A_k = C_k + \sum_l W_l S_{kl} \quad (5)$$

with:

- A_k : Association strength of term k
 C_k : Base-level activation of term k
 S_{kl} : Association strength of term l on element k in the current context
 W_l : Base-level activation of term l

The base-level activation of different language terms varies due to the given mental model of the manager. Language expressions that refer to relevant concepts in the mental model of the manager ought to have high association strengths, whereas low strengths denote dissociated terms. The association strength of a proximal cue (language term or concept of the mental model) is computed with the help of the following three equations (Pirolli & Card, 1999):

$$C_k = \ln \left(\frac{p(k)}{p(\bar{k})} \psi \right) \forall k = 1, \dots, K \quad (6)$$

$$W_l = \ln \left(\frac{p(l)}{p(\bar{l})} \psi \right) \forall l = 1, \dots, k-1, k+1, \dots, K \quad (7)$$

$$S_{kl} = \ln \left(\frac{p(l|k)}{p(l|\bar{k})} \psi \right) \quad \forall l \neq k \quad (8)$$

with $p(k)$ and $p(l)$ denoting the probabilities of language expressions k and l occurring in the world, while $p(\bar{k})$ and $p(\bar{l})$ reflect the probabilities that term k and l will not occur in the information environment. The posterior probabilities $p(k|l)$ and $p(k|\bar{l})$ denote the conditional probability of the occurrence of term l in the context of term k and the conditional probability of term l occurring in a context that does not contain word term k . The normalizing constant ψ is applied to yield positive values only.

The resulting *information scent* arising from the association strengths of language expressions that make up managers' mental models and occur in document d_{hi} is used to appraise the information gain of each document:

$$g_{hi} = \exp \left(\frac{\sum_{k \in (Q \cap d_{hi})} A_k}{Z} \right), \forall d_{hi} \in I, \quad (9)$$

where Z is a scaling factor that is estimated on an a priori characterization of the information environment (see Pirolli and Card (1999) for details). The set of relevant terms q is derived from the mental model of the manager. We denote this set of relevant terms as information structure. Scholz and Wagner (2005) show that this information structure is robust against serious contamination of irrelevant language expressions.

Proof-of-Concept Test

We implemented the above model in a prototypical scanning system to scrutinize its validity in the context of ES. Therefore, we selected 50 articles of the Reuters test text collection (Lewis, 1997), all of which refer to the domain of finance in various ways. We defined a typical scanning task. The task was to extract valuable information about up-and-coming general developments of financial markets. Due to globalization, Babbar and Rai (1993) argue that this domain is very important in ES. First, three experts were surveyed to elicit relevant concepts of their corresponding mental models helpful in dealing with this task. Subsequently, the three experts were asked to read each document in its entirety and evaluate the information gain by means of the Delphi method. The experts used a 12-point scale. Documents with high relevant information were given 12 points while documents containing no relevant information received 0 points. The

Figure 2. Distribution of experts' evaluation and information diet of the prototypical system

Figure 3. Relationship between profitability (π_{hi}) and rate of gain (R) for diet including items

average assessment of documents led to 4.1 points. The distribution of the experts' assessments is given in Figure 2.

The prototypical scanning system was instructed with the same task. The information structure of 129 language expressions was elicited from the experts' mental models. Figure 3 shows the computations of the profitability of the ordered 50 documents as well as the corresponding rate of gain as introduced in Equation 4. Function $R(n)$, which denotes the rate of gain for diet including items, increases as the diet is expanded up to five items and then starts to decrease slowly as additional items are added to the diet. Consequently, the optimal information diet consists of the five top-ranked documents only. It was found that this number is similar to the amount of documents selected by human experts confronted with the same task (Decker et al., 2005). In selecting five documents, the system yields an average performance of $(9+9+10+11+12)/5 = 10.2$ points (see Figure 2). While this result does not obtain the optimum average performance (which would have been $(10+10+10+11+12)/5 = 10.6$), it can be seen as a rather satisfying result. Thus, IFT proves to be able to use proximal cues to assess and select the relevance of documents in this ill-defined scanning task.

Conclusion and Managerial Implications

ES is found to be an overly complex task due to the spectrum of different subjects and perspectives. Starting from a distinction of external and internal ES, the weaknesses in current ES, BI and weak signal detection are explored with emphasis on digital resources available on the WWW. Linking these activities to the stages of the managerial decision-making process enables practitioners to choose a suitable sequence of information-gathering activities with respect to their individual situation. This may help overcome the problems of unsystematic ES processes prevailing in current business practices.

The Internet constitutes an ideal collection of resources to make up a well-elaborated mental representation of future changes. We argue that these mental models provide an expedient approach to understanding the shortcomings as well as the premises of promising ES activities. With respect to practitioners, it should be noted that new information has to be presented in familiar structures to enhance integration in already-existing mental models. Thus, the information-gathering activities must be adapted to the current knowledge infrastructure as well as the managerial decision problem at hand.

Scanning activities are done in different modes, which are related to the stages of the decision-making process as well as to the internal and external ES scopes. It turns out that the most crucial task in ES—the detection of new developments by means of weak signals identification—is not covered completely by already established typologies of scanning behavior modes. This also holds for current available ES software systems that support monitoring activities on the WWW. An additional drawback, particularly relevant from a practitioners' point of view, is the missing assessment of the information gained through documents monitored by these systems.

A remedy for this is introduced by a prototypic system based on the IFT. In a proof-of-concept test, the prototypic system shows promising performance in the identification of relevant information sources and significantly reduces the amount of information to be processed by humans. The most remarkable feature is the content-dependent ordering of sources combined with computing of the maximal number of documents to be studied by the managers. By considering information from sources arriving with different intensities, this approach offers an opportunity to balance internal and external ES with respect to the documents' content and the already-existing information structure. Rules of thumb are not needed anymore. In summary, it offers an operationalization of autonomous ES in virtual information environments, such as the WWW, but clearly has limitations. The current approach is restricted to written documents, unable to evaluate any kind of figures or numbers. Moreover, it is limited to information in written form—that is, verbal information cannot be considered. The next challenge is to evaluate the system proposed herein by managers in real-world ES tasks.

References

- Aguilar, F.J. (1967). *Scanning the business environment*. New York: Macmillan.
- Analoui, F., & Karami, A. (2002). How chief executives' perception of the environment impacts on company performance. *Journal of Management Development*, 21(4), 290-305.
- Anderson, J.R. (1990). *The adaptive control of thought*. Hillsdale: Lawrence Erlbaum.
- Anderson, J.R. (2000). *Cognitive psychology and its implications* (5th edition). New York: Worth Publishing.
- Ansoff, I.H. (1975). Managing strategic surprise by response to weak signals. *California Management Review*, 17(2), Winter.
- Babbar, S., & Rai, A. (1993). Competitive intelligence for international business. *Long Range Planning*, 26(3), 103-113.
- Boncella, R.J. (2003). Competitive intelligence and the Web. *Communications of the Association for Information Systems*, 12, 327-340.
- Buchanan, J., & Kock, N. (2001). Information overload: A decision making perspective. In M. Koksalan & S. Zionts (Eds.), *Challenges for MCDM in the new millennium* (pp. 49-58). Berlin: Springer.
- Chen, H., Chau, M., & Zeng, D. (2002). CI-Spider: A tool for competitive intelligence on the web. *Decision Support Systems*, 34, 1-17.
- Choo, C.W., Detlor, B., & Turnbull, D. (2000). *Web work—Information seeking and knowledge work on the World Wide Web*. Dordrecht: Kluwer.
- Choo, C.W., Detlor, B., & Turnbull, D. (2001). *Information management for the intelligent organization: The art of scanning the environment* (3rd edition). Medford: Information Today.

- Choudhury, V., & Sampler, J.L. (1997). Information specificity and environmental scanning: An economic perspective. *MIS Quarterly*, 21(1), 25-53.
- CIO-Insight (2003, May 15). *Research: Business Intelligence 2003 - Are your BI systems making you smarter*. Retrieved April 1, 2003, from www.cioinsight.com/article2/0,3959,1098923,00.asp
- Correia, Z., & Wilson, T.D. (1997). Scanning the business environment for information: A grounded theory approach. *Information Research*, 2(4), Paper 21. Retrieved November 8, 2003, from <http://informationr.net/ir/2-4/paper21.html>
- Daft, R.L., Sormunen, J., & Parks, D. (1988). Chief executive scanning, environmental characteristics, and company performance: An empirical study. *Strategic Management Journal*, 9(2), 123-139.
- Daniels, K., Johnson, G., & De Chernatony, L. (2002). Task and institutional influences on managers' mental models of competitions. *Organizational Studies*, 23(1), 31-62.
- Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.
- Davidson, J.E. (1995). The suddenness of insight. In R.J. Sternberg & J.E. Davidson (Eds.), *The nature of insight*. Cambridge: MIT Press.
- Day, G.S. (2002). Managing the market learning process. *Journal of Business and Industrial Marketing*, 17(4), 240-252.
- Day, G.S., & Nedungadi, P. (1994). Managerial representations of competitive position. *Journal of Marketing*, 58(2), 31-44.
- Decker, R., Wagner, R., & Scholz, S.W. (2005). Environmental scanning in marketing planning—an Internet-based approach. *Marketing Intelligence & Planning*, 23(2), 189-199.
- Ding, W., & Marchionini, G. (1996). A comparative study of the Web search service performance. In S. Hardin (Ed.), *Proceedings of the 59th Annual Meeting of the American Association for Information Science*. Medford: Information Today.
- Dishman, P., Fleisher, C.S., & Knip, V. (2003). Chronological and categorized bibliography of key competitive intelligence scholarship: Part 1 (1997—present). *Journal of Competitive Intelligence and Management*, 1(1), 13-79.
- Dishman, P., & Pearson, T. (2003). Assessing intelligence as learning within industrial marketing group: A pilot study. *Industrial Marketing Management*, 32, 615-620.
- Dollinger, M.J. (1984). Environmental boundary spanning and information processing effects on organizational performance. *Academy of Management Journal*, 27(2), 351-368.
- Ebrahimi, B.P. (2000). Environmental complexity, importance, variability and scanning behavior of Hong Kong executives. *International Business Review*, 9, 253-270.
- Fauconnier, G. (1997). *Mappings in thought and language*. Cambridge: Cambridge University Press.

- Frederickson, J.W. (1984). The comprehensiveness of strategic decision processes: Extension, observations, future directions. *Academy of Management Journal*, 27, 445-466.
- Frishammar, J. (2002). Characteristics in information processing approaches. *International Journal of Information Management*, 22, 143-156.
- Fuld & Company. (2003). *Intelligence software report 2003: Leveraging the Web*. Retrieved January 2, 2004, from www.fuld.com/Products/ISR2003/HomePage.html
- Garg, V.K., Walters, B.A., & Priem, R.L. (2003). Chief executive scanning emphases, environmental dynamism, and manufacturing firm performance. *Strategic Management Journal*, 24, 725-744.
- Goodstein, L.D., Pfeiffer, J.W., & Nolan, T.M. (1991). Applied strategic planning: A revised model for organizational growth and vitality. In J.W. Pfeiffer (Ed.), *Strategic planning, selected readings* (pp. ix-xxxix). San Diego.
- Goshal, S. (1985). *Environmental scanning: An individual and organizational level analysis* (unpublished doctoral dissertation). Cambridge, MA: Massachusetts Institute of Technology.
- Hambrick, D.C. (1981). Specialization of environmental scanning activities among upper level executives. *Journal of Management Studies*, 18, 299-320.
- Hamrefors, S. (1998). Spontaneous environmental scanning. *Competitive Intelligence Review*, 9(3), 68-75.
- Harrington, J.E. (2001). Comment on "Reducing Buyer Search Costs: Implications for Electronic Marketplaces." *Management Science*, 47(12), 1727-1732.
- Hodgkinson, G.P. (1997). Cognitive inertia in a turbulent market: The case of UK residential estate agents. *Journal of Management Studies*, 34(6), 921-945.
- Hough, J.R., & White, M.A. (2004). Scanning actions and environmental dynamism. *Management Decision*, 42(6), 781-793.
- Huang, A.H. (2003). Effects of multimedia on document browsing and navigation: An exploratory empirical investigation. *Information & Management*, 41, 189-198.
- Huff, A.S. (1990). *Mapping strategic thought*. New York: Wiley.
- Hunt, S.D., & Derozier, C. (2004). The normative imperatives of business and marketing strategy: Grounding strategy in resource-advantage theory. *Journal of Business and Industrial Marketing*, 19(1), 5-22.
- Ilmola, L., Aaltonen, M., & Autio, E. (2002). *Weak signal filters in vision building processes*. Paper presented at the meeting of the 22nd Annual International Conference of the Strategic Management Society. Retrieved December, 24, 2004, from www.strategysignals.com/pdf/liite5.pdf
- Jauch, L.R., & Glueck, W.F. (1988). *Business policy and strategic management* (5th edition). New York: McGraw-Hill.
- Johnson-Laird, P.N. (1983). *Mental models*. Cambridge: Harvard University Press.
- Kerne, A., & Smith, S.M. (2004). The information discovery framework. *Proceedings of the 2004 Conference on Designing Interactive Systems* (pp. 357-360).

- Krabuanrat, K., & Phelps, R. (1998). Heuristics and rationality in strategic decision making: An exploratory study. *Journal of Business Research*, 41(1), 83-93.
- Lawrence, S., & Giles, C.L. (1999). Accessibility of information on the Web. *Nature*, 400, 107-109.
- Lewis, D.D. (1997). *The Reuters-21578 text categorization test collection*. Retrieved September 13, 2003, from www.research.att.com/~lewis/reuters21578.html
- Lim, D., & Klobas, J. (2000). Knowledge management in small enterprises. *The Electronic Library*, 18(6), 420-432.
- Liu, R.-L. (2001). An adaptive agent society for environmental scanning. *Proceedings of the 4th Pacific Rim International Workshop on Multi-Agents, Intelligent Agents: Specification, Modeling, and Applications* (pp. 139-153).
- Liu, S. (1998). Business environment scanner for senior managers: Towards active executive support with intelligent agents. *Expert Systems with Applications*, 15, 111-121.
- Long, X., & Suel, T. (2003). Optimized query execution in large search engines with global page ordering. *Proceedings of the International Conference on Very Large Data Bases (VLDB)*, 1-12.
- Martino, J.P. (2003). A review of selected recent advances in technological forecasting. *Technological Forecasting & Social Change*, 70, 719-733.
- McDonald, M. (2000). *Marketing plans: How to prepare them, how to use them* (4th edition). London: Heinemann.
- McGoangle, J.J., & Vella, C.M. (1998). *Protecting your company against competitive intelligence*. Westport: Quorum Books.
- Miller, D., & Friesen, P.H. (1977). Strategy making in context: Ten empirical archetypes. *Journal of Management Studies*, 14(3), 253-280.
- Mitchell, T.R., & Beach, L.R. (1990). '...Do I love three let me count...' toward an understanding of intuitive and automatic decision making. *Organizational Behavior and Human Decision Processes*, 47, 1-20.
- Muralidharan, R. (1999). Headquarters' scanning of the foreign subsidiary environment: An empirical study. *Journal of International Management*, 5, 35-54.
- Myers, K. (1999). Technology for the environmental scanning process. *Systemic Practice and Action Research*, 12(4), 409-424.
- Nastanski, M. (2004). The value of active scanning to senior executives: Insights from key decision-makers. *The Journal of Management Development*, 23(5), 426-436.
- Neisser, U. (1987). *Concepts and conceptual development: Ecological and intellectual factors in categorization*. Cambridge: Cambridge University Press.
- Newell, A., & Simon, H.A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.
- Newgren, K.E., Rasher, A.A., & LaRoe, M.E. (1984, August 12-15). *An empirical investigation of the relationship between environmental assessment and corporate performance*. Proceedings of the 44th Annual Meeting of the Academy of Management, Washington, D.C.

- Ngamkroekjoti, C., & Johri, L.M. (2003). Coping with hypercompetition in the financial services industry in Thailand: Environmental scanning practices of leaders and followers. *International Journal of Bank Marketing*, 21(6), 359-368.
- Nielsen, J. (2000). *Designing Web usability* (2nd edition). Indianapolis: New Riders Publishing.
- Nikander, I.O. (2002). *Early warnings: A phenomenon in project management* (unpublished doctoral dissertation). Espoo, Finland, Helsinki University of Technology.
- Nitze, P.S., Parker, K.R., & Dishman, P.L. (2003). Multi-class interest profiles: Applications in the intelligence process. *Marketing Intelligence & Planning*, 21, 263-271.
- Nodine, M., Fowler, J., Ksiezyk, T., Taylor, M., & Unruh, A. (2000). Active information gathering in InfoSleuth. *International Journal of Cooperation Information Systems*, 9, 3-28.
- Nystrom, P.C., & Starbuck, W.H. (1984). To avoid organizational crises, unlearn. *Organizational Dynamics*, 12(4), 53-65.
- Olsen, M.D., Murthy, B., & Teare, R. (1994). CEO perspectives on scanning the global hotel business environment. *International Journal of Contemporary Hospitality Management*, 6(4), 3-9.
- Pawar, B.S., & Sharda, S. (1997). Obtaining business intelligence on the Internet. *Long Range Planning*, 30(1), 110-121.
- Petersen, J.L. (1999). *Out of the blue: How to anticipate big future surprises?* New York: Madison.
- Pirolli, P., & Card, S. (1999). Information foraging. *Psychological Review*, 106(4), 643-675.
- Porter, M.E. (1998). *Competitive advantage: Creating and sustaining superior performance*. New York: Free Press.
- Rainer, R.K., & Watson, H.J. (1995). What does it take for successful executive information systems? *Decision Support Systems*, 14, 147-156.
- Reger, R.K., & Palmer, T.B. (1996). Managerial categorization of competitors: Using old maps to navigate new environments. *Organizational Science*, 7(1), 20-39.
- Riedewald, M., Agrawal, D., El Abbadi, A., & Pajarola, R. (2000). Space-efficient data cubes for dynamic environments. *Proceedings of the International Conference on Data Warehousing and Knowledge Discovery (DaWaK)* (pp. 4-33).
- Rouse, W.B. (2002). Need to know - information, knowledge, and decision making. *IEEE Transactions on Systems, Man, and Cybernetics*, 32(4), 282-292.
- Sandstrom, P E. (1994). An optimal foraging approach to information seeking and use. *Library Quarterly*, 64(4), 414-449.
- Scholz, S.W., & Wagner, R. (2005). The quality of prior information structure in business planning—an experiment in environmental scanning. In H. Fleuren, D. den Hertog & P. Kort (Eds.), *Operations research proceedings 2004* (pp.238-245). Berlin: Springer.
- Seeley, M., & Targett, D. (1999). Patterns of senior executives' personal use of computers. *Information & Management*, 35, 315-330.

- Serpa, L.F. (2000). Epistemological assessment of current business intelligence archetypes. *Competitive Intelligence Review*, 11(4), 88-101.
- Simon, H.A. (1973). The structure of ill structured problems. *Artificial Intelligence*, 4, 181-201.
- Singh, S.K., Watson, H.J., & Watson, R.T. (2002). EIS support for the strategic management process. *Decision Support Systems*, 33, 71-85.
- Slaughter, R. (1999). A new framework for environmental scanning. *Foresight*, 1(5), 387-397.
- Stephens, D.W., & Krebs, J.R. (1986). *Foraging theory*. Princeton: Princeton University Press.
- Stigler, G. (1961). The economics of information. *Journal of Political Economy*, 69, 213-225.
- Subramanian, R., Fernandes, N., & Harper, E. (1993). Environmental scanning in US companies: Their nature and their relationship to performance. *Management International Review*, 33(3), 271-286.
- Sutton, H. (1988). *Competitive Intelligence*. New York: The Conference Board, Report 913.
- Tan, A-H. (2002). Personalized information management for Web intelligence. *Proceedings of the 2002 IEEE International Conference on Fuzzy Systems* (pp. 1045-1050).
- Tan, S.S.L., Teo, H.-H., Tan, B.C.Y., & Wei, K.-K. (2000). Environmental scanning on the Internet. *Proceedings of the International Conference on Information Systems* (pp. 76-87).
- Tan, W.D., & Arnott, D.R. (1999). Managerial information acquisition and the World Wide Web: A theoretical background. *Proceedings of the Fifth Conference of the International Society for Decision Support Systems*.
- Varian, H.A. (1995). The information economy—How much will two bits be worth in the digital marketplace? *Scientific American*, 200-201.
- Walters, B.A., Jiang, J.J., & Klein, G. (2003). Strategic information and strategic decision making: The EIS/CEO interface in smaller manufacturing companies. *Information & Management*, 40, 487-495.
- Walters, B.A., & Priem, R.L. (1999). Business strategy and CEO intelligence acquisition. *Competitive Intelligence Review*, 10(2), 15-22.
- West, J.J. (1988). *Strategy, environmental scanning, and their effect upon firm performance: An explanatory study of the food service industry* (unpublished doctoral dissertation). Blacksburg: Virginia Polytechnic Institute and State University.
- Wilson, T.D. (1997). Information behaviour: An interdisciplinary perspective. *Information Processing & Management*, 33(4), 551-572.
- Wind, J. (1997). Start your engines: Gear up for challenges ahead with innovative marketing research products and services. *Marketing Research*, 9(4), 4-8.
- Wright, S., Pickton, D.-W., & Callon, J. (2002). Competitive intelligence in UK firms: A typology. *Marketing Intelligence & Planning*, 20(6), 349-360.

Xu, X.-X., & Kaye, G.R. (1995). Building market intelligence systems for environmental scanning. *Logistics Information Management*, 8(2), 22-29.

Endnote

- ¹ For a complete derivation of this equation, see: Stephens and Krebs (1986) or Pirolli and Card (1999).