"STRATEGIES FOR IMPLEMENTING KNOWLEDGE-BASED SYSTEMS"

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Abstract

The permeation of knowledge-based technologies in organizational information systems is having important strategic impacts, specially on issues related to the management of a firm's knowledge assets. The challenges in implementing knowledge-based information systems have evolved from technical matters to organizational and strategic issues. This paper relates knowledge-based information systems to the management of organizational knowledge and specifies different strategies that can be adopted by companies for the successful implementation of such systems.

Keywords: Knowledge-based systems; Implementation strategies for knowledge-based systems

1. Introduction

This section describes the evolution of knowledge processing and outlines the focus and structure of the paper.

1.1 Knowledge Processing

It is possible to identify three waves of the information revolution as measured by the shifting focus of computing. Till the early 1970s, computers were being used solely for traditional *data processing* tasks. This gave rise to the large mainframe databases which form the core of computer systems in most organizations today. The emphasis then was primarily on building efficient data storage and retrieval systems. During the 1970s the focus of computing shifted from data processing to *information processing*. While the emphasis in data processing was on the storage and retrieval of raw data, information processing focused on management information systems [4] to aggregate the raw data and provide the required information (i.e., the aggregated data) to management.

The scope of computing has been enlarged since the mid-1980s to include *knowledge processing* [5,11] with knowledge-based information systems (KBSs). Broadly defined, KBSs use extensive domain specific knowledge to solve problems and support decision processes. Such information systems attempt to move the focus of computing a generation ahead by focussing on knowledge as opposed to information. The exact nature and definition of "knowledge" and "intelligence" have been debated extensively and inconclusively in the literature [3,16,21]. In more practical terms, knowledge in knowledge-based systems can be seen as being obtained from information by assigning it meaning and interpretation. This interpretation or meaning is typically given by humans and represents the domain specific knowledge which knowledge-based information systems attempt to exploit [5].

Though expert systems [5,7,8,9] represent the first (and much publicized) wave of KBS applications in the mid-1980s, organizations are today witnessing a wider, but less publicized, permeation of knowledge-based technologies. These knowledge-based applications are being facilitated by advances in knowledge-based technologies, a wider adoption of object oriented systems within organizations, and the incorporation of knowledge-based technologies within conventional databases. With the maturation of the enabling technologies, the challenges in successfully implementing knowledge-based systems have moved from technical matters to organizational and strategic issues.

1.2 Focus and Structure of Paper

While technological issues in the development of traditional expert systems and KBSs have been described fairly extensively in the literature [8,9], there has been relatively little research on the strategic and organizational concerns in the implementation of such systems. Some exceptions are research by O'Leary and Turban [22], Mumford [19,20], Sviokla [31,32], Sharma et. al. [27], and Prerau [25].

Sharma et. al. [27] have postulated different conditions under which the deployment of expert systems is beneficial for an organization. These postulates are partly technical in nature (focusing on the task domain and the knowledge engineering process) and partly organizational (focussing on the "fit" between the expert system and the organization). Prerau's work [25] is useful in describing specific experiences from the development and implementation of large real-life expert systems. These experiences are used to present some general principles or recommendations for the process of developing expert systems. Mumford's [19,20] research is similar to that of Prerau in analyzing the deployment of a large expert system within a company, but is more focussed on the organizational conditions facilitating the successful deployment of expert systems. Sviokla has analyzed the development of expert systems [32] and has also described the organizational impact of expert system deployment in a real company [31].

The focus of this paper is on strategies for implementing KBSs in organizations. The concept of organizational knowledge and the impact of KBSs on the management of a firm's knowledge assets is first developed in Section 2. Next, Section 3 outlines different corporate strategies for the development of KBS applications and highlights technical and managerial concerns in the adoption and implementation of these strategies. Section 4 provides guidelines for the identification of strategic KBS applications using conceptual models from the strategic planning literature which emphasize the perspective of organizational knowledge management. The last section (Section 5) concludes the paper. The adoption of the perspective of knowledge asset management in analyzing the organizational impact of KBSs and formulating strategies for their implementation distinguishes this work from prior related research.

2 Organizational Knowledge and KBSs

This section describes important issues in managing organizational knowledge and explores the interactions between KBSs and the management of a firm's knowledge assets.

2.1 Knowledge in Organizations

To effectively understand and evaluate the role of KBSs in organizations, it is important to understand the practical implications of "managing knowledge" in the general organizational context.

Knowledge exists in many different forms in organizations. Some of them are *tangible*, while others are more subtle and *intangible* in nature. Examples of tangible knowledge assets are patents, written procedures ("how to" knowledge about certain tasks), books, manuals, and research and development outputs such as papers published and new products. Intangible knowledge assets of a company include company "culture", the experience and expertise of employees, informal associations, and synergies from group interactions.

Managing knowledge is an challenging task because it is hard to identify, and even more difficult to value and deploy to give the organization a competitive edge in the market place. While many tangible knowledge assets such as software programs can be identified easily, it is often difficult to value them, and thus they rarely make it into the company's balance sheets. It is a more difficult task to identify the intangible knowledge assets of an organization, and most executives do not understand how to value them (if at all they are identifiable).

Moreover, knowledge after identification has to be shared so that the organization is able to translate it into a competitive advantage. Isolated islands of knowledge are not very useful to an organization. A company derives true benefits from its knowledge assets only when they are leveraged via a knowledge network, and diffused throughout the organization (and its partners, if appropriate). Complicating the scenario further is the fact that knowledge is never static; it is continuously changing and evolving. Tracking and managing a dynamic asset is always harder.

Companies are today realizing the importance of the competitive differentials achievable by effectively managing knowledge assets. In a recent cover story on this subject, a leading business magazine [30] stated this concisely as: "Intellectual capital is becoming corporate America's most valuable asset and can be its sharpest competitive weapon. The challenge is to find what you have - and use it".

2.2 Levels of Organizational Knowledge

An organization's knowledge assets can be analyzed in different ways. A useful classification is along the following four dimensions:

- **Individual**: The individual knowledge worker is the fundamental unit for knowledge creation, storage, and use within an organization.
- **Group**: Networks, both formal and informal, are usually an intangible, but important knowledge asset within a company. Groups of individuals often

represent a cumulative knowledge asset that is more than the sum of their individual skills, and can produce results of true competitive significance.

- **Organizational:** The entire organization with its own peculiar structures, division of functions, and processes can be viewed as embodying the result of a certain cumulative body of knowledge. The organization is designed to facilitate and direct knowledge flows, and evolves with changing knowledge needs.
- **Knowledge links:** Every company develops specific links with other firms (such as suppliers and customers) to exchange knowledge. Analogous to groups, knowledge links between groups of organizations can lead to the development of inter-organizational knowledge not possible with isolated organizations.

2.3 Managing Knowledge in Organizations

Figure 1 reflects the essential components of the process of strategically managing knowledge. A company has to identify its knowledge assets, leverage them by sharing in a knowledge network, and learn from experience (to adapt to the dynamic nature of knowledge). All of this has to be done, of course, within the context of the strategic objectives of the organization.

Figure 1 about here

Identification of specific assets at each of the levels of knowledge mentioned earlier is a challenging task for any organization. Individual expertise is not restricted to a company's professionals, or its top management. Often the best experts are found low down in the ranks of an organization [26]. It is also sometimes difficult to distinguish between a true expert (a knowledge asset), and someone who just has better access to certain information based on the power of his/her position. Locating group knowledge assets is difficult because formal groups seldom mirror real intellectual assets. Rather, informal networks of individuals often tend to form the most effective knowledge assets. Similar identification problems are also experienced at the organizational and inter-organizational levels.

Isolated knowledge is of little strategic benefit to an organization. The larger the extent to which knowledge is shared and disseminated within an organization, the higher the return on it. For example, most organizations are today making determined efforts to from groups of inter-disciplinary and cross-functional individuals in order to facilitate the transfer and dissemination of knowledge. This is helping them to design better products, reduce time to market, achieve a higher degree of customer satisfaction, and be more competitive on the whole.

Knowledge is inherently dynamic. To ensure long-term competitiveness in the market place, every organization has to be able to learn. The emphasis is on how closely an organization can track and adapt to the changing knowledge needs of its internal and external environment.

2.4 KBSs and the Management of Organizational Knowledge

KBSs have a direct impact on the management of knowledge within organizations. A KBS aims to extract a piece of the organization's intellectual capital, and capture it in an information system. Thus, the development of a KBS results in the creation of a tangible knowledge asset which can be distributed and leveraged within the company.

The knowledge targeted by a KBS can be either tangible (such as manuals and documents) and intangible (e.g., human expertise) in nature. While a conventional information system can store the information in a document or a manual, the additional power of a KBS lies in its ability to also store how the document or manual is interpreted (used) by experts/users (i.e., capture the intangible knowledge associated with the use of the tangible knowledge asset). The degree of automation with KBSs can be either *complete* or *partial*, as shown in Figure 2. In the former case, the KBS captures the tangible and intangible aspects of the knowledge asset in its entirety, and can be deployed as a complete or partial replacement for that knowledge asset. However, such situations are rare. The latter situation in which the KBS only partially captures the (tangible and intangible aspects of the) knowledge asset is more common. The KBS is usually used to augment the use of the knowledge asset and facilitate its dissemination in such situations.

Figure 2 about here

Most commercially successful KBSs have captured (usually partially) the intangible knowledge associated with individuals (more often) and groups (less often). Conventional expert systems provide a good illustration of such KBSs.

For example, it is important for American Express to take consistent (for enhanced customer image) and correct (to avoid fraud) credit approval decisions about credit requests from similar customer profiles. Achieving this consistency and accuracy is difficult in practice, because the staff taking such decisions differ in their levels of experience and knowledge, and are in addition, subject to a variety of local constraints. To solve this problem, American Express has (since 1987) been using an expert system called Authorizer's Assistant [12] to support the decision processes of their credit agents. This KBS captures both tangible (documents about credit approval procedures) and intangible (the expertise of the best agents) knowledge about the credit approval process. Most American Express credit agents use the Authorizer's Assistant KBS for increased consistency, speed, and accuracy in their decisions.

It is also possible for KBSs to capture knowledge at the organizational and knowledge link levels. A good example of this is Digital Equipment Corporation which has a VAX-based knowledge network (Figure 3), integrating and facilitating knowledge flows related to the sale of computers across several different functions [1]. Major components in Digital's VAX-based knowledge network are: XSEL (used to support field sales people in translating a customer's computing needs into computer orders which can then be configured by Digital), XCON (used to validate the technical correctness of customer orders and guide the assembly of these orders), CAN BUILD (used for inventory scheduling), MOS (used for manufacturing planning), NDR (used to control the scheduling of trucks), XFL (used for diagramming a computer room floor layout for the proposed configuration), XNET (used for designing local area networks), and SIZER (used for sizing computing resources according to customer needs). These expert systems, databases, and conventional management information systems cumulatively form a powerful KBS capturing important aspects of Digital's organizational knowledge in the domains of sales, engineering, manufacturing, and customer service.

Figure 3 about here

KBSs are tangible knowledge assets, and can be distributed widely within an organization. Inexperienced users can improve their performances significantly with the help of an appropriately designed KBS. The larger the difference between the performance levels of experts and inexperienced employees, the more noticeable are the improvements in performances with the use of KBSs (these benefits are common with conventional expert systems). Such applications of KBSs are particularly suited to geographically distributed tasks, such as remote diagnoses and repairs of equipment, and credit analyses at different locations. KBSs offer a practical and easy solution for companies to apply their critical knowledge at many different sites simultaneously and consistently.

KBSs also have an important impact on the rate of learning within an organization. With the help of a KBS, an inexperienced employee can reach a higher level of performance faster. The slower the normal rate of learning, the larger the impact of the KBS in speeding up the learning process. KBSs can also help in enhancing the learning rate of the entire organization. As an example, consider the ExperTax KBS of Coopers and Lybrand. ExperTax assists junior accountants in the tax auditing and planning tasks. A central office in Coopers and Lybrand is responsible for maintaining all changes in the knowledge base of ExperTax. Whenever tax laws change (and they do so frequently), the central office in Coopers and Lybrand makes the appropriate changes in ExperTax's knowledge base, and the revised version is shipped out to the hundreds of Coopers and Lybrand field auditors all over the USA. As all field auditors use the same ExperTax KBS, the changes in tax laws are immediately reflected in their task performances. Thus Coopers and Lybrand is able to propagate the effects of changes in the knowledge contents of critical tasks effortlessly and rapidly. When the US tax laws were changed radically in 1986, Coopers and Lybrand was able to incorporate and implement these changes nationwide within 6 weeks [6], and with minimal additional training. A short turnaround time in implementing such changes in a knowledge intensive company can lead to major competitive advantages in the marketplace.

3 Strategies for the Development of KBSs

This section outlines different phases in the development of KBSs and focuses on the formulation of corporate strategies for the development of KBSs.

3.1 Phases of Development

Five important phases can be identified in the process of managing the development of KBSs within organizations:

1. **Knowledge processing strategy**: The development of KBSs within an organization has to follow an overall strategy, which is determined by the knowledge and resource profiles of the organization.
2. **Strategic application identification:** Though many different KBS applications may be possible within an organization, competitive needs of the organization dictate the selection of an appropriate set of strategic KBS applications.
3. **Application feasibility**: Available organizational resources place additional constraints on the feasibility of building competitively desirable KBS applications.
4. **Application creation**: Once an application has been selected and deemed to be feasible, it has to be created, i.e., designed and implemented.
5. **Deployment and maintenance:** After creation, a KBS application has to be deployed in the field, and suitable arrangements have to be made for its maintenance.

The last three phases (3 through 5) listed above have received the most attention in the expert/knowledge-based systems literature. It is common to find detailed lists and questions in prior research specifying conditions under which it is feasible to develop expert/knowledge-based systems [10,13,25,28,32], descriptions of technological challenges in creating these systems [5,8,9,34], and guidelines for their successful deployment and maintenance within organizations [5,8,9,14,19,25,33]. In comparison, the first two phases of strategy formulation and strategic application identification have received less attention in the literature. Most of the attention on application identification has been devoted to task and domain characteristics (such as "cooperative and knowledgeable expert is available" and "domain knowledge is fairly structured"), more appropriately classified under the application feasibility determination phase (phase 3 in the above list).

Some researchers [2,15,17,18] have approached the idea of strategic planning for developing expert systems. With the exception of Meador and Mahler [17], few have focused on the importance of corporate strategies for developing expert systems. Most (such as [2]) touch upon the subject with a brief reference to the fact that expert systems should lead to a competitive edge for the company. Some others (such as [18]) mention that expert systems planning should address the creation, handling and dissemination of knowledge, but focus on issues related to knowledge engineering [5,8]. Meador and Mahler [17] explicitly outline two strategies for developing expert systems using the experiences of Digital and Dupont and their ideas are incorporated in this paper. However, they do not emphasize links between the proposed strategies to the management of an organization's knowledge assets.

3.2 Choice of a Corporate Strategy

As detailed in Section 2.2., there are four distinct levels of (organizational) knowledge: individual, group, organizational and knowledge links. We consider only two levels of knowledge in following analysis: individual and organizational. KBSs focused at the individual level of knowledge tend to capture and encode the expertise of an expert (or a group of experts) for a specific task. KBSs targeted at the organizational level tend to impact knowledge flows across different tasks or functions within the organization.

As the focus of this paper is on strategies for implementing KBSs, another important factor is the location of the responsibility for the development of KBSs. Restricting our analysis to the two levels mentioned earlier: individual and organizational, it is possible to identify two distinct types of location of KBS development responsibility. At one extreme, a centralized group can be made responsible for all aspects of the development of KBSs within the organization. At the other extreme, it is possible to have a completely decentralized approach to KBS development in which end users, or groups of end users are responsible for most aspects of KBS development.

Based on the different possible values along these two dimensions - *level of knowledge* and *development responsibility* - four different broad strategies (Figure 4) can be identified for KBS development within organizations as explained in the following sub-sections.

Figure 4 about here

3.2.1 Guided

This reflects a centralized approach to developing KBSs targeted at the individual level of knowledge. Corporations adopting this strategy typically form a centralized task force/development group for exploring the utility of KBSs for enhancing the effectiveness of individual performances. The emphasis is on capturing and distributing the knowledge of specific experts within the organization, whose expertise would be of use to other employees performing the same (or similar) task. The centralized KBS development group provides all resources - such as tools and engineers - for building the KBSs. It also usually controls all aspects of the development process. This is the cautious approach adopted by many companies experimenting for the first time with KBS technology. The developed systems are generally small in size as they attempt to capture the expertise of one (or a few) expert(s). Risks are low, and successful KBSs can be developed if the central group is capable, well qualified for the task, and has the support of management. Conventional expert/knowledge-based systems are good examples of systems typically developed under such a strategy.

3.2.2 Specialists

This strategy[1] also requires a centralized KBS development group, but it differs from the guided strategy in being focussed on the development of KBSs which span task/functional boundaries, and influence knowledge flows across the organization. Due to the large potential impact of the developed KBSs, the adoption of such a development strategy requires the total commitment of the top management of the company to the KBS development efforts. The central KBS development group is larger than in the guided strategy, and the developed KBSs are also more complex (usually a combination of databases, expert/knowledge-based systems, management information systems, and other conventional software programs). The complexity arises from not only from an increase in the size and scale of the problem being tackled (organizational as opposed to individual), but also from a need to integrate the individual (and varied) components of the KBSs across functional or task boundaries with the aim of improving the knowledge flows within the organization. The risks are high in this approach, and it calls for the highest calibre professional engineers, good funding, and total and sustained top management support.

A good example of a company adopting such a strategy is Digital [17]. Digital has established a major centralized KBS technology group called the Artificial Intelligence Technology Center (AITC) at Marlborough, Massachusetts. The AITC has a large staff (about 300) of specialized programmers and knowledge engineers, devoted to implementing and maintaining Digital's KBS (VAX-based

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[1] The term "specialist" has been used by Meador and Mahler [17] to describe the knowledge-based systems strategy of Digital.

knowledge network). The VAX-based knowledge network integrates different functions, and facilitates the flow of knowledge across different parts of the organization. For example, the XSEL, XCON, XFL, XNET, and SIZER KBSs (Figure 3) integrate and facilitate the flow of knowledge regarding computer configuration across the functions of sales, engineering, and customer service within Digital. Building the VAX-based knowledge network requires experience in building KBSs and sustained top management support. Though the AITC does not control all aspects of KBS development within Digital, it serves as an important locus for activities related to KBSs, and for ensuring that the developed KBSs meet certain communication and data standards so that they can be easily integrated into the organization.

3.2.3 Dispersed points

This strategy[2] is almost diametrically opposite to the specialist strategy in that it puts all (or most) of the burden of developing and managing KBSs on end users. In this approach a KBS tool (such as an expert system shell tool [9]) is promoted as a tool for enhancing personal productivity, in much the same way as spreadsheet and database packages. End users are trained on a particular KBS tool, and then given the freedom to develop KBSs to aid their own tasks or decision processes. The end users are both the developers and the users of the developed KBSs. Most of the developed KBSs are targeted at the individual knowledge level, and are typically small (in size) and simple (in complexity). Consequently, they are also developed rapidly, and maintained easily (by the users themselves). Risks and costs are fairly low in this approach, but it requires a reasonably large base of computer literate end users who are willing to invest time and energy in learning about KBS tools, and developing working KBSs. As this strategy assumes little centralized control, there can be problems of coordination, duplication, and standardization among the developed KBSs. Strong user groups (both formal and informal) are desirable for minimizing such problems.

A company such as DuPont is a good example for illustrating such a strategy. Since 1985, DuPont has been training its end users to develop their own KBSs. By 1990, they had approximately 600 different small PC based expert systems installed in their different business units [17]. This strategy is possible to

[2] The term "dispersed" has been used by Meador and Mahler [17] to describe the knowledge-based systems strategy of DuPont.

a large degree because DuPont had in 1990, about 30,000 Lotus literate managers, and this number is expected to grow to 60,000 by the end of the 1990s. As a direct result of this strategy, it is estimated that in 1990 about 1,800 DuPont managers were able to use KBS tools (usually PC-based expert system shell tools [9]) as readily as spreadsheets, electronic mail, and other office automation packages. As most KBSs are developed on personal computers with shell tools, their development costs are small (about $40,000 each). Though DuPont follows the dispersed points strategy, a centralized initiative was necessary to start the process. This was provided by limited seed money ($3 million given by top management), and a small centralized task force (of about a dozen people) which started and coordinated the process of training end users on KBS tools.

3.2.4 Dispersed clusters

This strategy can be considered as a hybrid between the pure specialist and dispersed point strategies. There is no one strong locus of centralized control, but rather a few loci of activities related to KBS development. These clusters can exist in different business divisions, subsidiaries, or groups. Each cluster is responsible for the development of KBSs within its own span of control. This strategy is conceptually similar to the dispersed point strategy, except for the difference that the "points" are not direct end users, but rather groups or divisions. Problems of coordination can arise if there are many clusters. Thus, such a strategy is useful if the organization is in a few distinctly different businesses.

Xerox is following a KBS development strategy that is a mix of the specialist and dispersed clusters approaches. Since 1989, Xerox's centralized Knowledge-Based Systems Competency Center (KBSCC) has initiated an innovative KBS Circles Program [15] to leverage Xerox's "Leadership through Quality" program. Each KBS circle consists of a group of individuals who are operating as a "quality improvement team". KBSCC provides hardware and software support to each KBS circle, and helps them to interface with departmental information management departments. Each KBS circle attempts to use KBS technology to address a high corporate priority, knowledge intensive problem. Ten circles were started in April 1989, and the benefits from their efforts are around $20 M at the end of 1992.

3.3 Factors Affecting the Choice of Strategy

No one KBS development strategy is inherently superior. The choice of the appropriate strategy to adopt is dependent on several factors including the following:

Familiarity: If a company is new to the domain of KBSs, it is best to pursue a guided strategy because it minimizes risk and costs, and provides a good environment for experimenting with the technology. Though the dispersed points strategy is of low cost, it should be avoided if KBS technology is new to the company because end users can be easily misguided during the experimental stages, and their initial results (or failures) can be misinterpreted by management. All other strategies require a larger degree of commitment ,and should be chosen only after the company has acquired a certain degree of familiarity with, and confidence in KBS technology.

Knowledge flows: A centralized approach, such as the specialist strategy, is desirable if there is a high degree of integration in knowledge flows across different functions in an organization. This integration can be easily seen in Digital which is in the sole business of selling (a large variety of) computers, and requires a tight integration of knowledge flows across sales, engineering, manufacturing, and customer service. Decentralized strategies are more preferable if the organization has many different sub-units, each of which is relatively independent in its knowledge requirements. DuPont is a good example of such an organization. DuPont has some 1,700 different product lines, with relatively independent knowledge profiles. To stay at the leading edge in so many different products, DuPont encourages a strong sense of independence and technical excellence amongst its employees. Thus a dispersed point strategy seems appropriate for the knowledge flows within DuPont.

Resources: Resources such as people, capital, and information systems architectures also impact the choice of a KBS development strategy. If a company has a large base of computer literate end users (as in DuPont), decentralized strategies may be appropriate; but if there is a limited number of computer literate end users, centralized strategies may be better. Large capital investments are required for the specialist and dispersed cluster strategies. The guided and dispersed points strategies are relatively less expensive to implement. Centralized strategies are facilitated by the presence of an uniformly consistent information systems architecture. For example, Digital has fairly uniform data and communication standards throughout the company. Digital's centralized AI Technology Center ensures that developed KBSs fit into this information architecture. However for a company such as DuPont, there is no common information systems architecture with IBM mainframes, Digital and HP minicomputers, and IBM and Apple personal computers being used in a relatively uncoordinated manner. It is not possible to enforce the use of only one (or a small number of) KBS development tools, or system integration strategies. A decentralized development strategy is thus more suited to the information systems architecture of DuPont.

An organization is not limited to any one strategy for nurturing the development of KBSs. It may change strategies with time, and can even pursue more than one strategy simultaneously. For example, an organization may initially use the guided strategy to gain familiarity with KBS technology, and with time and increased confidence, adopt a combination of the specialist and dispersed points strategies. Regardless of the chosen strategy, it is important that there is some thought and consensus about it.

3.4 Strategic Implications

There are important technical and managerial implications of choosing a particular KBS implementation strategy as summarized in Figure 5. While many of the issues mentioned in Figure 5 have been discussed in Sections 3.2 and 3.3, some elaboration is needed upon the strategic implications of the different strategies. This is done below with the help of three different conceptual models from the strategic management literature: value chain [23], core competencies [24] and capabilities [29].

Figure 5 about here

Considering the value chain [23] model of a firm, the following types of strategic KBS applications can be identified:

Enhanced knowledge processing at value activities: KBSs can be used to capture and enhance the knowledge related to particular value activities. In such a role, KBSs can significantly enhance the value generated by that activity, specially if that activity has to be performed in geographically distributed locations simultaneously. For example, the Authorizer's Assistant KBS enhances the knowledge processing in the credit approval activity within American Express.

Enhancing knowledge transfers across value activities: KBSs can capture and enhance the information/knowledge transfers across value activities. The enhancements in the information and knowledge transfers can be experienced in the form of increased sharing, faster transfers, better reliability, and increased consistency. For example the XSEL and XCON KBS applications (Figure 3) provide for an enhanced knowledge transfer between the sales and engineering activities within Digital.

Reconfiguration of knowledge flows: KBS applications can also change the structure of the value chain of the company. In doing so, they help in reconfiguring the knowledge flows within the organization such that the organization realizes a competitive advantage.

The guided and dispersed points strategies are well suited for enhancing knowledge processing within specific value activities. With some central coordination, these strategies can possibly lead to limited knowledge transfers across value activities. The specialist and dispersed clusters strategies are best suited for enhancing knowledge transfers across value activities and for reconfiguring knowledge flows across the organization. The organizational benefits and risks are also higher with these strategies because they deal with changes in organization-wide knowledge assets.

A core competency has been defined [24] as the ability of an organization to "coordinate diverse production skills and integrate multiple streams of technologies". The dispersed clusters and specialist strategies can lead to such an integrative coordination which gives the organization a special skill (competency) which is not easily duplicated by organizations.

The concept of capabilities [29] represents an alternative approach to strategic modelling. In comparison with the value chain model [23], while the notion of a core competence can be thought of as the existence of special technological and production expertise at specific points in the value chain, capabilities are more broadly based, emphasizing integration across the entire value chain. The specialist strategy is well suited to integrating knowledge across activities in key processes and helping the organization enhance appropriate capabilities.

4 Identification of Strategic KBS Applications

KBS applications, even if successful and technically advanced, may fail to impress and win top management support if they do not yield a competitive advantage to the firm in the long run. A KBS application, if identified as of strategic benefit to the firm, will (with proper communication) be better placed to win sustained management support and resources even if it is technically complex.

4.1 Value Chain and Value Activities

Potentially strategic KBS applications can be determined by analyzing the following types of activities and links within the value chain [23] of the company:

High value activities: Activities which create high value to the company (in the context of its overall competitive strategy) are obvious first places to look for potential KBS projects. The knowledge processing occurring within high value activities should be analyzed carefully to determine whether it may be possible to leverage that knowledge with a KBS. For example, computer configuration is a high value activity for Digital, and Digital's first large KBS project (the XCON system) was designed for that activity.

Activities interfacing with high value activities: Activities which either influence or are influenced by high value activities are sources for potential KBS projects. Such activities are important, but frequently overlooked sources of value to a company. For example, within Digital the activities of selling and manufacturing computers respectively influence, and are influenced by the high value engineering activity of configuration. Digital has therefore appropriately built KBSs for these activities also (Figure 3).

Junctions: Activities which serve as a junction for many linkages across different value activities can also lead to strategic KBS projects. Though such activities may not obviously appear as high value activities, they are often areas for intense knowledge processing.

Bottleneck activities: Bottleneck activities are undesirable because they slow down the generation of value in the value chain. KBSs can potentially be used in such activities to alleviate the bottlenecks. Though many high value activities are bottlenecks, the two need not always be the same. For example, invoice processing can be a bottleneck (but not a high value) activity within a particular firm.

Boundary linkages: Linkages between value activities across boundaries, both external (such as those between a firm and its suppliers or customers) and internal (such as those between different sub-divisions of the same firm) are usually associated with intense knowledge flows. KBSs can potentially be used to facilitate the flow of knowledge across these boundary linkages. For example, a KBS can be used by a supplier to get "intelligent" assistance while ordering products from the company. Such a KBS can facilitate the flow of knowledge about a company's products across to its customers.

4.2 Core Competencies and Capabilities

The core competencies [24] of a corporation are loci of intense knowledge processing as they represent the coordination and integration of a diverse set of skills. From a knowledge management perspective, a company is able to leverage its core competencies if it can (a) identify its set of core competencies, (b) collect the necessary (diverse) knowledge to build its core competencies, (c) integrate and coordinate the knowledge elements related to its core competencies, and (d) disseminate knowledge about its core competencies to all relevant parts of the organization.

KBSs can play an important role in steps (b), (c), and (d) listed above. KBSs can facilitate the transfer of diverse knowledge elements from across the company to the "core competency center" within the company. This is possible with either KBSs targeted at the individual (or group) level (collect the expertise of several experts) or the organizational and knowledge-links level (share expertise across the organization). KBSs can help with the integration and coordination of knowledge elements related to the core competency. This is specially useful if numerous, complex knowledge elements need to be aggregated and managed. Specific integrated knowledge about specific core competencies can also be distributed and shared within the organization with the help of KBSs (targeted at either the individual or the organizational levels).

While core competencies are focused on the integration and coordination of knowledge at specific centers within the corporation, capabilities [29] are concerned with the development of skills across different activities in core business processes. From a knowledge management perspective, a company is able to build strong capabilities if it can (a) identify its set of core processes and their constituent activities, and (b) share relevant knowledge across activities within core processes (and across core processes if required). KBSs targeted at the organizational and knowledge links levels can help with the sharing of critical knowledge within (and across) core processes and help the organization build a set of core capabilities. The knowledge-network of Digital (described earlier in Section 2.4) is an example of an organization-wide KBS which strengthens Digital's core capability in the manufacture and sales of computers.

5 Conclusion

Knowledge processing has become an important function of information system applications within organizations. KBSs are an important enabler of this shift from data and information processing to knowledge processing.

The management of organizational knowledge is a relatively new and challenging concept for most organizations. KBSs can have an important role in the management of organizational knowledge at all levels: individual, group, organizational, and knowledge-links. With considerable progress in the underlying technologies, the major challenges in the implementation of KBSs have evolved from technical matters to organizational and strategic issues. This research has focused on the relationship between KBSs and the management of an organization's knowledge assets. Specifically, four different strategies (guided, specialist, dispersed points, and dispersed clusters) have been proposed and described in relation to the different levels of organizational knowledge. The technical, managerial and strategic implications of each of the four strategies have also been discussed. Finally, guidelines for identifying potentially strategic KBS applications have been suggested.

The research presented in this paper is by no means complete. There are several additional important concerns in the implementation of KBSs such as cost-benefit analyses, technical development challenges, and field deployment strategies. These issues have not been covered in this paper. More details on these issues can be found in references such as [5,8,9,25].

On issues related to the scope of this paper, the strategies for the development of KBSs can be honed further by considering all four different levels of organizational knowledge. Particularly interesting results can probably be obtained by focusing on the knowledge-links level of organizational knowledge.

Knowledge is also a multi-faceted and rich concept. This research has essentially considered one classification (along the four levels) of knowledge. Different insights can probably be obtained by considering other aspects of organizational knowledge. Some thorough empirical research would also help in validating the ideas presented in this paper.

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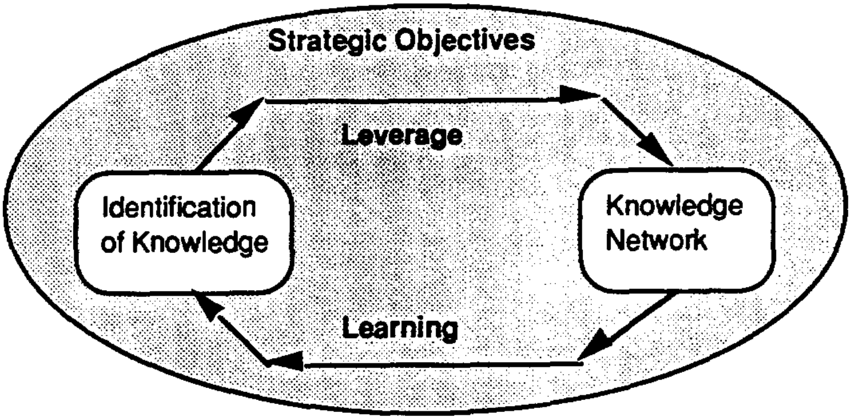

Figure 1: The strategic management of knowledge

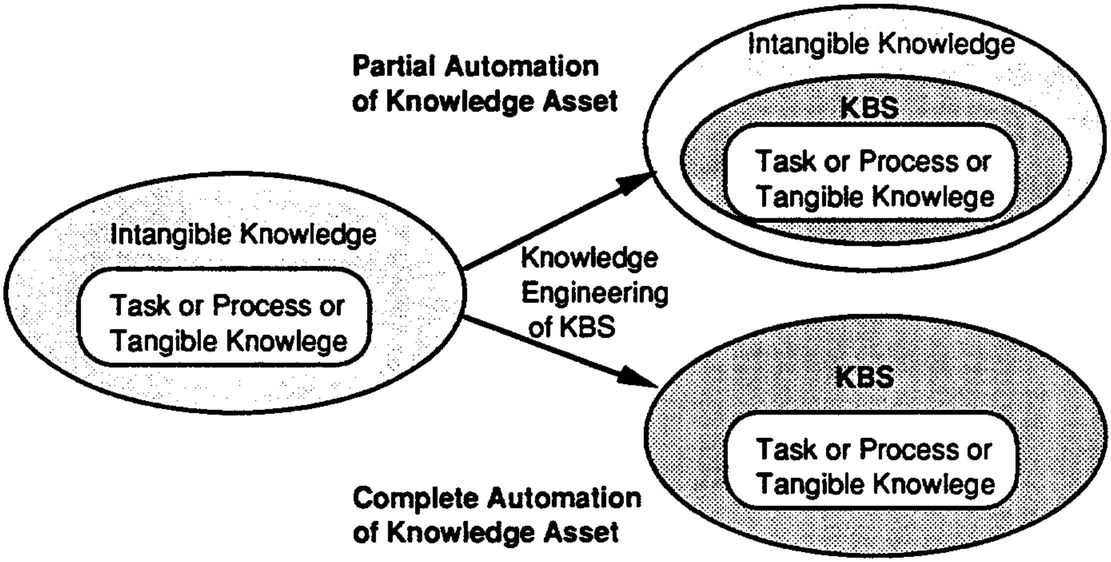

Figure 2: Creation of a tangible knowledge asset using a KBS

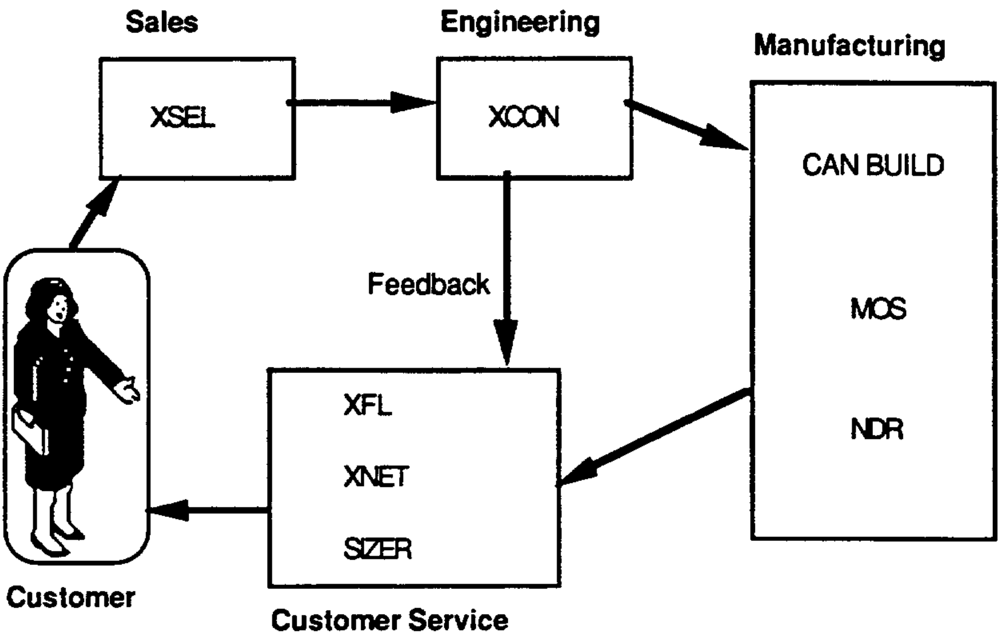

Figure 3: Digital's VAX-based knowledge network

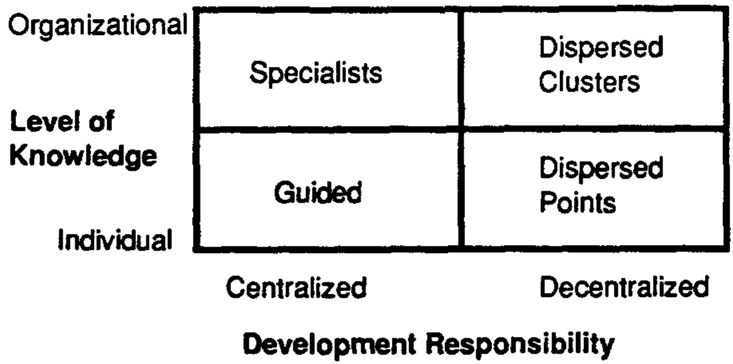

Figure 4: Different corporate strategies for KBS development

	Guided	Specialist	Dispersed points	Dispersed Clusters
Technical Concerns				
Size of KBSs	Small to medium	Large	Small	Medium to large
Complexity of KBSs	Simple	Complex	Simple	Complex
Technical skills in users	Useful, but not required	Not essential	Critical	Useful
Central pool of technical experts	Essential	Critical	Not essential; some central coordination useful	Useful
Technical risks	Low	High	Low	Medium to high
Costs	Low	High	Low	Medium to high
Time horizon for development	Short term (< 1 year)	Long term (2-3 years)	Short term (< 1 year)	Medium/long term (1 - 3 years)
Organizational Concerns				
Organizational risks	Low	Medium to high	Medium to high	High
Top management commitment	Low to medium	High	Low	Medium to high
Type of KBS applications possible	Added knowledge processing in value activities	• Added knowledge transfers across value activities • Reconfiguring organizational knowledge flows	Added knowledge processing in value activities	• Added knowledge transfers across value activities • Reconfiguring organizational knowledge flows
Development of competencies and capabilities		Development of a competency and/or capability possible		Development of a competence possible

Figure 5: Technical and organizational implications of different KBS strategies

List of Figure Captions