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Abstract

Globalization and digitization are compelling companies to reconsider fundamental business assumptions. These two intertwined strategic forces translate into competition that is increasingly knowledge-based. Knowledge is now becoming a major driving force for organizational change and wealth creation. Effective knowledge management is considered an increasingly important source of competitive advantage, and a key to the success of contemporary organizations. As a result, companies are now showing a tremendous interest in implementing knowledge management processes and supporting technologies. This paper provides a review of the information methodologies used in support of knowledge management.

1 Introduction

Knowledge management systems (KMS) refer to a class of information systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application (Alavi and Leidner, 2001). Using IT to manage knowledge is not new. Organizational efforts in support of knowledge management through information technologies can be traced back to artificial intelligence methodologies such as expert systems, and case-based reasoning systems. Recent progress in IT, especially Internet and database technology, has transformed the processes applied towards management of organizational knowledge. Various information technologies, like knowledge networks, communities of practice, and virtual communities, are applied to better manage organizational resources, especially the knowledge stored in human minds, so-called tacit knowledge. Tacit knowledge is highly personal and hard to encode. It plays a unique role in building and conserving core competence. The challenge is how to support the sharing of tacit knowledge using information technologies. This paper provides and discusses the basic issues in support of knowledge management through information technology, especially knowledge networks, communities of practice, and virtual communities. We will discuss the concepts and related technologies.

This paper is constructed as follows. Section 2 describes knowledge management and competence. Several major knowledge management approaches, mainly knowledge networks and virtual communities, are described in section 3. In section 4, we will focus on discussing the current group technologies and their major challenges. In the last

section, 5, we will explain the significance of filtering information flow among decision makers to reduce the effect of information overload.

2 Knowledge Management and Competence

Knowledge management can be defined as a formal, directed process of figuring out what knowledge individuals within a company have that could benefit others in the company, then devising ways of making it easily available (Harvard Management Update, 1999). Civi (2000) defines knowledge management as the acquisition, sharing and use of knowledge within organizations, including learning processes and management information systems. Although there still does not exist a standard definition of knowledge management, knowledge management has already been a common accepted practice within organizations. Today most advanced industries are knowledge-based. In 1996, the Journal of Knowledge Management did a survey sponsored by Ernst & Young/Business Intelligence on senior management's views toward knowledge management (Chase, 1997b). From this survey, some 92% of the respondents reported that they worked in knowledge-intensive organizations. Also from this survey, nearly two-thirds of the respondents reported that costly mistakes were made due to "insufficient knowledge about technology" and "vital knowledge was lost without timely warning." The benefits of knowledge management are visible in knowledge intensive industries such as software, pharmaceuticals, health care, financial services, communications, and consulting.

The business environment is increasingly competitive and the rate of innovation is rising. Companies compete with each other in ways different from before. "Dr. Dorothy Leonard of the Harvard Business School maintains that: It used to be that organizations could compete on the basis of either quality or low cost. Today, almost every organization competes on its ability to continuously innovate – in product, service or concept" (Chase, 1997a). A company's competency can be classified into similar competencies and core competencies. Similar competencies are those common processes that successful companies adopt within an industry. Core competencies, however, are processes unique to individual firms that give rise to their competitive advantage. Whereas generic knowledge is the basis of the competence possessed by all the firms in an industry, specific knowledge is particular to individual firms, resulting in their individual core competencies and potential competitive advantage (Pemberton and Stonehouse, 2000). Firms' "competitive advantage" is based on firm-specific core competencies (Prahalad and Hamel, 1990). To this end, knowledge plays a unique role in building and conserving an organization's core competencies.

Recent literatures on knowledge management classify knowledge within an organization into two categories: tacit knowledge and explicit knowledge. Explicit knowledge can be documented and shared in forms of scientific formula, specifications, manuals, documents, reports, mission statements, etc. Tacit knowledge is knowledge that cannot be articulated because tacit knowledge is highly personal and hard to encode. For example, a physician can use her tacit knowledge to diagnose a rare disease. Nonetheless, she may be unable to easily provide a detailed model of her thought process

leading to her final diagnosis. Developments in information technology have transformed the ability of organizations in knowledge management. Present applications of information technology in support of knowledge management mainly deal with explicit organizational knowledge. The integrated solution, known as enterprise resource planning (ERP), promises benefits from increased efficiency to improved quality, productivity, and profitability. ERP systems are software applications that provide transaction management to enable timely execution of decision support systems to plan and manage resources across an enterprise. These systems facilitate well-managed resource planning in the face of rapidly changing constraints such as materials availability, market readiness, plant capacities, personnel certification and business costs per location. Software vendors such as SAP AG, Baan, PeopleSoft and Oracle provide a host of integrated ERP products.

Tacit knowledge is highly personal and hard to encode. Individuals are the primary repositories of tacit knowledge that, due to its transparent characteristics, is difficult to communicate. The main difficulties of sharing tacit knowledge are as follows (Haldin-Herrgard, 2000):

- Perception and language are considered the main difficulties in sharing tacit knowledge.
    - Perceptually the characteristics of unconsciousness entails a problem of people not being aware of the full range of their knowledge.
    - Difficulties with knowledge lie in the fact that tacit knowledge helps in a non-verbal form.

- Time also raises difficulties for sharing tacit knowledge. The internalization of this form of knowledge requires a long time both for individual and organizational forms of knowledge. To not only experience but also to reflect on these experiences is time consuming but a necessity to develop tacitness in one's work.
- Value is another field with difficulties in sharing tacit knowledge as well as explicit knowledge. Many forms of tacit knowledge, like intuition and rule-of-thumb, have not been considered valuable (Zack, 1999).
- Another difficulty is that it is not only valuable and beneficial knowledge that is shared as true organizational or personal tacit knowledge. Bad habits and obsolete behavior are also diffused. Once shared and internalized, these bad habits tend to be difficult to stop.
- Distance also raises difficulties for sharing tacit knowledge. The need for face-to-face interaction is often perceived as a prerequisite for diffusion of tacit knowledge.

Tacit knowledge plays a unique role in building and conserving core competence, i.e., tacit knowledge is lost to a competitor when a knowledge worker leaves the firm. The business value of tacit knowledge lies at (Horvath, 2000):

- Innovation

  Tacit knowledge is strongly implicated in organizational innovation. People develop and use tacit knowledge before they are able to formalize or codify it. Thus the leading edge of the firm's learning (and a source of its future innovation) is often to be found in tacit knowledge.

- Best practices

  Attention to tacit knowledge can enable firms to identify and transfer best practices more effectively. Excellent business practices cannot be typically transferred unless they are well understood, and effective practices cannot be understood without reference to the tacit knowledge of the people who do the work.

- Imitation

  Tacit knowledge can help firms to resist imitation by competitors. Because it is embodied in people and embedded in the things they create, tacit knowledge tends to be "sticky"--to resist transfer to new groups and settings. Thus, firms that work effectively with tacit knowledge can expect to increase both their ability to innovate and their ability to extract innovation in the marketplace.

- Core competence

  A consideration of tacit knowledge can illuminate the emerging core competencies of the firm. Tacit knowledge represents the unique value added by the people who generate it. It emerges from their particular situations, skills, and experiences and, in the aggregate, reflects the history and circumstances of the firm. Tacit knowledge needs to be considered in the evaluation of the firm's core capabilities--those best-in-the-world capabilities with the potential to distinguish the firm from its competitors.

Knowledge management intends to capture and use organizational knowledge resources as effectively as possible. Today and increasingly in the future, the transfer of knowledge and expertise, and the creation of a "learning" organization, has become a critical factor to company innovation and competitiveness. Developments in technology, and particularly those in information and communications technology, have played a vital role in providing the infrastructures for management of tacit knowledge both within and between collaborating companies. The question addressed here is: how can we use information technology in support of knowledge management, especially tacit knowledge?

3 Knowledge Management Approaches

As we said early in this paper, organizational efforts in support of knowledge management through information technologies can be traced back to artificial intelligence methodologies such as expert systems and case-based reasoning systems. Expert Systems (ESs) use human knowledge in the form of If-Then rules to solve problems that ordinarily require human expertise. ESs imitate the reasoning processes that experts use to solve specific problems. Novices can use ES to improve their problem-solving capabilities. Experts can also use ES as an assistant. Most commercial ESs are rule-based systems; that is, the expert's expertise (tacit knowledge) is stored mainly in the form of production rules. The benefits brought by ESs are apparent. For example, ES can capture scarce expertise and distribute such expertise over a broad geographic area; many tasks require humans to operate in hazardous environments while ES may enable humans to avoid

such environments. Expert systems are used by a variety of organizations as a major tool for improving productivity and quality (Turban and Aronson, 1998). For example, Digital Equipment Corp. (DEC) uses an ES called XCON in support of the VAX system configuration. Stanford University developed an ES called DENDRAL to infer the molecular structure of unknown compounds from mass spectral and nuclear magnetic response data. Ford Motor company uses an ES called "Direct Labor Management System" to improve efficiency in all phases of the production process (Awad, 1996).

The case-based reasoning (CBR) paradigm is based on the premise that expertise comprises experience and in solving new decision problems, decision-makers rely on their experience with similar decision problems. For example, a physician – after having examined a patient – gets a reminder about another patient that he treated before. If the reminder was caused by a similarity of important symptoms, the physician uses the diagnosis and treatment of the previous patient as a base and modifies it to incorporate the differences between the new and previous patient. Finally he determines the disease and treatment for the new patient. CBR systems have been adopted successfully in support of complex decision problems within a variety of decision environments (Watson, 1997). For example, a CBR system is used to improve jet engine maintenance and reduce cost in Snecma, a leading French manufacturer of aircraft engines. The project was designed to perform engine troubleshooting using CBR; it performs technical maintenance of the Cfm 56-3 aircraft engine on all Boeing 737s.

The state of the art of IT in support of organizational knowledge management initiatives reveals three common applications: (1) the coding and sharing of best

practices, (2) the creation of corporate knowledge directories, and (3) the creation of knowledge networks (Alavi and Leidner, 2001). There are two schools of thought regarding externalization and codification of tacit knowledge. One school believes that tacit knowledge must be made explicit for sharing, and another school regards tacit knowledge as always tacit. For example, now the common form of knowledge management technologies is the electronic knowledge repository (Kankanhalli, et al., 2001). With knowledge repository technologies, organizations capture, organize, store and disseminate knowledge. For example, Ernst & Young has made significant investments in codification of the firm's internal knowledge and development of large knowledge repositories (Horvath, 2000). Andersen Consulting encourages employees to transfer their "tacit" knowledge to "explicit" knowledge in the form of written reports or video presentations (McCampbell et al., 1999). The explicit knowledge is then saved in repositories, such as databases and Intranet Web servers for users to access and use.

Since tacit knowledge is mostly stored in human beings, the chief characteristic of tacit knowledge is the difficulty in coding it so as to be shared. On the other hand, even coding the tacit knowledge successfully does not necessarily lead to improved performance and innovation, because knowledge management that focuses on creating network structures to transfer only explicit forms of knowledge will be severely limited in terms of the contribution to innovation (Swan et al., 1999). Even worse, attempts to codify tacit knowledge may only produce knowledge which is:

- Useless-- if it is too difficult to explain
- Difficult to verify-- if it is too uncertain

- Trivial--if it is too unimportant
- Redundant-if it is subject to continuous change
- Irrelevant to a wider audience--if it is context dependent
- Politically naïve--if it is too political sensitive
- Inaccurate--if it is too valuable and is therefore secreted by the "knower" (Swan et al., 1999)

To avoid problems related to codification of tacit knowledge, many new knowledge management strategies are toward transferring and exchanging tacit knowledge as tacit. In the network model of knowledge management systems, knowledge remains with the individual who develops and possesses it and is transferred mainly through person-to-person contacts. For example, Hoffman-LaRoche, a pharmaceutical company, has developed a knowledge map of its drug approval process (Lynne, 2001). For each step of the process, yellow pages listing relevant people organized according to their knowledge of the key issues are developed. This application of knowledge management is the creation of corporate directories, also referred to as the mapping of internal expertise (Alavi and Leidner, 2001). Because much knowledge in an organization remains uncodified, mapping the internal expertise is a potentially useful application of knowledge management (Ruggles, 1998). With this approach, people with one specified internal expertise can be retrieved from the directory, and then the user can contact this expert for specified knowledge. For example, one novice in Java can find the name and contact information from the yellow pages, and then ask the Java expert for

advice on programming questions. But in real life, the issues of knowledge sharing are not all that simple. People discuss many issues with peers but not experts. For example, music fans discuss pop songs with each other. In this case, the yellow page could not help in narrowing the search of wanted peers, since all people in the yellow pages are like-minded.

Besides yellow pages, another important application of IT to organizational knowledge management is the creation of knowledge networks. Knowledge networks bring experts together so that important knowledge is shared and amplified (Alavi and Leidner, 2001). Next, along with discussing the concept of knowledge network and its applications, we will discuss the concepts of the informal knowledge network: community of practice and virtual communities.

3.1 Knowledge Network

Firms in technologically intensive fields rely on collaborative relationships among their knowledge workers to access, survey and exploit emerging technological opportunities (Powell, 1998). Network-like relationships within and between such firms are becoming common. For example, in automotive industries, more and more parts and components from stand-alone suppliers are linked into a system of industrial partnerships (Lodge and Walton, 1989). Under such circumstances, traditional knowledge management techniques are not enough to satisfy the increasing demand for knowledge sharing in support of organizational processes such as innovation and competition. To survive, corporations need a knowledge network that captures and stores pertinent

knowledge, innovations and new ideas. They also need to distribute the stored knowledge to the decision makers on demand (Hogberg, 1998). To this end, the term "Knowledge networking" is used to signify a number of decision makers, resources and relationships among them, who are assembled in order to accumulate and use knowledge primarily by means of knowledge creation and transfer processes, for creating value. As shown in Figure 1, knowledge network makes it possible for valuable knowledge within the organization to be exchanged and advanced at the personal and group level (i.e., knowledge work processes) (Seufert et al., 1999). The structure and culture of the organization (i.e., facilitating conditions) compose the enabling and inhibiting environment for the creation and transfer of knowledge. Knowledge activities as well as information and communication tools is the tool-set (i.e., knowledge network architecture) supporting the social relationship (Von Krogh et al., 1997). A possible framework of knowledge network would include the following components:

1. Actors -- individuals, groups, organizations;
2. Relationships -- relationships between actors, which can be categorized by form, content and intensity; resources -- used by actors within their relationships;
3. Institutional properties -- including structural and cultural dimensions such as control mechanisms, standard operating procedures, norms and rules, communication patterns, etc.

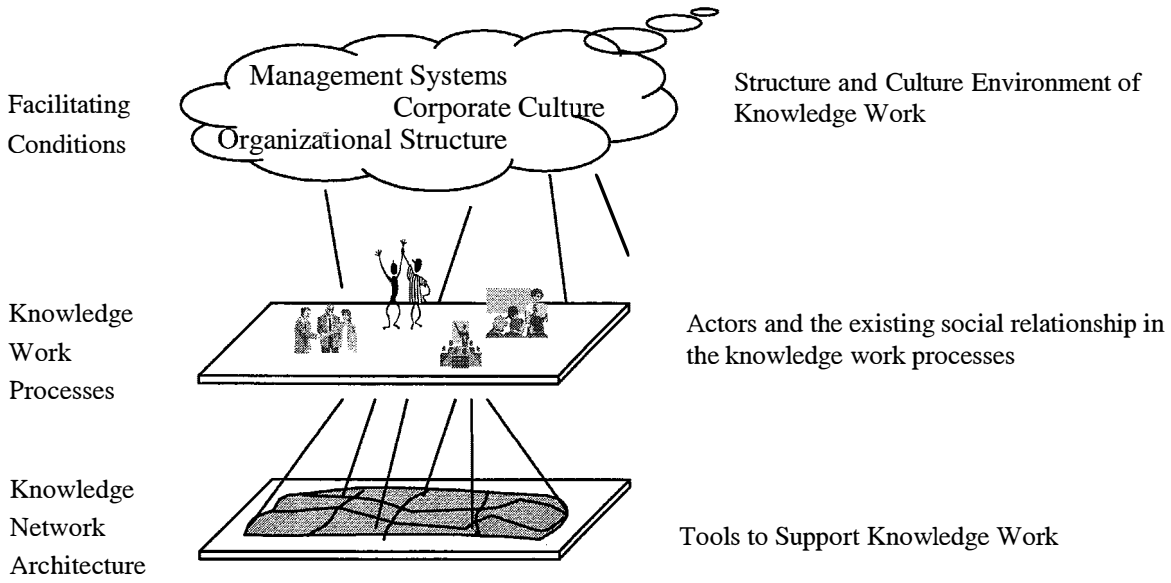

Figure 1: Framework of knowledge networks – a micro perspective (Adapted from Seufert et al., 1999)

The knowledge networking could yield great benefits. The openness and richness of networks is expected to foster a fertile environment for the creation of entirely new knowledge, while also accelerating the innovation rate. For example, Ericsson has developed many projects in knowledge networking: Image is used to align web-pages for easy Intranet searches; Knack offers web resources for competence development; Zopps is a general Ericsson knowledge base for off-duty staff; BIC offers business intelligence for middle-top management; Stargate offers web resources for competence and knowledge exchange. More details about these projects are given as follows (Hellström et al., 2000):

The Image initiative originates from Ericsson Radio, and has so far been developed by individuals outside and below the top-management level. The purpose of the Image initiative is to create a structured approach for standardizing and controlling intranet operations at Ericsson. This structure is then going to be applicable as a group-wide tool for intranet processes, rules, policies, etc.

Knack presents a more comprehensive and ambitious version of Competence Exchange. Knack, which is an educational portal on the Ericsson intranet, has a strong emphasis on KM and on providing learning resources for a number of possible users. From the Knack portal, materials, templates, information about internal courses and programs can be found as well as job listings and newsletters. There is also a "coffee shop" on the Knack site where discussion groups and specialist forums are maintained. Apart from these discussion groups, Knack offers competence inventories of experts in different fields.

Zopps is a type of "knowledge web" portal, or an Internet based competence boosting network outside the firewalls of Ericsson. The idea is that families of Ericsson employees, as well as the employee him/herself, can inconspicuously and spontaneously participate on the Zopps web pages, which contain among other things Ericsson information, and form interaction, reflection and knowledge transfer. Zopps provides families and employees with a "playground" for enhancing their computer skills as well as their knowledge of the company.

The BIC at Ericsson is built around an intranet portal, and consists of two core activities: (1) the EBIN network (Executive Business Intelligence Network) for top

management, which is a password-protected "executive corner" for strategic information sharing; and (2) the BIC (Business Intelligence Center) for the purchasing, coordination and distribution of external information. Newly developed features include personalized news bulletins. Today the BIC is staffed by four full-time Help Desk personnel who act as "knowledge brokers" and who work intensively with regulars, plus a network of about 200 analysts, who, in addition to their normal roles in the production line, are also trained in business intelligence. They distribute and direct information between groups and individuals who possess or lack valued knowledge.

Stargate is a new initiative growing out of Ericsson Business Consulting, and is an on-line tool for systematizing strategic competence areas of consultants. Stargate originated in the need for re-using experiences and adding value to organizational and structural capital. For several years, "islands" of best practice have emerged at Ericsson, partly as results of the work on quality within the ISO 9000 certification efforts. Initially consultants specialized in SAP and I-Net were targeted and offered "introduction kits" with templates etc, but gradually Stargate expanded and encompassed other competence profiles and project documents as well. Additional content areas became customer and market segment information, products and services, agreements and resource planning.

Several knowledge network software tools are already on the market. For example, KnowNet (Hogberg, 1998) is software that can be used as an enabler of knowledge flow within an organization. The software captures and visualizes knowledge that the employee stores in order to increase the company's total skill availability. It offers an efficient and fast way to spread knowledge among employees. It also is a tool

for creating a learning environment within an organization and enables knowledge workers to identify experts and areas of expertise within the organization.

Rather than being an issue of controlling and directing flows of knowledge, the task of managing knowledge networks is one of creating accessibility (Augier and Vendelo, 1999). For example, most of us have experienced the case that our specific skill in one aspect (e.g., selecting a book, a piece of music, or a company's stock from the stock market) can be enhanced by collaboration with like-minded individuals.

In organizations, people also use different kinds of informal communication methods to enhance learning within organizations. Informal networks provide critical channels for collective sensemaking and shared understandings (Lang, 2001). Evidence of such efforts can be seen in Japan, where "talk rooms" are deliberately established in which people meet to converse when they wish (Dougherty, 1999). Within organizations, informal networks of employees play a critical role in managing and transferring organizational knowledge. People share knowledge and work together to solve problems within these kinds of informal groups. We call these groups "communities of practice." In many organizations, people organize communities of practice to share knowledge and skills. These participants are motivated by a desire to use and develop their skills and competencies and to work together on issues of common interest (Regan and O'Connor, 2002). "Community of practice" is a hot term in contemporary knowledge management and refers to a theory that builds on learning as social participation (Wenger, 1998). In knowledge management, a change is occurring in how people think about who in the organization has credible and valuable knowledge that the organization can use to solve

its difficult problems. This shift is a movement from the idea that knowledge is found only in a select group of experts or "best" practitioners, and toward the idea that useful knowledge is distributed throughout the whole of an organization (Dixon, 1999). With community of practice, knowledge transfer goes on between "like people" rather than flowing from the "best" to the "less able" (Dougherty, 1999).

Communities of practice have an informal membership that is often fluid and self-organizing in nature. They are formed over time by individuals with a need to associate themselves with others experiencing similar issues and challenges within the organization (Lesser and Prusak, 2000). Communities of practice are important because of the following:

- They provide the opportunity for decision-makers to develop a network of individuals with similar interests. This is particularly valuable as the organization grows "virtual" and individuals find it increasingly difficult to know "who knows what."
- They foster the interpersonal interactions necessary to build a sense of trust and obligation. By being able to bring people together to create and share knowledge, the community creates the condition where individuals can "test" the trustworthiness and commitment of other community members.
- They tend to be organized around common issues or themes to maintain the shared vernacular.

Intranet/Internet are now widely used by organizations to communicate and share knowledge. An intranet, which can be defined as a private network implemented using Internet concepts and technology to disseminate and exchange data, sound, graphics, and other media, is one of the concrete methods that organizations are using to change the way they communicate internally and share information (Stoddart, 2001). Some organizations already display a culture of connection – people regularly meet formally, exchange documents and e-mails, talk, share ideas and meet socially.

For example, IBM Global Services (Mertins et al., 2001) developed an Intranet-based community of practice to enhance knowledge sharing and creation. In order to get in contact with the community and to get the opportunity to identify the requirements of the community the members of the core team organize "ShareNet Meetings" where the participants get the chance to exchange and spread tacit knowledge. The ICM-tool (Intellectual Capital Management) supports the movement of the individual tacit knowledge of each of the numerous members of one network to explicit knowledge that is available to all members of the network. Work Room, Team Room, etc. are Lotus Notes applications that promote the cooperation of real and virtual (i.e., international) teams. In the framework of intellectual capital management (ICM), these applications facilitate the transfer of individual tacit knowledge into explicit public knowledge. A new, even more comfortable application called the "knowledge café" is now available within the ICM framework.

Buckman (Pan and Scarbrough, 1998) identified knowledge as one of the most important resources that contribute to the competitive advantage of an organization.

K'Netix, Buckman's global knowledge transfer network, was introduced, supporting seven forums to coordinate Buckman's on-line conversation. By March 1993, every employee was able to access K'Netix, enabling Buckman associates to share knowledge, setting in motion the delivery of enhanced services to customers in over 90 countries worldwide in the form of virtual communities of practice.

3.2 Virtual Communities and Support Technologies

There has been considerable growth over the past two decades in the use of electronic discussion groups (Gray and Meister, 2001) -- such as bulletin boards, list-serves, collaborative media, discussion forums, instant messaging, and chat rooms -- as follows:

- **E-mail:** Full-service electronic mail (e-mail) systems send messages or documents from location to location. Usually email systems are considered one-to-one communication, but users also can use email to send messages to multiple recipients at the same time. This function supports people working in one group. Email is used to support the asynchronous (i.e., different time) communication among people.
- **Instant Messaging:** Allows users to see all the online users in a group communication. It is used to support the synchronous (i.e., same time) communication among users. A real-time electronic forum, visitors can meet others via Instant Messaging and share ideas on a particular subject.
- **Newsgroup:** A discussion group on the Internet, which is focused on exploring a particular topic. Discussion takes place by posting messages for everyone to read,

having online conversations, and sending email messages to individuals or the group. There are thousands of newsgroups on different topics.

- **BBS:** Bulletin Board System (Forums or Message Boards). Bulletin board systems offers one-to-many asynchronous communication. BBS is a computerized version of the bulletin boards found in stores and other public places, where people can leave messages and advertise things they want to buy or sell. BBS can be open to anyone or restricted to registered users only. Some BBS can be searched and some allow image posting. The main topics in a typical discussion forum are listed along with the date of the last message posted in that topic. Choosing one of the topics either opens a list of subtopics or goes directly to the discussions. The messages themselves may be in chronological order or reverse chronological order (Notess, 1999).
- **Chat Room:**

  There are many chat programs available that can be installed on a Web server or used via a chat hosting company. Some are free (ad-based) services and others range widely in price and features. Rather than the one-way interactivity of guest books or message forums, chat promotes live two-way (or more) interactive discussions. One user types a message, and another user can respond even while the first is still typing. Typically, chat sessions are not archived, so they're not searchable unless someone chooses to record the session and post it on the Web (Notess, 1999).

Interaction via these existing electronic discussion group technologies entice millions of people online (Preece, 2002). Communities of practice are moving beyond face-to-face exchanges, to interact in online environments, shared Web spaces, email

lists, discussion forums, and synchronous chats (Millen et al., 2002). One of the fast growing, high-tech office trends today is "virtual team" or "virtual community." The conception of virtual communities is often that of a virtual place in which people can meet to socialize, exchange experiences, and enjoy the possibility of establishing relationships without having to expose the physical self (Holmström, 2001; Tung et al., 2001). The team crosses time, space, and cultural boundaries and does so effectively with the use of technology (Johnson et al., 2001). An on-line community is a group of people who use computer networks as their primary mode of interaction. "Virtual communities encourage a diversity of participants to share their knowledge as a specific subject. Geography is expected to have no effect on an online community, where people can participate 24 hours a day at their convenience. Such subject-specific virtual meeting places are seeded with content by virtual community "hosts" whose job it is to draw new and existing members into the conversation (Barnatt, 1998). A virtual community of practice offers an excellent opportunity for members in different geographical locations to engage in a focused conversation about the future (Michelle, 2001). For example, by using a virtual community as a means to reach the expertise of experienced gamers, Daydream was able to get valuable input in the product development process. Daydream involved their customers in the development process of the online game Clusterball™ (Holmström, 2001). In online music message boards, music lovers share their interests and knowledge about music with each other (www.mp3.com).

The use of virtual teams is increasingly popular, especially when the members are in different geographic locations. With more users in the virtual communities, finding the

right person to contact is becoming challenging. The selection of the right person to contact is a highly personal experience in the virtual communities, and very difficult when there are thousands of members with different knowledge about the specific topic of discussion. Therefore, an effective supporting technique is needed to help users find like-minded people (buddies). A popular research effort in helping find like-minded people in communities is collaborative filtering. Collaborative filtering provides computer-based support for the forwarding of information to others who might be interested in the information (Maltz and Ehrlich, 1995). Collaborative filtering is used in a large number of online companies, such as Amazon (www.amazon.com), Levi's (www.levis.com), and Moviecritic (www.moviecritic.com) (Good et al., 1999). Collaborative filtering works roughly as follows: networked minds provide information concerning their likes or dislikes in the form of ratings. These ratings are aggregated and are then used to compile recommendations for particular items (Maltz and Ehrlich, 1995). For example, a recommender system for movies may recommend movies that received mostly "good' or "very good" ratings and it may not recommend movies that were mostly rated "bad." Social navigation uses data generated by crowds of networked minds and denotes movement from one item to another influenced by the activity of others. Also, a user may choose to read only those messages in a news group that were rated as good. In collaborative filtering, the subjects are requested to evaluate different items. Based on their evaluation of various items, the highest level of overlap indicates that these subjects have similar interests (i.e., they are buddies) (Hayes et al., 2001):

The basic idea of automatic collaborative filtering (ACF) can be shown using Figure 2. In this figure three users have all shown an interest in assets A, B & C (for instance they all have rented video A, B & C). This high level overlap indicates that these users have similar tastes. Further, it seems a safe bet to recommend asset D and E to User 1 because they are 'endorsed' by User 2 and 3 that have similar interest to User 1.

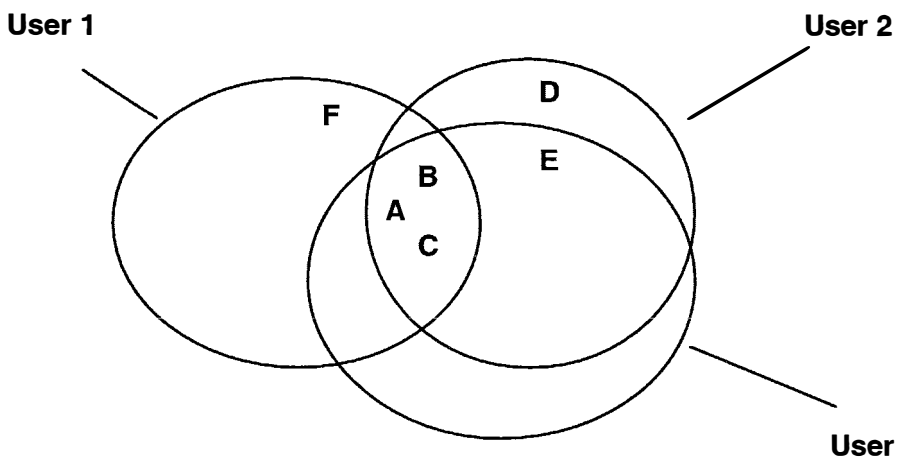

Figure 2: A Venn diagram showing interests of three users in assets ABCDEF (adapted from Hayes et al., 2001)

One of the greatest strengths of ACF is that, if enough data is available, good quality recommendations can be produced without needing representations of the assets that are being recommended. There are two distinct approaches to the ACF idea, that are termed invasive and non-invasive. With the invasive approach the user is explicitly asked to rate assets. This approach clearly contains more information (see Table 1). Non-invasive data contains less information and can be noisy in the sense that customers may not like some of the items they have used. This can be seen in Table 2.

Table 1: Data for use in ACF where users have explicitly rated assets (adapted from Hayes et al., 2001)

	A	B	C	D	E	F	G
User 1	0.6	0.6	0.8			0.8	0.5
User 2		0.8	0.8	0.3	0.7		
User 3	0.6	0.6	0.3	0.5		0.7	0.5
User 4					0.7	0.8	0.7
User 5	0.6	0.6	0.8			0.7	
User 6		0.8	0.8	0.7	0.7		
User 7	0.7	0.5			0.7		
User 8					0.7	0.7	0.8

Table 2: Data for use in ACF where users have not explicitly rated assets (adapted from Hayes et al., 2001)

	A	B	C	D	E	F	G
User 1	1	1	1			1	1
User 2		1	1	1	1		
User 3	1	1	1	1		1	1
User 4					1	1	1
User 5	1	1	1			1	
User 6		1	1	1	1		
User 7	1	1			1		
User 8					1	1	1

The collaborative filtering technique is a popular research effort used by many online shopping companies, but it is not a panacea for all situations. In the next section we will discuss the major problems and limitations of current electronic discussion group technologies in buddy finding. From there, we will introduce our agent-based buddy finding methodology.

4 The Basic Need for Collaborative Filtering

Virtual communities are becoming an increasingly important means for people to share and manage tacit knowledge. For example, in 2000, at least 8 million messages were unevenly distributed over 50,000 or more newsgroups devoted to every topic of possible human interest, from reselling Taiwanese household goods, to debating religion, to trading software (Smith, 2002). However, as Cothrel et al. (1999) found, in the virtual community, based on the study of 15 on-line communities in Europe, the key is to build community. Community members need to find the right person to ask questions and get timely responses. Therefore, "the development of personal relationships between team members is recognized as an important factor in enhancing effective working relationships among members" (Pauleen and Yoong, 2001). For example, experienced Usenet users exploit their knowledge of other members (i.e., personal relationships) to find interesting discussions among those off-topic articles and less interesting discussions (Lueg, 2001). A key finding of collective action studies is that mutual awareness of other

participants' histories and relationships is critical to useful cooperation among the members of community (Smith, 2002). In fact, with very low response to the requests in virtual communities, it is difficult for the members to get such kinds of awareness in the virtual community (Gould, 1999; Smith, 2002). Therefore, ignorance is a big burden in keeping virtual communities from optimal collaboration; those who have the knowledge are not aware that others may find it useful. Also those who could benefit from the knowledge of some of the community members are not aware of who has it (O'Dell et al., 1998).

Experiences with the Usenet indicate that people learn about other participants and their habits and interests over time by reading their public statements or by exchanging private e-mails (Lueg, 2001). A major problem with virtual communities is for people to find other members by means of posting, searching, reading and replying. It is time-consuming and frustrating for users to read all the postings in one usual message board. Information overload--including the overload of totally irrelevant information which the Internet provides--discourages many people from joining a virtual community (Geyer, 1996). More seriously, there are many occasions when "team members would send out questions and would never get back a response" (Gould, 1999). For example, Smith (2002) found that "newsgroups are actually remarkably non-responsive, only about 2% of the message in these newsgroups are replies." Dron et al. (1998) found in an experiment using Usenet Newsgroups to accelerate the evolution of a learning resource within a group of students, that some questions remained unanswered and users could not get a solid picture from using the newsgroup. Reasons for such a low response rate are as

follows. First, replying to a request requires time for processing and preparing a response. Members must expend effort not only in formulating a response to a request for advice; but also, in a large electronic discussion group, a potential advice-provider may have to read through many requests before finding one to which he/she can respond (Gray and Meister, 2001). Second, some participants post requests/responses that are unnecessarily long; or they lurk rather than contribute to the give-and-take that is an essential feature of any newsgroup; or they post off-topic requests/responses; or violate the local rules of decorum (Smith, 2002). Several researchers have developed some norms to guide users' behavior in electronic discussion groups. For example, Gordon (2000) suggested avoiding posting unsolicited commercial come-ons, avoiding flaming other participants, etc. But "monitoring for compliance with group norms is difficult in an electronic discussion group" (Gray and Meister, 2001). Moreover, information and knowledge are unlike most public goods in that their contribution has potential benefit to everyone except the individual who contributes it. When by definition the content of one's own advice cannot benefit oneself, the incentive to contribute is lower. Self-interested individuals would be motivated to receive others' knowledge but not to share their own (Gray and Meister, 2001).

With little sense of the presence of other people, individuals have a difficult time forming cooperative relationships (Smith, 2002). The existing electronic discussion group tools supply the platform for communication between users. Finding the right person to contact is still a trial and error procedure. To a great extent, the success of using forums depends on how lucky members are, and the process can be time-consuming and

frustrating for the members. To this end, Gordon (2000) suggests that "patience is critical to the success of using forums, since you may have to wait hours or even days for another user to stumble across and reply to your message rather than receiving an instantaneous response."

5 Issues Affecting Collaborative Filtering

As discussed in the previous section, one popular research effort in helping to build personal relationships in virtual communities is by means of collaborative filtering. Two distinct approaches to collaborative filtering were discussed earlier: invasive and non-invasive (Hayes et al., 2001). In the invasive approaches, the user must evaluate every item. For example, to select music, after listening to songs, the users need to evaluate those songs. This creates an extra workload for the users. In the non-invasive approach, users do not need to evaluate each item, but, as mentioned earlier, "non-invasive data contains less information and can be noisy in the sense that customers may not like some of the items they have used" (Hayes et al., 2001). Other limitations of collaborative filtering include (1) the relationship among users being based on item selections overlapping; (2) the centralized mechanism usually owned by one organization. In the following we discuss these two limitations. First, in collaborative filtering, "only users with the highest level of overlap might be considered as buddies" (Hayes et al., 2001). In that case, if users choose similar but not the same items (e.g., similar but not the same songs), since there are no overlaps between their selection, the users will never have opportunities to be identified as buddies with the collaborative

filtering. That is, collaborative filtering may keep many potential users with similar interests from being buddies. Secondly, as a centralized mechanism, all customer data are stored in the server. Based on various analyses of the centralized data, the collaborative filtering determines the buddy list of customers and recommends products (Hayes et al., 2001). But the buddy relationships among members are private and users do not want to let others know about and control it. More importantly, for many cases in virtual communities, the data of users are naturally distributed, but not centralized. For example, music lovers use Napster within a distributed environment to share music with each other in a peer-to-peer mode. If a member wants a new music item, he or she types the music title or the author's name. Napster will search all distributed members' sites and return the addresses of music file locations. Then the music requester can download the desired music from a remote site. Napster offers members a platform to share music, but the user needs to search all members when he or she wants a piece of music. Napster cannot help users to organize into like-interest user groups. Within such a like-interest group, the user can recommend new music to their group members directly.

Let us look at another example, that of stock selection by a group of investors. Assume that a group of investors wants to help each other in selecting "favored" stocks. This group can start a news group and members can post the characteristics of their desired stocks so that others can suggest similar stock(s) they know about. For example, an investor posts news that he/she wishes to know about stocks similar to IBM. Those news-group members who care to read the news, search through their portfolio and identify stocks similar to IBM, and then post their view. This is a typical knowledge

management issue that requires selecting supporting information technologies, such as a news group support system, to enable members to post their requirements/responses (e.g., see www.Etrade.com). The problem with news group systems is that: (1) members are unable to share their knowledge (i.e., suggesting possible stocks) if they miss the news (i.e., don't read the request for information). This results in a second problem: (2) how can we identify the group of investors who are most likely to provide a good response to the posted request?

It is commonly assumed that learning in firms is enhanced when technically skilled employees are encouraged to collaborate with like-minded individuals. To this end, Li and Montazemi (2001) proposed a combination of agent technology and distributed CBR systems in support of sharing knowledge among like-minded members. To place this in perspective, let us use the example of collaboration among investors to help each other in selecting a stock. In this case, each stock can be considered as a "case" and each investor's portfolio can be considered as a distributed case library. The request of an investor (e.g., for stocks similar to IBM) is communicated to the case-base of other investors to identify the stocks that closely match the characteristics of the requested stocks. The characteristics of matched stocks are sent back to the requesting investor as depicted in Figure 3. This process works well as long as there are a small number of investors (members). However, traffic generated by sending a message from one member to every other member is inefficient and can clog the network of an online brokerage firm such as Etrade, which has thousands of members. In this case, we need to identify the subset of members (termed buddies) who are most likely to have stocks

similar to the requesting investor (see Figure 3). Li and Montazemi (2001) developed a methodology to identify buddies in the form of intelligent agents operating in a knowledge network decision environment, such as that which shares information about available stocks or shares music information among music lovers.

Development of well-integrated enterprise information systems (e.g., SAP AG, PeopleSoft), to share data optimally across the organizations, took more than 50 years of research and development. Sharing tacit knowledge is far more complex than enabling flow of data through enterprise systems. Nonetheless, increased research and development in capturing tacit knowledge and disseminating it on demand will provide us with much needed tools and techniques in support of effective management of organizational knowledge.

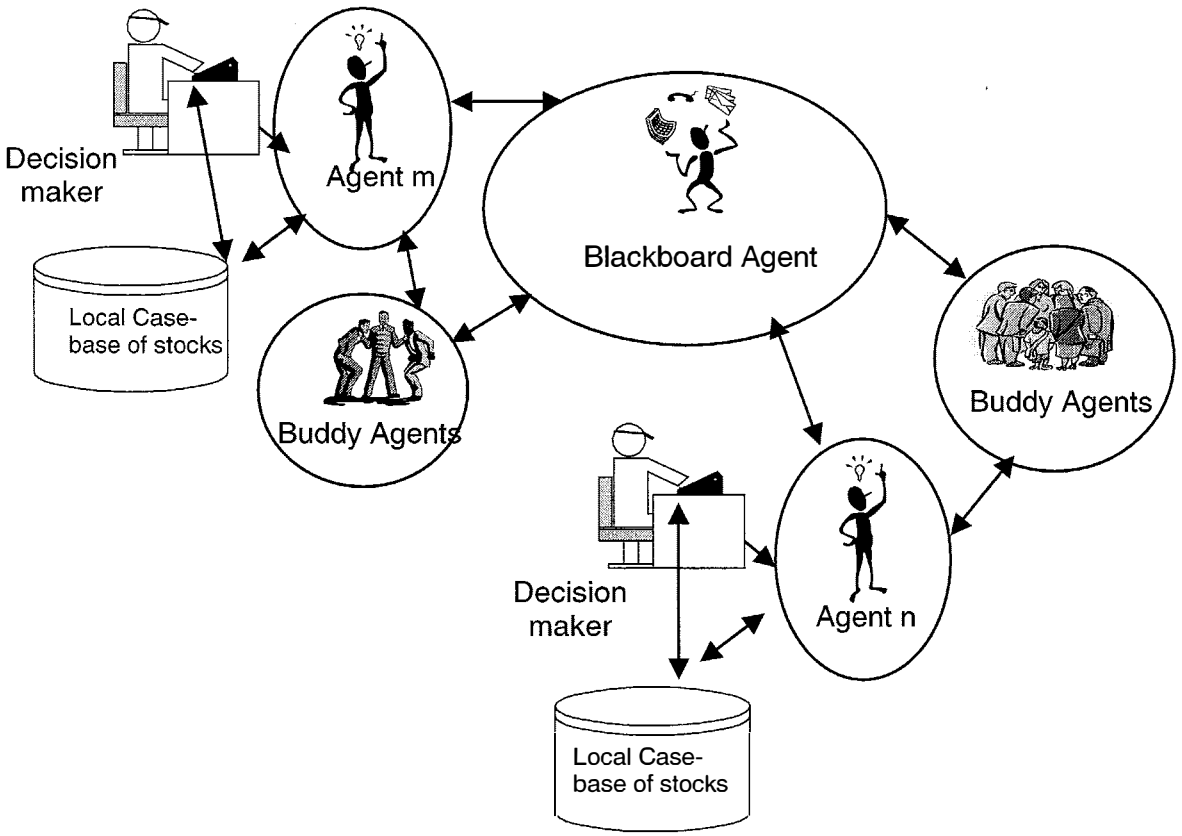

Figure 3: An overview of the MAS system in support of stock selection

References:

Alavi, M., and Leidner, D. E., "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues", *MIS Quarterly,* Volume 25, Number 3, March 2001, pp. 107-136.

Augier, M., and Vendelo, M.T., "Networks, Cognition and Management of Tacit Knowledge," *Journal of Knowledge Management,* Volume 3, Number 4, 1999, pp. 252-261.

Austin, J. R., "A cognitive framework for understanding demographic influences in groups," *International Journal of Organizational Analysis,* Volume 5, Number 4, Oct 1997, pp.342-359.

Awad, E. M., *Building Expert Systems: Principles, Procedures, and Applications*, West Publishing Co., Los Angles, CA, 1996.

Barnatt, C., "Virtual Communities and Financial Services-on-line Business Potentials and Strategic Choice," *International Journal of Banking Marketing*, Volume 16, Number 4, 1998, pp. 161-169.

Chase, R.L., "Knowledge Management Benchmarks," *The Journal of Knowledge Management*, Volume 1, Number 1, September 1997a, pp. 83-92.

Chase, R.L., "The Knowledge Based Organization: An International Survey," *The Journal of Knowledge Management*, Volume 1, Number 1, September 1997b, pp. 38-49.

Civi, E., "Knowledge Management as a Competitive Asset: A Review," *Marketing Intelligence & Planning*, Volume 18, Number 4, 2000, pp.166-174.

Cothrel, J., and Williams, R. L., "On-line Communities: Helping Them Form and Grow," *Journal of Knowledge Management*, Volume 3, Number 1, 1999, pp. 54-60.

Dixon, N. M., "The changing face of knowledge," *The Learning Organization*, Volume 6, Number 5, 1999, pp. 212-216.

Dougherty, V., "Knowledge is about people, not databases," *Industrial and Commercial Training*, Volume 31, Number 7, 1999, pp. 262-266.

Dron, J., Mitchell R. and Siviter P., "From Answer Garden to Answer Jungle," *Education + Training*, Volume 40, Number 8, 1998, pp. 353-358.

Regan, E. A., and O'Connor, B. N., *End-User Information Systems: Implementing Individual and Work Group Technologies*, 2nd ed., Prentice Hall, New Jersey, 2002.

Geyer, F., "Virtual Communities in Cyberspace," *Kybernetes*, Volume 25, Number 4, 1996, pp. 60-66.

Good, N., Schafer, J. B., Konstan, J. A., Borchers, A., Sarwar, B., Herlocker, J., and Riedl, J., "Combining Collaborative Filtering with Personal Agents for Better Recommendations," *Proceedings of the Sixteenth National Conference on Artificial Intelligence and Eleventh Conference on Innovative Applications of Artificial Intelligence*, July 18-22, 1999, Orlando, Florida, USA. AAAI Press / The MIT Press, 1999, pp. 439-446.

Gordon, R. S., "Online discussion forums," *Link – up,* Volume 17, Number 1, Jan/Feb 2000, pp12.

Gottschalk, P., "Knowledge Management in the Professions: The Case of IT Support in Law Firms," *Proceedings of the 33rd Hawaii International Conference on System Sciences*, Volume 3, Maui, Hawaii, January 4-7, 2000.

Gould, D., "Virtual organization," in *Leading Virtual Teams* (online) 2, www.seanet/com/-daveg/ltv.htm, September 1999.

Gray, P. H., and Meister, D. B., "Anomaly Reconciliation in Electronic Discussion Groups," *Twenty-Second International Conference on Information Systems*, New Orleans, LA, USA, 2001, pp. 339-348.

Haldin-Herrgard, T., "Difficulties in Diffusion of Tacit Knowledge in Organizations," *Journal of Intellectual Capital*, Volume 1, Number 4, 2000, pp. 357-365.

Harvard Management Update, "Do We Know How to Do That? Understanding Knowledge Management," February 1999, pp. 1-5.

Hayes, C., Cunningham, P., and Smyth, B., "A Case-Based Reasoning View of Automated Collaborative," *Case-Based Reasoning Research and Development, LNAI 2080, 4th International Conference on Case-Based Reasoning, ICCBR 2001, Vancouver, BC, Canada, July/August 2001,* Aha, D. W. and Watson, I. (Eds.), Springer-Verlag, Berlin, 2001, pp. 234-248.

Hellström, T., Kemlin, P., and Malmquist, U., "Knowledge and Competence Management at Ericsson: Decentralization and Organization Fit," *Journal of Knowledge Management*, Volume 4, Number 2, 2000, pp. 99-110.

Hogberg, C., "A Design for Futurizing Knowledge Networking," *Journal of Knowledge Management*, Volume 2, Number 3, December 1998, pp. 81-92.

Hu, Y., "Some Thoughts on Agent Trust and Delegation," *Proceedings of the Fifth International Conference on Autonomous Agents, AGENTS'01*, Montreal, Quebec, Canada, May 28-June 1, 2001, pp. 489-496.

Holmström, H., "Virtual Communities as Platforms for Product Development: An Interpretive Case Study of Customer Involvement in Online Game Development," *Twenty-Second International Conference on Information Systems*, New Orleans, LA, USA, December 16-19, 2001, pp. 299-306.

Horvath, J. A., "Working with Tacit Knowledge," *The Knowledge Management Yearbook 2000-2001*, Cortada, J. W. and Woods, J. A (Eds.), Butterworth Heinemann, Boston, MA, 2000, pp. 34-51.

Irma, B., and Rajiv, S., "Organizational knowledge management: A contingency perspective," *Journal of Management Information Systems*, Volume 18, Number 1, Summer 2001, pp. 23-55.

Johnson, P., Heimann, V., and O'Neill, K., "The Wonderland of Virtual Teams," *Journal of Workplace Learning*, Volume 13. Number 1, 2001, pp. 24-29.

Lang, J.C., "Managing in Knowledge-Based Competition", *Journal of Organizational Change Management*, Volume 14, Number 6, 2001, pp. 539-553.

Lesser, E., and Prusak, L., "Communities of Practice, Social Capital, and Organizational Knowledge," *The Knowledge Management Yearbook 2000-2001*, Cortada, J. W. and Woods, J. A.(Eds.), Butterworth Heinemann, 2000, pp. 251-259.

Li, X., and Montazemi, A. R., "A Modeling Technique to Assess Buddy-Agents Membership for Multi-Agent Systems", *Working paper # 452*, Michael G. Degroot School of Business, McMASTER University, Hamilton, Ontario, Canada, March, 2001.

Lodge, G.C., and Walton, R.E., "The American Corporation and Its New Relationships," *California Management Review*, Volume 31, 1989, pp. 9-24.

Lueg, C., "Information, Knowledge, and Networked Minds," *Journal of Knowledge Management*, Volume 5, Number 2, 2001, pp. 151-160.

Lynne, M. M., "Toward a Theory of Knowledge Reuse: Types of Knowledge Reuse Situations and Factors in Reuse Success," *Journal of Management Information Systems*, Volume 18, Number 1, Summer 2001, pp. 57-93.

Maltz, D., and Ehrlich, K., "Pointing the way: active collaborative filtering", *Conference proceedings on human factors in computing systems, 1995, Denver, Colorado,* ACM Press/Addison-Wesley Publishing Co., New York, NY, USA, 1995, pp. 202-209.

McCampbell, A. S., Clare, L. N., and Gitters, S. H., "Knowledge Management: the New Challenge for the 21st Century," *The Journal of Knowledge Management*, Volume 3, Number 3, 1999, pp. 172-179.

Mertins, K., Heisig, P., and Vorbeck, J., *Knowledge Management-Best Practices in Europe*, Springer-Verlag, Berlin, 2001.

Michelle, M., "Creating a Community," *Association Management,* Volume 53, Number 8, August 2001, pp. 82-83.

Millen, D. R., Fontaine M. A., and Muller M. J., "Understanding the Benefit and Costs of Communities of Practice," *Communications of the ACM*, Volume 45, Number 4, April 2002, pp. 69-73.

Notess, G. R., "Communications and community on Web sites," *Online,* Volume 23, Number 4, July/August 1999, pp. 65-68.

O'Dell, C., Grayson, C. J., and Essaides, N., *If Only We Knew What We Know: The Transfer of Internal Knowledge and Best Practice*, New York, The Free Press, 1998.

Pemberton, J. D., and Stonehouse G. H., "Organizational Learning and Knowledge Assets- an essential partnership," *The Learning Organization*, Volume 7, Number 4, 2000, pp. 184-194.

Pan, S. L., and Scarbrough, H., "A Socio-Technical View of Knowledge-Sharing at Buckman Laboratories," *Journal of Knowledge Management*, Volume 2, Number 1, September 1998, pp. 55-66.

Pauleen, D. F., and Yoong, P., "Facilitating Virtual Team Relationships via Internet and Conventional Communication Channels," *Internet Research: Electronic Networking Applications and Policy*, Volume 11, Number 3, 2001, pp. 190-202.

Powell, W.W., "Learning from Collaboration: Knowledge and Networks in the Biotechnology and Pharmaceutical Industries," *California Management Review,* Volume 40, Number 3, 1998, pp. 228-240.

Prahalad, C.K., and Hamel, G., "The Core Competence of the Corporation," *Harvard Business Review*, May-June 1990, pp 79-91.

Preece, J., "Supporting community and building social capital," *Communications of the ACM*, Volume 45, Number 4, April 2002, pp. 51-55.

Ruggles, R., "The State of the Notion: Knowledge Management in Practice," *California Management Review*, Volume 40, Number 3, 1998, pp. 80-89.

Seufert, A., Krogh, G. V., and Bach, A., "Toward Knowledge Networking," *Journal of Knowledge Management*, Volume 3, Number 3, 1999, pp. 180-190.

Smith, M., "Tools for Navigating Large Social Cyberspace," *Communications of the ACM*, Volume 45, Number 4, April 2002, pp. 51-55.

Stoddart, L., "Managing Intranets to Encourage Knowledge Sharing: Opportunities and Constraints," *Online Information Review*, Volume 25, Number 1, 2001, pp. 19-28.

Swan, J., Newell, S., Scarbrough, H., and Hislop, D., "Knowledge Management and Innovation: Networks and Networking," *Journal of Knowledge Management*, Volume 3, Number 4, 1999, pp. 262-275.

Turban, E., and Aronson, J.E., *Decision Support Systems and Intelligent Systems*, 5th ed. Prentice-Hall, NJ, 1998.

Von Krogh, G., Nonaka, I., and Ichijo, K., "Develop Knowledge Activists!" *European Management Journal*, Volume 15, Number 5, 1997, pp. 475-483.

Watson, I., *Applying Case-Based Reasoning: Techniques for Enterprise Systems*, Morgan Kaufmann Publishers, Inc., San Francisco, CA, 1997.

Wenger, E., *Communities of Practice: Learning, Meaning, and Identity*, Cambridge University Press, Cambridge, 1998.

Zack, M., "Managing codified knowledge," *Sloan Management Review*, Summer 1999, pp. 45-58.

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