Software Tools for Knowledge Management

A DACS State-of-the-Art Report

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14. ABSTRACT

A variety of software tools for knowledge management have become available, some commercial and some academic. Not all tools that are labeled KM tools are indeed KM tools; their vendors attempt to make them more attractive by attaching this buzzword to them. The KM tools generally provide features such as search and database maintenance, intranet features, security, FAQ lists, logged chat features, find-an-expert features, personalization, etc., which aid in knowledge-sharing within an organization. With features like instant messaging and on-line chat, knowledge management systems have grown to offer a common meeting place for all users other than the traditional coffee break area.

In this report we present a survey of tools for KM. The information we present is primarily compiled from published material (i.e., mostly material provided by the vendors). For some of the tools we have tried the demo version provided through the Internet, but we basically rely on the material compiled from the public domain.

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Introduction

The term "knowledge management" has been around since the mid-1980s. Every organization that wants to be competitive must identify, manage, protect and exploit its assets. For many companies, by the very nature of their business, knowledge is their most important, valuable, and critical asset. For example, this situation exists in fields including software development, consulting, advertisement, and media. However, as we will show in this report, other industries have identified problems that lead them to recognize the necessity of managing their knowledge. For example, due to the fact that a large amount of organizational knowledge is undocumented, companies have realized that they lose knowledge when employees leave the company. The increasing mobility of employees has created a growing need to retain employees and, more importantly, their knowledge, which has led to a growing call for knowledge management (KM). Another aspect of knowledge management is that of lessons learned. Avoiding repeating mistakes could save money for most organizations; hence, they need to gather and maintain lessons learned from the various projects undertaken. Organizations also strive to repeat successes, making it important to manage knowledge about strategies that led to previous successes. Knowledge management has been integral to the success of many companies. Customer knowledge, an important part of organizational knowledge, has helped companies understand their customers, making it possible to better satisfy their needs.

Knowledge sharing and learning can happen ad-hoc (e.g. water cooler or coffee breaks). It is, however, more efficient if it is organized. Even if organized, knowledge management can be performed without tool support (e.g., having a physical library of artifacts, incidents, lessons learned, standards collected on paper). In the electronic age, though, hardware and software advances allow handling of electronic objects in a very effective and efficient way. Software tools enable:

- capturing of knowledge (transforming it from volatile and tacit to non-volatile and explicit)
- storage and organization (by distributed databases and document management technology)
- reliable and secure access from various locations (by using the Internet, intranets and portals)
- efficient search and retrieval (supported by search engines and databases enhanced with artificial intelligence techniques)
- collaboration between people who are not geographically collocated (by e-mail, bulletin boards, chat, on line document sharing and net-meetings)

A variety of software tools for knowledge management have become available, some commercial and some academic. Not all tools that are labeled KM tools are indeed KM tools; their vendors attempt to make them more attractive by attaching this buzzword to them. The KM tools generally provide features such as search and database maintenance, intranet features, security, FAQ lists, logged chat features, find-an-expert features,

personalization, etc., which aid in knowledge-sharing within an organization. With features like instant messaging and on-line chat, knowledge management systems have grown to offer a common meeting place for all users other than the traditional coffee break area.

In this report we present a survey of tools for KM. The information we present is primarily compiled from published material (i.e., mostly material provided by the vendors). For some of the tools we have tried the demo version provided through the Internet, but we basically rely on the material compiled from the public domain.

The purpose of this report is to survey, characterize and classify software tools for knowledge management. The tools presented here were selected on the following basis. We looked for tools with multiple features that could support many aspects and activities of knowledge management (for example, document management and portals). We also selected some tools that provided specific KM services (for example, knowledge discovery and e-learning). We describe two models of knowledge evolution that we used to characterize and classify the tools.

Of course, tools are not everything. Buying a tool is the easiest part of implementing KM. The difficult but unavoidable tasks are defining (and following) an implementation strategy (or process or methodology); motivating people to be a part of the system and to use it; and the overall culture change involved. To illustrate this statement, we present a set of case studies that show how large and well-known organizations implement their KM programs.

The report speaks to organizations that want to implement KM (or some aspect of it), and companies who want to find what this KM hype is about and if they should bother considering it at all. It also addresses tool developers and vendors (to help them form a picture of the market and its potential gaps) and to researchers (to aid them in identifying trends and future work).

Following this introduction, Section 1 discusses various concepts of knowledge management from the literature. Based on these concepts, we establish the definition of knowledge management that we will use in this report. Then, we discuss the various issues addressed by knowledge management and discuss common motivations for using software tools for knowledge management. In Sections 2 and 3, we describe two common knowledge transformation and evolution models that will be used in Section 4 for describing, analyzing, and classifying the tools. In Section 5 we present examples of KM tools application and KM system implementation. The last section contains a summary and conclusions.

Section 1.
Knowledge and Knowledge Management

What is Knowledge?

Before we can define knowledge management, we must first establish a definition of knowledge. There are several ways of defining knowledge. We adopt the following definition:

"Knowledge is a mix of framed experience, values, contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and information." (Agresti, 2000)

An organization gains knowledge from the daily work it does over the years. There are questions raised, such as Can this knowledge be captured? Is it manageable? How is knowledge different from information and data? Specifically for this report, how can software tools manage knowledge?

We consider ***data*** as raw numbers, which convey little unless processed. Processed data is called ***information***. Information with context and experiences is called ***knowledge*** (Agresti, 2000). However, the same object can be information for some people and knowledge to others, as we will see in the Hewlett-Packard case study in Section 5. Knowledge is valuable as it is, but it can and should be leveraged when shared within the organization. Knowledge allows employees to re-live others' experiences and learn important lessons without repeating similar mistakes. Knowledge within the organization should be organized, stored and made accessible to all employees who need it, whenever they need it and wherever they are.

What is Knowledge Management?

Knowledge management is a term that has a variety of definitions. Here we choose to present two definitions, one by Agresti and another by a knowledge management tool developer, Hyperwave[1], to compare the different viewpoints in research and industry. Agresti defines knowledge management as "*the practice of transforming the intellectual assets of an organization into business value*" (Agresti, 2000). The developers of Hyperwave present an alternative definition of knowledge management, i.e., it is "*the task of developing and exploiting an organization's tangible and intangible knowledge resources. Knowledge management covers organizational and technological issues.*"[2]

[1] http://www.hyperwave.com
[2] http://www.hyperwave.com

We understand ***intangible knowledge resources*** as the knowledge of the employees in the organization and ***tangible knowledge resources*** as the various knowledge items available in that organization. We define a ***knowledge item*** as an item that contains knowledge, and can be distributed because it is recorded in a non-perishable way (such as paper folders, electronic files containing text, pictures, audio, or video). For the purpose of this report, knowledge items will be restricted to items recorded in an electronic form. Examples of knowledge items will include lessons learned from a project in a documented form such as a video recording of a meeting, etc.

The importance of intellectual assets is emphasized in both knowledge management definitions given above. Intellectual assets of an organization include not only written projects, reports or lessons learned from projects, but also the knowledge of its employees. Knowledge management aims to leverage this knowledge in order to improve the performance, business value, and competitive advantage of the organization.

Why Knowledge Management?

In this highly competitive world, retaining key employees is a major problem for most organizations. When an employee leaves, the organization also loses the knowledge the employee gained. How does one minimize the loss of knowledge that occurs because someone has left the organization?

Organizations direct large amounts of effort, time and money to ensure that similar tasks are completed. When people in the organization commit similar mistakes, the organization ends up wasting time and money to rectify them. How to minimize such losses?

Locating people who have experience in a particular task becomes difficult, as records may not be maintained. What is the most effective way to maintain records and create an expert and expertise repository? It is important to make experts available and support experts in a way so that they are not just bogged down by the same questions all the time. How can this be done easily and efficiently?

Organizations might have a lot of knowledge (for example, about products, processes, practices, and policies, customers, vendors, and partners) already captured, but spread in disparate locations and using different applications. This makes staff access to this information very difficult, if not impossible. The company ends up having tons of information stored but not used. How can this information be organized and stored such that every employee can retrieve it easily?

Knowledge management offers solutions to such problems. In a typical knowledge management system, a knowledge base is maintained which documents and organizes the knowledge of the organization. It keeps track of the individuals of the organization and the collective knowledge, too. Such a system also maintains FAQ lists and expert lists which aid in running the organization more smoothly and profitably.

The DACS report on "Knowledge Management in Software Engineering" discusses in more detail the importance of knowledge management and the construction of a knowledge management system (Rus, et. al., 2001).

Why Software Tools for Knowledge Management?

The amount of information and knowledge that needs to be captured, stored and shared; the geographic distribution of sources and consumers; and the dynamic evolution of information (just to mention a few characteristics of knowledge in our e-lives) makes the use of tools not an option, but a necessity.

Fortunately, the progress of technology (such as Internet, group support systems, search engines, portals, data and knowledge warehouses, and the application of statistical analysis and artificial intelligence (AI) techniques) facilitates knowledge management. It has become quite easy to manage and maintain huge knowledge bases and access them from anywhere in the world. Software tools provide good support to knowledge management systems and, thus, a variety of knowledge management tools are available today.

How do you keep track of millions of documents in a big organization? How do you search and locate a particular knowledge item from the knowledge base? How do you provide 24/7/365 customer service? The solution for all the above problems lies in software tools.

Software tools in knowledge management have the advantage of using the organization's existing Internet and information technology (IT) infrastructure. With the growth of IT, organizations undertake projects to empower their employees with information access, creating knowledge bases, intranets, chat rooms, full-text indexing tools, and document management tools as required by knowledge management. Applying those technologies to knowledge management and applying the theories of knowledge management in creating these tools has facilitated development and evolution of a large number of software tools for knowledge management.

In this report we intend to characterize and classify these tools. First, we describe two models of knowledge characteristics (the knowledge sharing model) and the evolution of knowledge (the knowledge life cycle model), to which we will refer when describing each tool category. Later we describe and classify a selected list of tools, mainly based on their features (functionality) and the aspect of knowledge management they support.

A General Architectural Model of Software Tools for Knowledge Management

KM is a collection of technologies for authoring, indexing, classifying, storing, and retrieving information, as well as for collaboration and application of knowledge. A friendly front-end and a robust back-end are the basic necessities of a software tool for

knowledge management. Figure 1 shows a possible model of a knowledge management system architecture, as presented in (Lawton, 2001).

The back-end is composed of sources of explicit or implicit knowledge. Explicit knowledge resides in repositories as documents or other types of knowledge items (e.g., e-mail messages). Standard authoring tools (such as word processors) and database management systems (DBMS) packages support this layer. File servers, e-mail tools and Internet and intranet services support the infrastructure layer. The knowledge repository layer handles content management. Knowledge must be organized according to the context of each company. This organization is based on a corporate taxonomy and serves as a "knowledge map" supported by classifying and indexing tools. Tools also support, at the next level, knowledge discovery and collaboration services. Through portals, knowledge can be distributed as needed by different applications, such as product development, competitive intelligence, customer relations, and best practices.

Since knowledge is such a valuable asset for organizations, a major concern that has to be addressed by all tools used in knowledge management is security. This can be implemented by using the inherent mechanisms in each tool (such as allowing different users to performed predefined operations on a specified set of objects), or by using special tools in addition to the existing system.

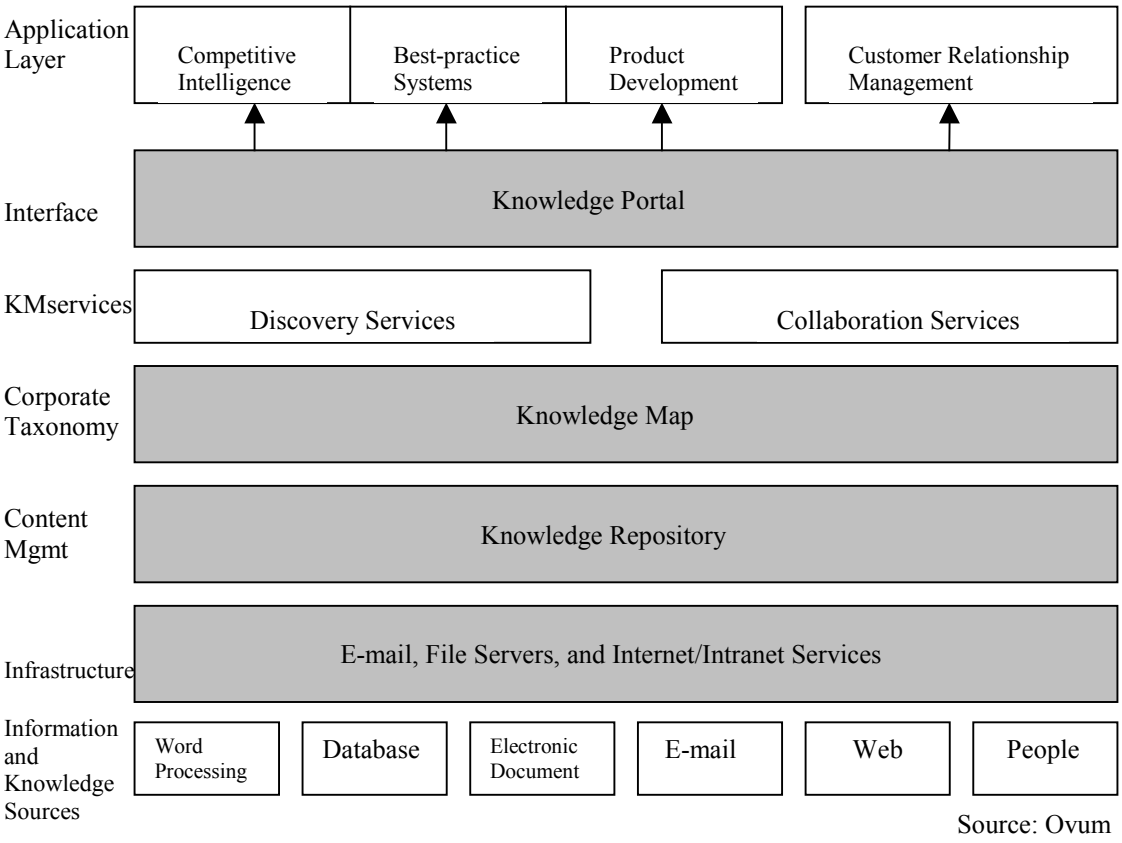

Figure 1: A Model KM Architecture (Lawton, 2001)

Knowledge items that a company might want to manage can have different forms and content. For example, they can include manuals, correspondence with vendors and customers, news, competitor intelligence, and knowledge derived from work processes (such as software documentation, proposals, project plans, and post-mortem analysis).

Regardless of the knowledge objects type, or their format (text, pictures, audio, or video), they have to be kept in repositories. All tools that support repositories must have common features such as organization, storage, search and retrieval, content delivery, and content evolution. These features correspond to the operations in the knowledge life cycle. In Section 4, we will show how tools in different categories provide these services.

Section 2.
The Knowledge Sharing Model

The knowledge-sharing model is also called the tacit-explicit model (Agresti, 2000) (Nomaka and Takeuchi, 1995). Knowledge management advocates capturing organizational knowledge and sharing it within the organization in order to aid in its growth. Knowledge in an organization resides in two pockets: one with the employees and the second in the knowledge base of the organization. The unrecordable knowledge that only resides with individual employees or a group of individuals is not readily accessible for the rest of the employees, so mechanisms have to be developed so that this knowledge can be made more widely available (Nomaka and Takeuchi, 1995). Knowledge in an organization can be classified as tacit or explicit. ***Tacit knowledge*** is knowledge that rests with the employees and ***explicit knowledge*** is the knowledge that resides in the knowledge base. Conversion of knowledge from one form to another could lead to the creation of new knowledge. The definitions of tacit and explicit knowledge, as given in (Nomaka and Takeuchi, 1995), are:

- "Tacit knowledge is internalized, context-specific. Tacit knowledge is the knowledge of the employees."
- "Explicit knowledge refers to that type of knowledge which is transmittable in formal, systematic language. Explicit knowledge is easily distributable."

For example, consider Ms. X working for organization Z, Inc. Ms. X has just completed creating a software tool. In the process of working on that project, Ms. X gained insight into the use of some new tools in the market. As part of her job, she prepares a project report. The insight Ms. X gained using the tools is her *tacit knowledge,* and the project report is *explicit knowledge.* The project report represents that part of her tacit knowledge that she chose to and could make explicit. The organization has gained in terms of the project report, and also because Ms. X has gained good insight into the use of the new tools. The organization would have gained more if Ms. X had documented her insights (that she chose not to make explicit) in a non-volatile distributable form (*explicit*), so that more employees could learn from her experience. Knowledge is converted from one form to another in the process of knowledge sharing by **combination** (explicit to explicit), **internalization** (explicit to tacit), **externalization** (tacit to explicit), and **socialization** (tacit to tacit) (Agresti, 2000;Nomaka and Takeuchi, 1995), as summarized in Figure 2.

	Tacit	Explicit
Tacit	Socialization	Externalization
Explicit	Internalization	Combination

Figure 2. - Knowledge Conversion (Nomaka and Takeuchi, 1995)

Explicit-Explicit Knowledge Conversion or Combination

Reconfiguration of existing knowledge through sorting, adding, combining and categorizing leads to new knowledge. Knowledge in explicit form is combined and new knowledge is created, hence this process is called *combination* (Nomaka and Takeuchi, 1995).

A search for similar knowledge items in the organization's knowledge base permits the user to combine multiple knowledge items in a new form, thus creating a new knowledge item. Searching or browsing the knowledge base would be simple, provided that the knowledge base is well organized and well indexed.

A variety of tools come under this category. Document-management tools fall into this category as they help organize documented knowledge or explicit knowledge. Some tools provide automatic indexing and full text searching. Examples are *Semio*[3], an indexing tool; *Xerox DocuShare*[4], an indexing, search and document management tool; and *Hyperwave*[5], also an indexing, search and document management tool. An indexing tool like *Semio* helps organize and index the organization's documents automatically. A document-managing tool organizes and updates the various documents in the organization. It also keeps track of various changes in the documents.

Explicit-Tacit Knowledge Conversion or Internalization

Tacit knowledge is personal. When one assimilates knowledge acquired from knowledge items, knowledge is *internalized*. This category of conversion is closely related to "learning by reading". Thus, the knowledge of the user increases with such a conversion,

[3] All the tools mentioned in this section will be discussed later.
[4] http://docushare.xerox.com
[5] http://www.hyperwave.com

thereby increasing the knowledge of the organization. The human act of assimilating the explicit knowledge is called ***internalization*** (Nomaka and Takeuchi, 1995).

A computer-based search in the knowledge base for details about a project and similar projects yields project proposals, project reports, white papers, lessons learned from previous projects, customer requirements, etc. The knowledge user can *internalize* this knowledge and be better prepared for the next assignment. This *internalization* will contribute to the tacit knowledge of the user and help him/her in make decisions on future projects.

The tools in this category are content-delivery mechanisms, visualization tools, relevance ranking tools, etc. Knowledge in the form of knowledge items is placed in the user workspace and the user is *expected* to *internalize* it.

Examples of tools in this category include *Autonomy*[6] *(Update*) (which has content delivery components and is based on a user-defined profile. It automatically fetches knowledge items for the user), *Spotfire*[7] and *VQI*. The e-learning tools also support the internalization process.

Tacit-Explicit Knowledge Conversion or Externalization

The process of converting one's personal knowledge into transmittable knowledge items is called ***externalization***. Externalization involves transforming context-based facts into context free knowledge, with the help of analogies. Once explicit, the knowledge is free to be distributed within the organization. Tacit knowledge is personal, depending on the experiences of the person in various conditions. As a result, it consequently has a contextual component. Once explicit, this knowledge will not have much value unless the contextual information is somehow retained (Nomaka and Takeuchi, 1995).

When a person records her experiences and lessons learned about a particular task and puts them into the knowledge base of the organization, she has essentially *externalized* his/her knowledge about the project. Now the knowledge the person made external can be distributed throughout the organization and shared.

E-mail agents, word-processing tools, electronic communication tools and documentation tools support externalization. All documentation tools aid in converting the tacit knowledge of the user into explicit knowledge (documents). E-mail agents and other communication tools that log the proceedings (chat, discussions) convert the tacit knowledge of one or more users into documents.

[6] http://www.autonomy.com
[7] http://www.spotfire.com

Examples of tools in this category include *Microsoft SharePoint*[8], which uses *MS Word* for authoring and documentation, and Tacit's *Knowledge-mail*[9], which identifies de-facto experts by analyzing their e-mail messages.

Tacit-Tacit Knowledge Conversion or Socialization

Sharing one's experiences, working together on a team, and direct exchange of knowledge lead to a tacit-to-tacit knowledge conversion. Knowledge exchange around the coffee pot, the water cooler, or the lunch table, i.e., places where people *socialize,* leads to tacit-to-tacit conversion. Tools that provide such an environment (i.e., a virtual place to socialize) come under this category.

Socialization is an informal platform where co-workers discuss projects and experiences, share views, brainstorm on projects, etc. Knowledge is converted from tacit-to-tacit form as the internal knowledge of one user gets converted to the internal knowledge of another. The break room and the water cooler are places where such interaction takes place. Software tools can create virtual places or provide electronic communication features to encourage such an interaction.

E-mail agents, threaded discussions and groupware systems that only provide a medium for exchanging information, but do not capture it, are some of the tools that come under this category.

Examples of tools in this category are *IBM/Lotus Domino*[10] suite's instant messaging tool, *Hyperwave's*[11] on-line chat and e-mail tools, *Groupsystems'*[12] on-line collaboration system, and *Microsoft Net Meeting*[13], an electronic meeting environment with audio and video support.

To summarize:

- *Externalization* creates knowledge items that enhance the knowledge base of the organization
- *Internalization* enhances the knowledge of the knowledge user
- *Socialization* increases the knowledge of the users
- *Combination* might add more explicit knowledge to the knowledge base of the organization

All of these categories of knowledge sharing are important. The organization should aim to have an evolving knowledge base and also seek the growth of their employees'

[8] http://www.microsoft.com/sharepoint
[9] http://www.tacit.com/knowledge-mail
[10] http://www.lotus.com/home.nsf/welcome/km
[11] http://www.hyperwave.com
[12] http://www.groupsystems.com
[13] http://www.micosoft.com/netmeeting

knowledge. Better informed employees and a healthy knowledge base that contributes to the growth of the organization are the ultimate goal of knowledge management.

An Example of the Knowledge Conversion Model in Action

The following hypothetical example aids in internalizing the knowledge-sharing model described above. Consider a software developer "X", a manager "Y" (to whom "X" reports), in a software organization "Z". The organization had implemented a state-of-the-art knowledge management software tool. The software developer is given the task of writing a proposal for a new project and will also participate in the project.

Developer "X" runs into problems writing a new project proposal, but manages to find a project proposal which she feels is a good starting point. She finds one more similar project proposal with the help of the document management tool's "Find similar" feature. She *combines* the two project proposals from the company knowledge base (maintained by the tool) and *generates (externalizes)* a new project proposal. After submitting the new project proposal, "X" also uploads it in the organization's repository. She then retrieves and reviews the project reports of those two projects for which she had read the proposals (that served as the basis for her proposal) and *internalizes* their lessons learned.

While working on the project, "X" runs into trouble with a software program. She uses the instant messaging feature of the tool to communicate with "Y", who helps her solve the problem. She could have chosen to call "Y", but by using the "Instant messaging" feature, she made possible capturing of the her chat with him. Thus, *socialization* in the form of instant messaging helped a tacit-to-tacit knowledge conversion. Manager "Y" also instructs "X" to document their communication as a FAQ. She does so successfully with the help of the "Log chat" feature and, thus, *externalizes* the knowledge she gained from "Y".

A complete software tool for knowledge management should support all components of the knowledge conversion. There are tools with components that address all of the four modes. There are also more focused tools that support only one or some of the conversion processes. Classification tools, instant messaging tools, document management tools, etc., are available in easily customizable forms. An organization could either try to acquire a tool that comprises a set for all conversion modes, or, alternatively, it can integrate separate tools and implement a customized knowledge management system.

Section 3.
The Knowledge Life Cycle Model

Knowledge in an organization follows the cycle described in Figure 3 where the arrows represent the direction followed by the knowledge flow during its life cycle.

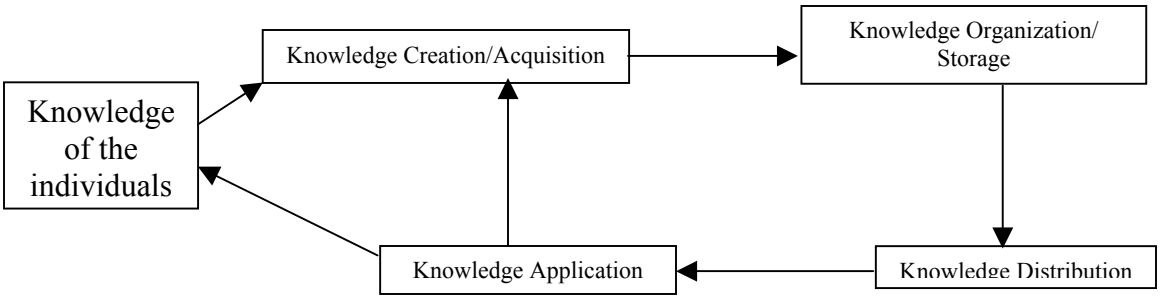

Figure 3: Knowledge Life Cycle (Wiig, 1999)

The knowledge of the employees and knowledge in the form of new knowledge items is captured and acquired. Thus, knowledge enters the knowledge life cycle model at the ***knowledge creation/acquisition*** stage. This knowledge follows the path and is organized and stored in the ***knowledge organization/storage*** stage. Now the knowledge in the knowledge base is ready to be distributed and enters the ***knowledge distribution*** stage. At this stage, the knowledge is distributed within the organization, to the relevant people. The distributed knowledge finds application or is reused in the following stage, the ***knowledge application*** stage. Reuse of knowledge or application of knowledge from the knowledge repository provides the opportunity for fresh knowledge to be acquired. Knowledge about reuse and the newly created documents are again put back into the cycle at the next stage, i.e., the *knowledge creation/ acquisition* stage.

A good knowledge management tool supports knowledge flow in this life cycle without inhibition. Often, we find that the tools cannot completely service the knowledge life cycle. In such cases, the organization might have to integrate different components of tools from different vendors, fitting them into different stages of the cycle in order to complete it.

Next, we discuss each stage of the knowledge management life cycle, with software tools as the primary focus.

Knowledge Creation/Acquisition

Knowledge is captured only in explicit form. Tacit knowledge resides in the minds of people and has to be made explicit in order to be captured. This is accomplished with the

aid of *knowledge acquisition tools* or *knowledge creation tools*. Knowledge is developed through learning, innovation and creativity, as well as imported from external sources. Knowledge acquisition evolves and builds the knowledge base of an organization (Sestito and Dillon, 1994).

A new knowledge item can be captured when it is shared electronically, either by e-mail, on-line chat, or documented. Therefore, tools that support authoring and documentation also help capture knowledge. All document-creating tools like word processors or scanners come into this category. An interesting group of tools that belong in this category are collaboration tools that possess a feature for saving conversations or chats. Logging chats, threaded discussions, or instant messages help capture knowledge. Once a document is created it must be integrated into the repository. All document management tools support this operation.

Knowledge Organization/Storage

Activities through which knowledge is organized, classified and stored in repositories comprise this category.

Explicit knowledge needs to be organized and indexed for easy browsing and searching. It must be stored efficiently to minimize storage space. All indexing tools, search tools and document management tools support these activities. Tools in this category include *Semio*[14] and *Verity*[15], which are indexing tools. An indexing tool automatically indexes the various items in the knowledge base and makes searching through the knowledge base easy and efficient.

Knowledge Distribution

Individual knowledge has to be shared to enrich organizational knowledge. When knowledge is distributed, more users can access and internalize that knowledge; hence, there is a growth in organizational knowledge. A variety of tools have been developed to distribute or deploy knowledge. Agresti refers this to as "push and pull technology" (Agresti, 2000). Knowledge can be distributed thorough training programs, automatic knowledge distribution systems and expert systems. Making the knowledge base of the organization available to the users who require it, and delivering the right knowledge at the right time, are the basic goals of knowledge distribution.

All portals, content delivery systems, e-mails, FAQ lists, etc, which can deliver knowledge to employees fall in this category. Examples include *Optimalview*[16] and *Axielle*[17], which are portals.

[14] http://www.semio.com
[15] http://www.verity.com
[16] http://www.OptimalView.com
[17] http://www.ascentialsoftware.com/products/axielle

Knowledge Application

Through application, knowledge becomes the basis for further learning and innovation. Applying knowledge (from the knowledge base) to benefit the organization is the payoff for knowledge management (Rus, et. al., 2001).

Tools with "Find similar" features fall into this category (for example, document management tools). The software tool can provide a similar template or a knowledge item for a particular task. Tailoring the available template or object to the requirements of the problem at hand creates a new knowledge item which should be reintegrated into the cycle.

E-learning tools like *Tutor.com*[18] and *Hyperwave E-learning Suite*[19] fall into this category, as they not only facilitate the transfer of knowledge from the teacher to the student, but also support internalization and application of the learned material (for example, assigning homework and class projects, and providing feedback and grading).

[18] http://www.tutor.com
[19] http://www.hyperwave.com/e/products/els.html

Section 4.
Software Tools for Knowledge Management

This section discusses a number of tools that we have divided into different categories. The categories are based on different components that the commercial market actors usually include in knowledge management. An example of a website that provides useful insights into what the market offers in terms of knowledge management is KMWORLD[20].

It is hard to draw the line between regular IT and tools for knowledge management. We have decided to view tools from a knowledge management perspective and discuss the needs of employees that consume knowledge, the types of knowledge conversion that occurs and a common set of features provided by tools from each category. For each category, we also present representative examples of tools we found during our survey. These are tools that are widely used, as well those that provide interesting features. The survey is not intended to cover all tools on the market, but gives the reader a sense of the various tools that are available for knowledge management.

Much of the information in this and the next section has been directly excerpted from the manufacturers' websites and other promotional materials, or has been minimally edited to present the most important information to our audience. The authors, the DACS, the University of Maryland, and the Fraunhofer Center in no way intend any information contained in this report to be construed as an endorsement of the tools discussed or the capabilities of their vendors. Rather, we have attempted to convey to our audience the manufacturer's claims and reported experiences directly as they have been presented to their companies' wider audience of potential customers and clients via the Internet.

Document and Content Management

All organizations have documents that need to be managed (where a document could be any form of file). In many cases, a common repository for files could be sufficient, but organizations that want to go beyond simple file sharing need to look into tools for document management. In terms of knowledge management, the documents that the organizations produce represent their explicit knowledge. One can argue about what knowledge is within regular office documents such as proposals, memos, blueprints, and notes, but it is clear that, without these documents, life would be much harder. New knowledge can be generated based on documents. An example of knowledge generation is the identification of defacto experts based on authors of documents.

Document management is a basic component of knowledge management. People need to share documents and, in order to do so, must be able to find them. Common questions that arise in a document-sharing environment are:

[20] http://www.kmworld.com

- How do you identify the latest version of a document?
- How do you access your documents when you are not in the office?
- How do workgroups share documents?

Most document management systems address all of these questions, enabling people to share documents remotely. An important aspect is security. An organization wants to share its explicit assets (its documents) while, at the same time, protect them from unauthorized use.

Document management systems enable *explicit-to-explicit* knowledge conversion. They take explicit knowledge, then store, organize, and provide it to users in the form of explicit knowledge. One could argue that a form of tacit-to-explicit knowledge conversion occurs when experts are determined based on the documents they authored. Expert identification certainly results in *knowledge creation*. The document management system is based on repository technology and, as such, touches most areas of the knowledge life cycle such as knowledge storage, organization, and distribution.

Document management systems offer features that include storing/uploading of documents/(files); version control; organization of documents in different ways; search and retrieval based on indexing techniques and advanced searching mechanisms; and access from any Internet connected workstation. Most document management systems also provide some kind of search for experts based on authorship.

Examples of document management systems are Microsoft Sharepoint, Verity, Lotus Domino, and Xerox Docushare that we describe here. Other examples include Hyperwave and Documentum.

Microsoft SharePoint[21]

Microsoft SharePoint arrived on the market in 2001 and is available in two formats: SharePoint Team Services and SharePoint Portal Server. SharePoint Team Services supports small workgroups (5–75 users) that need an informal means to work together, share documents, and communicate with each other. SharePoint Team Services will initially be included with the FrontPage version 2002 Website creation and management tool, and those versions of Office XP that contain FrontPage.

SharePoint Portal Server supports larger workgroups (more than 75) with structured processes that require greater management over their information. Such workgroups often require formal publishing processes and the ability to search for and aggregate content from multiple data stores and file formats. SharePoint Portal Server 2001 is a stand-alone server product. The Portal Server supports document management by offering features for check-in, check-out, versioning, routing, and publishing, while the lightweight version, Team Services, only provides features for publishing.

[21] http://www.microsoft.com/sharepoint

Xerox DocuShare[22] and Other Products

Xerox believes that knowledge sharing is the natural way to leverage knowledge. Xerox offers a set of tools that find, store, share, view, represent, protect and make sense of knowledge in the digital and paper domains. Xerox FlowPort integrates various paper-driven devices (faxes, photocopiers, etc.) into groupware, e-mail and document management.

Xerox DocuShare is a web-based document management system that lets users store, access, and share information in a secure and collaborative work environment. DocuShare allows users of any system to post and retrieve information in any format. Text, scanned images, video clips, Microsoft Office documents, sound files, executables, web links, bulletin boards and calendars can be managed over the web. DocuShare uses the search engine from Verity to allow users to search for documents.

Lotus Domino Suite of Tools[23]

Lotus provides a suite of tools to support document management and knowledge management. The Lotus Discovery Server is a knowledge server that provides search and expertise location solutions designed to ensure that all of the relevant knowledge and collective experiences of an organization are readily available to help individuals and teams solve everyday business problems. The Discovery Server extracts, analyzes and categorizes structured and unstructured information to reveal the relationships between the content, people, topics and user activity in an organization. It automatically generates and maintains a knowledge map to display relevant content categories and their appropriate hierarchical mapping that can be searched or browsed by users. The server generates and maintains user profiles and tracks relevant end-user activities, identifying those individuals who may be subject matter experts. Through this expertise profiling and content discovery, the server uncovers organizational know-how in terms of where things are, who knows what, what is relevant, and which subjects generate the most interest and interactivity. Document summaries are provided that display the most important concepts within a document when viewed in the K-map. It allows the end-user to see key concepts of a document before drilling down, instead of manually opening each document to see if it is relevant.

Domino.doc provides document and records management. Domino.Doc delivers scalability, flexibility and low cost of ownership required to support both enterprise-wide documents and records management, while serving as a foundation for knowledge management. Domino.Doc offers complete Document Life Cycle Management, from authoring through review, approval, distribution and archiving.

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[22] http://docushare.xerox.com
[23] http://www.lotus.com/home.nsf/welcome/km

Competence Management

Along with Document Management (DM), we view Competence Management (CM) as most crucial. If DM represents the explicit knowledge assets of the organization, then CM represents its tacit knowledge. As described before, tacit knowledge cannot easily be captured, but the organization can track who has this tacit knowledge.

Organizations need to know what and where knowledge is, answering questions like: Who knows what? and Who knows who? Once such a knowledge map is in place it can be used to identify appointed and defacto experts; to staff new projects based on skills and experience required to identify knowledge gaps that indicate the need to hire new people; or to develop training programs. Such knowledge maps can even be used to identify core competencies for organization marketing.

Tools that support competence management become necessary, especially for large organizations, when people do not know each other. Their necessity also becomes obvious in any distributed, decentralized, and mobile organization.

The knowledge transformations that occur in these tools are mostly explicit-to-explicit because they are based on repository technology in which information about knowledge possession is stored. One can argue that tacit-to-explicit knowledge conversion takes place when people fill out forms about their own knowledge. One can also argue that knowledge creation takes place when the DM system analyzes the stored information and generates knowledge maps showing who knows what, or what competence the organization has or does not have.

A typical feature of this class of tools is profiling. Profiles of employees, customers, subcontractors, vendors, partners, projects, and positions can be generated manually, automatically or semi-automatically. Other typical features, which are based on the profiles, are identification of and search for experts.

Examples of tools in this category are Skillscape and Knowledge-mail. Other examples include Autonomy Clusterizer. Also, most document management tools have a feature to identify experts.

Skillscape[24] Competence Manager

Skillscape is an example of a system that helps an organization manage its competence. The system supports assessment and ranking of individual skills and competencies and builds snapshots of the organization's overall knowledge capital. The tool helps utilize this information to perform individual and organizational analysis, reduce education costs, and improve hiring practices and human resources performance. It also facilitates developmental planning processes and effective deployment of human capital, and helps management make strategic decisions regarding readiness to take on more or new

[24] http://web.skillscape.com

projects. The Competence Manager of Skillscape automatically recommends training to employees based on their skill gaps, and can automatically launch technology-based training.

The Starter Skills dictionary is the knowledge base used by the Skillscape tool. The dictionary is populated with skill definitions, job profiles, and descriptions of courses. The dictionary continuously grows through cooperation with the users of the tool. Whenever a new definition is created, this information is (supposed to be) fed back to the developers of Skillscape, who then review it and add it to the dictionary. The addition and change of definitions are propagated to other users. Currently this process has resulted in more than 10,000 skill definitions, including 4000 IT skills, more than 380 job profiles, and more than 1650 links to SmartForce courses.

Another example of a tool that uses the dictionary is the Student SkillScreener. It uses the Internet for posting job descriptions and receiving resumes en mass. The tool helps employers manage posting of jobs to the Internet and, when the job applications arrive, lets them screen the applicants for the best candidates and match their resumes to the skills needed for the job.

Knowledge-Mail[25]

Most systems for competence management rely upon manual entry of employees' profiles in terms of skills and expertise. Such manual entry can be time consuming and it is hard to keep the information about each employee up to date. Knowledge-mail addresses this problem by automatically creating profiles of employees by mining various sources of information. The profiling mechanism works by extracting terms and phrases from e-mail communications and more than 30 types of documents produced or shared by individual users. Information about these terms and phrases is added to the employee's expertise profile. Consequently, the profiles are kept up to date, always reflecting the current skills of the employees. Each user profile provides a detailed index of an individual's knowledge, experience, and work focus. It also reflects the amount of time that any given individual spends on a topic. A set of profiles, therefore, represents a composite "snapshot" of all the expertise within an organization.

A profile contains a readable list of keyword phrases and terms. To present the most accurate portrait of the user, these phrases are assigned a weighted value based on occurrence, relevance, and other statistics. An example provided by the vendor illustrates the importance of this capability. "Consider the differences between a person who mentions 'Java debugging' 30 times in a single document, a person who mentions 'Java debugging' 30 times in the course of two years, and a person mentioning 'Java debugging' 30 times over a series of documents in a single month." The tool takes into account all of these aspects when creating profiles and ranking them to support the search for experts on a particular topic.

[25] http://www.tacit.com/solutions/km.html

Profiles are kept private until the employee wishes to make them public. Private profiles cannot be searched in the same way as public profiles. Instead, Knowledge-mail hints to the user that a range of employees (for example somewhere between 0 – 10) has the keywords the user is searching for in their private profile. Knowledge-mail can contact those users, and it is up to these employees to respond to the request.

The same technology is used to create profiles of any entity in the organization, such as projects, customers, partners, vendors, etc. This information can be used to better understand them. For example, a project profile can be used for marketing purposes, while a customer profile can be used to better serve the customer.

Collaboration Tools

Knowledge Management focuses on delivering the right information at the right time. In order to do so, employees need to collaborate and communicate. This is the reason why collaboration tools often are mentioned as an important part of the knowledge management strategy.

Collaboration and communication become problems when people work in an environment that is distributed in time and space (which is the reality for many organizations). Business travel can only solve part of this problem. Instead, different kinds of computer-based tools are used to overcome distances.

The knowledge conversions that take place in this category of tools are mainly tacit-to-tacit, which occur, for example, when two or more users communicate using a chat tool or an instant messenger. One can argue that since the conversation is in an electronic form, a form of tacit-to-explicit conversion also takes place. Some tools make an effort to capture this conversation so that it can be published and used for other users, and even analyzed in order to create new knowledge, which strengthens the argument for a tacit-to-explicit knowledge creation.

The basic functionality of tools in this category is to connect employees by providing a computer-based communication channel. This communication can be either synchronous or asynchronous. Synchronous means that the communication occurs in real time. Asynchronous means that the communication is extended over a period of time. Chatting using a chat tool or a messenger tool (e.g., Microsoft Netmeeting, Lotus SameTime and QuickPlace) would be an example of the former, while e-mail, bulletin boards, and newsgroups would be examples of the latter. Any form of data can be shared using these tools. Examples include documents, audio, and video. A common technique is to use a tool to share a presentation so that two or more geographically distributed groups can see and hear the same presentation. Some tools are designed to capture the communication and the work results for further use and refinement (e.g., Fraunhofer's chat tool). Some tools are designed to support concurrent co-authoring of documents over a distance (e.g., Groupsystems). Other tools support active knowledge sharing in the form of e-learning.

Other examples of tools and systems that provide communication and collaboration features are Microsoft Sharepoint, Windows XP, and E-learning tools.

Lotus and Netmeeting

There are many different tools on the market that support communication and collaboration. Noteworthy examples are **Lotus Sametime**[26] **and Microsoft Netmeeting**[27]**,** which are real-time collaboration software tools with chat, white-boarding and application sharing capabilities. Using these tools, two or more employees can communicate and collaborate over a distance.

QuickPlace[28] is a team collaboration software for capturing discussions, documents, tasks, etc,. for projects and ad-hoc initiatives. QuickPlace can be used to coordinate people, tasks, plans, and resources. It can also facilitate collaboration; share ideas and discussion; resolve issues; co-author documents; exchange files; and manage due diligence. Finally, it also aids in communicating actions and decisions; key findings and lessons learned; and publish captured knowledge to a broader base of readership.

Fraunhofer's Chat Tool

Fraunhofer Center Maryland has developed a tool that supports e-workshops (on-line meetings between expert participants). By using this format, experts from all over the world can participate in workshops for a couple of hours without leaving their office. The results of the meeting are captured and analyzed in order to generate new knowledge in a particular area. The tool runs in a simple browser and invited participants join the meeting by clicking on a web link. A moderator and a lead discussant run the meeting. The moderator is responsible for the process of the meeting, while the lead discussant is responsible for the content of the meeting. A scribe takes notes during the meeting, which are immediately posted to the white board of the chat tool. The tool illustrates that technology and process can be used to bring people together and generate new knowledge (Basili, et. al., 2001a).

Groupsystems[29]

GroupSystems is a system for same-time, same-place meetings that allows employees to communicate and generate ideas, evaluate their relative merits, make decisions and reach consensus. GroupSystems has a number of different features to help work with the ideas generated by a group of employees. Before and during a brainstorming session, the group can create a list of keywords. The keywords help users view the ideas from different perspectives. The "categorizer" lets the group organize ideas in different

[26] http://www.lotus.com/home.nsf/welcome/sametime
[27] http://www.microsoft.com/windows/netmeeting
[28] http://www.lotus.com/home.nsf/welcome/quickplace
[29] http://www.groupsystems.com

categories for further analysis and work. A typical session starts with idea-generating activities like brainstorming. When a reasonable number of ideas have been generated, the next step is to select a subset of ideas to pursue. Consensus can be reached by using features provided by the tool. The first step of reaching consensus is to vote on the ideas. During the voting process, participants can check where they stand in relation to others, and they can change their votes to reach consensus more quickly. The system can be customized to fit different purposes. One such example is the easy Win-Win application, which is used to negotiate system requirements. This application brings out stakeholders' needs in regards to a system to be built, and attempts to formulate a system description that takes all stakeholders' requirements into account. One can argue that the system creates and documents knowledge about the system to be and the stakeholders' success criteria.

Customer Support

A popular area of knowledge management is customer support. New technology such as the Internet has made it possible to drastically change the way customers can obtain support from organizations. There are mainly two forms of customer support tools:

- Tools that let customers help themselves (self-help)
- Tools that help customer support personnel (help-desk)

The strategy is often to let the customers help themselves first, and if they don't succeed, enable them to contact the help desk or customer support desk. In some cases, vendors even set up areas for customers to help each other, i.e., to share knowledge about the products and the services the organization offers.

The motivation behind the development of this area is customers' need of support in order to efficiently use a company's services and products. Customers demand such support 24 hours a day, every day of the year. In order to deliver such support, organizations are forced to develop a systematic, consistent, and continuous customer support strategy. Other motivating factors are that customer support personnel lack appropriate knowledge, so they need systems that support them with knowledge while they gain it through experience. There is a lack of consistency in giving support so they need systems that guide them through the support process. There are many cases where a high repeatability in the support process can be leveraged by reusing the answers to the most common questions. Over time, support personnel also acquire a vast amount of knowledge about the products and services the organization offers, as well as information about customers and their behavior. This knowledge is a resource for the organization as a whole and should be captured and spread throughout the organization.

The knowledge conversation that takes place in customer support is mainly tacit-to-tacit, but with customer support systems that use knowledge bases it is possible to turn the process into first tacit-to-explicit, and then explicit-to-explicit, conversion. When customers search for (and later apply) knowledge, one can argue that explicit-to-tacit

knowledge conversion takes place. Applications for customer support are often based on repository technology and, therefore, support knowledge creation, storage, organization, distribution, and knowledge application.

Systems that support Help Desks typically have features that automatically direct customer requests to representatives based on profiles of the customers, as well as on the expertise of the representative. Past customer behavior and connections to product catalogs are other factors that can assist in the helping process.

Knowledge bases that store information about previous customer support cases, previous incidents, and general product information are common. Knowledge bases can also contain Frequently Asked Questions (FAQs) and lessons learned. Metrics on previous cases and frequency of use can be captured for later analysis.

Support for self-help is often provided out of a website where many of the tools and knowledge bases mentioned above are used. The knowledge bases typically also provide an interface to capture new knowledge about the products, services, and their use so that new cases, new incidents, and new lessons learned can be captured and shared. On-line customer support often links the self-help with the Help Desk and can be accomplished via live chat, often through software systems that are capable of answering questions.

An example of system that supports Help Desks is Remedy. An example of a system that provides self-help is AskIT. A third category identifies customer support tools, where the customers are peers within the company. Examples are AskMe and Xerox Eureka.

Remedy Customer Support[30]

Remedy is an example of a system that provides Customer Relationship Management (CRM) support. CRM systems span across an enterprise to help focus on its customers' and prospects' higher-level needs and goals. Customer support is part of CRM.

Examples of features included in Remedy are the tracking of customer issues, problems, suggestions and requests for information. Support personnel can access customer data, review call histories, verify support entitlements and view attachments. Remedy automatically directs customer calls to suitable customer support personnel based on criteria like product expertise and a customer's past behavior.

Remedy has a built-in knowledge base that captures difficult customer problems and stores reusable solutions. Support personnel can use the knowledge base and respond quickly. Remedy's E-mail Management System is very similar to Knowledge-mail and has been integrated with Remedy Customer Support. This system automatically analyzes incoming e-mail, generates an automatic response and routes it to the appropriate customer support person based on his/her previous responses to similar kinds of e-mail.

[30] http://www.remedy.com

AskIt[31] and AskMe[32]

AskIt and AskMe are very similar systems. They both build upon the notion of frequently asked questions. AskIt allows external customers to review frequently asked questions through a web interface and to ask new questions if satisfactory answers cannot be found. AskMe enables employees to learn from the expertise of coworkers. AskMe gives employees an interface in which they can submit problems and receive solutions from others within the organization. In both systems, the resulting solutions are cataloged and stored in a searchable knowledge base so that other employees can benefit from the shared knowledge.

Both systems analyze incoming e-mail, which may contain requests or discussion for information. These e-mails are transferred to experts based on their profiles. Users can select options in which their e-mail is broadcast to everyone, to users of certain groups or directly to a particular expert. AskMe has a feature that lets users update their own profiles. The system changes an individual's profile based on the replies the person composes. Upon receiving the answer, the asker can rank it based on his/her satisfaction. The system manages this ranking and shows it when a new e-mail question on the same topic is initiated so that the next asker can judge whom to best send the inquiry to. Both systems are examples in which knowledge is collected through e-mail and made available to others through the use of knowledge bases.

Xerox Eureka![33]

Xerox Eureka is an internal tool that is probably not available to the public. Eureka started as a way to help customer service engineers at Xerox become more effective and efficient by capturing and sharing the knowledge they collected in their field experience. Xerox realized that much of this knowledge was not contained in standard service manuals. Instead, it was usually gained by solving very difficult, complex or rare problems and was often passed along informally through the telling of "war stories" in the tight community of customer-service engineers. Xerox built a system that supports this knowledge sharing explicitly and is probably the best-known example of a successful peer-to-peer system for knowledge management.

Data and Knowledge Discovery

The goal of this category of tools is to generate new knowledge from existing data, information, and knowledge bases. Examples of tools in this category include visualization and data mining, as well as analysis and synthesis tools. The idea behind visualization tools is to show the data in such a way that the human being actually performing an analysis can make decisions based on the data. Data mining tools try to

[31] http://www.askit.com
[32] http://www.askmecorp.com
[33] http://www2.xerox.com/go/xrx/knowledgest/knowledge_section.jsp?id=19238

automatically reveal patterns and relationships between data and generate new knowledge about the underlying data and what it represents.

Knowledge management tools often deal with raw data and singular data points, yet in order to create theories, these data points need to be analyzed. Raw data and singular data points are, for example, documents, frequently asked questions, lessons learned, and other knowledge items stored in knowledge bases. Data and knowledge discovery can reveal what is hidden in the data. Such tools can be used to identify patterns in the usage of knowledge bases, as well as the types of knowledge items used the most or the least. It also identifies groups of users which are active, inactive and de-facto experts (as compared to appointed experts). Such tools can also be used to analyze knowledge bases in order to form more complex knowledge items. An example is best practices based on lessons learned and frequently asked questions.

The knowledge conversion that takes place as a result of data and knowledge discovery is, first and foremost, explicit-to-explicit due to the fact that all knowledge in the knowledge base is already explicit and the discovery process creates new explicit knowledge based on it. One could also argue that there is a portion of explicit-to-tacit knowledge conversion occurring in the process when the analyst looks at the data from different perspectives and gains a better understanding of it.

Typical features of the tools in this category provide for the visualization of data in different ways. Features for statistical analysis are also common, along with different features for decision support. These features are sometimes based on artificial intelligence (AI) techniques that can help in the discovery process.

Examples of tools in this category are Autonomy VoiceSuite, Visual Query Interface (VQI), Spotfire, and digimine Analytic Services.

Autonomy VoiceSuite[34]

Autonomy's technology is interesting because it applies the same kind of technologies to audio content that previously have been applied to electronic text. The VoiceSuite first analyzes multimedia content and transcribes it into text. Then it identifies and ranks the main concepts within it, and automatically personalizes and delivers that information to those who need it. Delivery can occur across the Internet, the extended enterprise or by using other digital channels such as mobile phones, PDAs, etc.

Spotfire[35]

Spotfire is an example of a general visualization tool. Spotfire's product offering begins with the capabilities of DecisionSite, its core eAnalytic application. DecisionSite incorporates an intuitive dynamic visualization environment to help end-users rapidly

[34] http://www.autonomy.com/autonomy_v3/Content/IDOL/APPOLS/Voice_Suite
[35] http://www.spotfire.com

explore and interpret data and make informed decisions. DecisionSite also provides a platform environment for simplifying data access through its Information Library and configuration of end-user Guides that automate common decision-making tasks.

Spotfire provides a number of applications customized towards a specific industry need. Spotfire DecisionSite for lead discovery is, for example, designed for researchers and scientists involved in new product development in drug discovery and chemical companies. Spotfire DecisionSite for process analysis is designed for process engineers and managers who monitor and manage batch and continuous manufacturing processes and their impact on quality. Spotfire Computational Services is designed for professionals who utilize advanced data mining and statistical techniques.

The Visual Query Interface (VQI)

A tool that also uses the star field display technology is the Visual Query Interface (VQI). VQI is especially developed for organization and analysis of knowledge and experience bases. Using the taxonomy editor of VQI, a classification manager can develop taxonomy for the experience base. VQI can also connect to any existing knowledge and experience base and visualize its content. Examples of experience bases that VQI has been used to develop and analyze are frequently asked questions and lessons learned. VQI has been used to analyze growth trends of knowledge and experience bases and related analyses (Basili, et. al., 2001b)

digiMine Analytic Services[36]

digiMine Analytic Services is a business intelligence solution that delivers insight and decision support. digiMine shows how customers interact with a website, and in what combination they consume content or purchase merchandise, so the company can organize content and merchandise to provide a more targeted and profitable customer experience.

digiMine Slurper encrypts and compresses company data for transmission at predetermined times. digiMine's Slurper software has the ability to pull Web server logs and gather data from any kind of database. Once data is transferred to digiMine's data center, it is parsed, cleaned and loaded into a data warehouse. digiMine then produces detailed and accurate analytics that are delivered 24 hours a day, 365 days a year. Customers can access its reports through a dedicated https connection using a standard browser.

[36] http://www.digimine.com

Intellectual Property

Knowledge management often includes management of intellectual property such as copyrights, trademarks, and service marks. We wanted to briefly mention this area because it has become more of an issue to many organizations.

Organizations who own intellectual property need ways to automate workflow and support the management and analysis of inventions, patents and related matters. It often takes a long time to file and get approved rights to intellectual property, and organizations need support to track this process. For international organizations, the management of intellectual property becomes even more of a problem due to the fact that every country has different laws and regulations. Other aspects of intellectual property require owners of copyrights, trademarks, and service marks to pay legal fees at specific points in time, otherwise the rights can be lost. For licensing issues, it is also important to track licensees and royalties.

Intellectual property management is mainly an explicit-to-explicit knowledge conversion. It is based on repository technology and, thus, deals with all aspects of knowledge storage, organization and knowledge distribution in a controlled way. Typical features for tools in this area include search for patents, support to file for patents, searchable knowledge bases with rules and regulations and support for legal help, as well as collections of forms and standard letters. Other related issues that these tools support are licensing of patents and tracking of licenses, as well as calculation of fees. Another aspect of intellectual property is the protection of digital content covered by copyright.

Examples of tools in this area can be found by visiting a general website for intellectual property issues at patentcafe.com. Some examples include a tool provided by Dennemeyer Co., and Xerox ContentGuard.

PatentCafe[37]

PatentCafe is a portal for Intellectual Property issues. It provides all kinds of support and advice to anyone who is interested in this area.

Dennemeyer & Co.[38]

Dennemeyer provides services in intellectual property and asset management. The systems they offer include:

- Individual Patent, Trademark and Matter Management Systems
- Integrated Patent, Trademark and Matter Management Systems

[37] http://www.patentcafe.com
[38] http://www.dennemeyer.com

- Enterprise-Wide Intellectual Asset Management Systems

Xerox ContentGuard[39]

Electronic content is easy to distribute, but producers ask themselves how they can protect their content. Publishers, record companies, movie studios and corporate enterprises are constantly seeking to meet the demand for digital content. As industries seek dynamic ways to meet obligations to content creators and content for sale, they also seek to protect the rights of the owners of the content. Digital Rights Management (DRM) will enable the growth and success of the e-Content market. The technology was originally developed at the Xerox PARC facility. This group has also created and advocates usage of XrML (extensible *rights* markup language), a rights specification language. Xerox ContentGuard enables rights management with ongoing tracking and protection of digital content (audio, video, e-books, etc.) so that publishers can assign rights and sell content, assured it cannot be used in unauthorized ways.

Expert Networks

Expert networks provide a forum for people who need or can provide help and establish knowledge-sharing focused on solving a problem. Expert networks are typically based on peer-to-peer support, meaning that experts help other experts. Expert networks often emphasize the importance of acknowledging that most knowledge cannot be made explicit and stored in a computer, but will reside in the brains of experts. We have mentioned expert networks earlier as part of other tools, but because it is such a growing phenomena, we wanted to mention it separately. The section on Teltech should provide interested readers with very valuable information.

It is clear that expert support can drastically reduce the time it takes to solve a problem. It can, however, prove to be extremely difficult to locate experts. This is particularly true in organizations in which people are geographically distributed. Expert networks connect people with experts to solve problems and often store solutions in a knowledge base for reuse.

Peer-to-peer support is tacit-to-tacit when experts use a chat tool to communicate, but it is also tacit-to-explicit when solutions are stored for future use and reference. One could also argue that an explicit-to-tacit conversion occurs when someone finds a solution to a problem in the knowledge base of stored solutions.

Common features among this category of tools are expertise brokerage and expert identification. There are even third-party expertise brokers that help users connect with experts to solve certain problems. Other features of these tools are communication and collaboration between people and features for capturing questions and answers. These

[39] http://www.contentguard.com

tools typically track and rate expertise, customer satisfaction, and rewards that are handed out to people who contribute to the success of the system.

Examples in this category are Abuzz and the service provider Teltech.

Abuzz[40]

Abuzz is an interactive knowledge-sharing community provided by the *New York Times* for its readers. It is very similar to AskMe, but it is in the form of a Web Portal. It is open for everybody who wants to ask or answer questions. Abuzz is a system that receives e-mail containing requests for information and routes it to experts, based on profiles. It updates profiles based on who answers the question. The system comes in intranet, extranet, and Internet versions and provides different categories such as art, education, cities, careers, health, travel, sports, etc. It has a central repository that stores the top-ranked question-answer e-mail series.

Teltech[41]

Teltech provides expertise broker services. Knowledge is defined as information with a high degree of added value, i.e. the interpretation, context, and implications of information that experts can provide. Teltech maintains a network of thousands of experts in various technical fields. The experts, over 3000 of whom can be found in Teltech's on-line system, are typically academics, recent retirees from industry, or consultants.

"When a client calls Teltech, they engage in a dialogue with a Teltech `knowledge analyst' about their problem, or they are given one or more names of experts who can speak knowledgeably on the customer's issue. These names are principally found in Teltech's expert database. If the client calls the expert and has a discussion, Teltech bills the client and the expert receives a payment from Teltech."

Teltech also offers access to over 1600 on-line databases. Searches are assisted by Teltech knowledge analysts. When a client calls Teltech for a literature search, he or she dials into Teltech computers. The analyst explores the search topics by telephone with the client and then accesses the appropriate databases. Using special Teltech software, the analyst can then "take over" the client's screen, displaying the formats and results of searches to the client and discussing the search. Both the client and the analyst are accessing the same screens simultaneously from different sites and are talking on the telephone at the same time. After useful sources have been located, the search results can be saved or printed by the client. The average search interaction takes 25 minutes.

Teltech found that clients were often interested in whether vendors existed for particular technical products or services. It now offers a vendor search service. The service begins

[40] http://www.abuzz.com
[41] http://www.teltech.com

when the client calls and describes the desired product or service over the telephone. Then, using a combination of databases, printed buyers' guides, and the Teltech expert network, the analyst locates a likely vendor. The analyst calls the vendor, confirms that it offers the product or service, and discusses availability issues. The client is then given the results of the search.

Teltech was founded on the assumption that people are effective guides to information and knowledge. Expert, database, and vendor searches are all mediated through the Teltech knowledge analyst. While clients are entitled to search through Teltech's expert database themselves, most do not choose to do so (70% of the Teltech services are provided by phone).

Most clients who call Teltech have not perfectly articulated their information need. It is only through the dialogue with the knowledge analyst that the connection between the true information need and the available sources really emerges.

A key premise of Teltech's business model is that people are not only guides to information, but also an important repository of expertise. Teltech does not attempt to capture the experts' knowledge in a database, but only the topics about which they are expert, and the means for connecting topics to people.

One client noted that even when the expert referred by Teltech was not the ideal source for a problem, he or she invariably had enough knowledge about the topic to refer the client to the right expert. The client then has the option of pursuing the referred expert through Teltech.

The useful lesson here is that knowledge management is not just accomplished through the copying of knowledge from the heads of people and storing it in computers. Instead, computers can store databases of names and locations of individuals who have not only raw information, but also experience and expertise.

When clients call for access to experts, they are unlikely to always use the same terms as the experts use in describing their work. Therefore, there is some "translation" function performed by Teltech in connecting client needs to available expertise. This function is performed by knowledge analysts in combination with Teltech's on-line search and retrieval system, the "KnowledgeScope". The KnowledgeScope includes a thesaurus of over 30,000 technical terms. It is maintained by several full-time "knowledge engineers" who add 500 to 1200 new concepts per month to the database and remove outdated ones as well.

Teltech is highly oriented to the "information behavior" of its clients: i.e., how they seek out, use, share, and manage information. In conversations with Teltech employees, one often hears references to research or experience regarding the information behavior of technical professionals. There are no general rules about managing information behavior, but Teltech undertakes many projects and actions to try to improve the information behavior of clients.

Teltech also attempts to cultivate senior technical or research managers, who typically agree to sign usage agreements with Teltech. Their active encouragement of Teltech use by technical professionals can have a major influence on information behavior.

E-Learning Management Systems

Knowledge management includes acquiring new knowledge, as well as packaging and teaching existing knowledge. E-learning is a relatively new area that includes computer-based and on-line training tools for e-teaching and e-learning. People need to continuously learn new skills and new technologies due to the dynamic nature of their business and technology.

E-learning is appealing to people because it offers flexibility in time and space. Attendees do not have to travel to a specific location to take a class. The tutor does not have to be physically available. Recorded courses can be taken whenever students want to take them. The collaboration between students and tutors is also more flexible, and many of the collaboration and communication tools mentioned before can be used to support this activity.

E-teaching supports tacit-to-explicit knowledge conversion in that the teacher's tacit knowledge is converted to explicit learning material. E-learning supports explicit-to-tacit knowledge transformation in that students learn and internalize the explicit material. Both e-teaching and e-learning support tacit-to-tacit knowledge sharing when the tutor and student communicate. E-teaching involves knowledge creation, and both (e-learning and e-teaching) involve knowledge distribution, storage, and organization, as well as knowledge application when the students apply the newly-acquired knowledge to problems.

Common features for tools in this category include reusable learning object libraries; adaptive web-based course delivery; component-based authoring, scheduling and reporting tools; features for student progress tracking; and building of skills inventories. They often also include collaboration tools and support for all kinds of content, i.e., video, audio, documents etc. Searching and matching of tutorials with student needs and on-line facilitation are also often supported.

Examples of tools in this area are E-learning Hyperwave, Scenarios, First Door, Knowledge Mechanics, and Lotus Learning Space.

Hyperwave eLearning Suite[42]

Hyperwave eLearning Suite encourages informal learning with numerous synchronous and asynchronous communications tools such as e-mail, chat, and discussion forums that

[42] http://www.hyperwave.com/e/products/els.html

are tailored and available specifically for each course. Hyperwave eLearning Suite lets users create private or public notes directly in the course content and then send them to the respective tutor for a response. The Hyperwave eKnowledge Suite captures and organizes information of an organization, distributes the information within the organization, and also renders it available to business partners and customers.

Scenarios[43] (E-learning)

Scenarios is a web-based learning tool that bases its training strategy on interactive storytelling. Scenarios uses the inherent power of storytelling to deliver real learning in a contextually-rich format. Scenarios can be accessed anywhere, at any time. Scenarios creates active sharing of ideas and technology among multiple users. A facilitator who raises probing issues, responds to questions, and oversees learners' progress through the Scenario can guide scenarios. Scenarios features embedded work tools and other resources to overcome the disconnect between work and learning. Scenarios features characters that are custom-created to reflect your company's culture and values.

Firstdoor Enterprise Solution[44]

Firstdoor integrates Human Resource (HR) knowledge management with corporate learning. Corporate E-Learning, the integration of content and technology, is now available as a mechanism to distribute knowledge, training, guidance and best practices across the enterprise, on demand, to managers, supervisors, executives and others.

ASK Firstdoor is an on-demand ask-and-answer HR learning tool with customized answers which are made available from FirstDoors' HR professionals. The person seeking answers types in a plain-language question, phrase, or set of keywords to search Firstdoor's knowledge base. Firstdoor is similar to other knowledge bases in its functionality. The difference is that it also provides an expert network responsible for answering new questions. ASK Firstdoor's responses are reviewed and updated regularly to reflect the latest changes in laws and best practices, and to ensure accuracy.

RESEARCH Firstdoor brings a complete HR research library to the desktop. Users will find an evolving knowledge base of HR and benefits information, including law summaries, best practices, and case studies, all written to provide the background knowledge necessary to make informed decisions in the workplace.

TRAIN with Firstdoor is a HR-specific, on-line training tool complete with courses and tracking capabilities. TRAIN with Firstdoor brings employee and management training to the desktop. A high quality training tool, TRAIN with Firstdoor offers employees and managers a Web-based training application designed to improve HR knowledge and decision-making skills.

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[43] http://www.wisdomtools.com
[44] http://www.firstdoor.com

TRAIN with Firstdoor is self-paced, interactive, and customizable. The instructional design features real time tracking, administrator control over courses, quiz-as-you-go pages, and a final test that improves knowledge retention and enables the student to see the information in situational settings.

Tutor.com[45]

Tutor.com is an on-line-learning website with different sections for students, tutors and parents. The website provides on-line tutoring and Live Homework Help services to public libraries and community-based organizations.

On-line Tutoring means that any person who thinks he/she is capable of handling any educational subject, either from grades 1 to 12 or at the college level, can put a profile on this website as a tutor. General profiles include educational background, teaching experience, teaching awards, etc.

Tutors decide what they will charge and suggest times for classes. Tutors can teach off-line on a personal basis, in which case students or parents contact the tutor and decide on the subject, rates and class timings. Tutors may also agree upon on-line teaching.

Students can see tutors' profiles, their background, charges and availability for on-line meetings. If a student wants to have an on-line session with the tutor, then he/she has to pay before starting any session.

After the session, students can evaluate both the session and the tutor. Tutors are given rankings based on their evaluations and the number of sessions they delivered.

The Live Homework Help services to public libraries targets public and school libraries. Students access Live Homework Help via the library's computers. After entering their grade level and the subject they need help with, students are instantly connected to expert tutors in the Tutor.com On-line Classroom for 20-minute Homework Help sessions.

Portals

Portals create a customized single point of access to a wide and heterogeneous collection of data, information, and knowledge.

Knowledge workers use many different computer-based information sources that behave differently. These information sources need to be integrated and accessed through a common, yet personalized, interface. For example, some knowledge workers need to monitor current sales results, manufacturing activities, inventory levels, and customer orders, as well as their own personal information.

[45] http://www.tutor.com

Different types of systems use different interfaces and different ways of accessing the information. Yet, different users need to display and interact with the systems in different ways, calling for advanced and "automatic" personalization features. The portal becomes the one-stop-shop for the individual's all-information systems.

Portals pull information together from different sources and display it in a coherent way, performing an explicit-to-explicit knowledge conversion. Portals support knowledge distribution, as well as organization of the display.

A common feature of portals is that they provide a single gateway to information, data, and knowledge. This implies that users can go to one location, typically accessed through a web browser, for all the content they require. They also provide different kinds of personalization so that content is presented in a manner that suits the individual's role within the organization and reflects personal preferences. Both the organization and the user can control which information is made available and how it is displayed. Employees make decisions every day, but not all of them are informed. When critical data is hard to find, or takes too long to locate, it won't be available when a decision is made. Making the best decisions requires current and relevant information, which is what portals deliver.

Examples of portals that we present are Optimalview, Axielle and Lotus K-station. Almost all document management systems have a portal component (e.g., Hyperwave, Sharepoint, Autonomy and Plumtree corporate portal).

OptimalView[46] (Portal- Enterprise Wide)

Business success relies on productive employees. However, industry estimates reveal that employees spend, on average, 30 minutes per day looking for the information they need to do their jobs. OptimalView creates a customized, single point of access to critical information, applications and business processes. OptimalView is a web-based portal that provides a framework to integrate key applications and automate company processes.

Axielle Portal tool[47]

Axielle provides a Warehouse-to-Web solution that delivers information with a single entry point to the enterprise, providing users with access to a company's information assets through the use of meta data integration.

Axielle contains the most flexible platform in the industry for building, managing and delivering information across the Web.

[46] http://www.OptimalView.com
[47] http://www.ascentialsoftware.com/products/axielle

Section 5.
Case Studies

This section presents examples of well-known companies that realized the value of their knowledge and the need for knowledge management. They implemented and supported knowledge-related activities by using one or more tools from the categories described in the previous sections. In all of the case studies that we found, the organizations decided to implement different aspects, in order to solve concrete problems they were facing. They focused on problems that had high priority and for which knowledge management would be most effective and efficient. Their needs are expected to be common for other companies as well, which can learn from the experiences presented here. The examples in this section cover a wide spectrum of industries such as electronics (Sony and Hewlett-Packard), software (Microsoft and Hewlett-Packard), telecommunications (AT&T and Verizon), airlines (Delta), banks (Bank of Tokyo and Juniper Bank), the oil industry (British Petroleum and Chevron), the food industry (Frito Lay), consulting (Ernst & Young), and many others. Most of the large organizations started their knowledge management either organized, or ad-hoc (due to real needs), in some departments or divisions. The rationale was to start small and identify what works for each specific company, how people receive the new system and what are the benefits and the payoffs, and then extend the successful implementations company wide.

Some of the tools they used were available on the market, while others were developed in-house or "custom-built". We list here only a few of the companies using commercial tools presented in the previous section, to make the point that organizations have really started to employ knowledge management technology to solve their problems and improve their business.

For example, *Verity* is used for document management and collaboration support by consumer product, high-tech, telecommunications, publishing and media corporations (Colgate, Alcatel, Apple, AT&T, Verizon, BBC, and Financial Times). Another document management tool, *Documentum 4i eBusiness Platform* is used by airlines, control equipment, consumer product, banks, and financial organizations (Delta Airlines, Honeywell, Adidas-Salomon AG, Bank of Tokyo, and Zurich Capital Markets). *Autonomy*'s customers include the US Department of Commerce, NASA, MCI WorldCom, Sun Microsystems, AstraZeneca, and Seagate. *Lotus Domino* is probably the most common document and knowledge management tool, and is used by IBM Personal Computing Division, Novartis, ABN Amro, Novozymes, and many others. *Hyperwave* is used by BMW, Diamler Chyrsler, Fujitsu Siemens, Fraunhofer-USA, Telekom Austria, and the US Government.

Portals have more and more users, with the increase of companies' need for a personalized gateway to all their resources. The *Axielle* portal has been bought by media, banks, and telecommunications (CNN, Juniper Bank, Microcell Telecommunications, and SC Johnson). *Plumtree* is applied by the US Air Force, Ford, Ames, K-mart, and AmeriKing.

Customer support and customer relations management tools are being used by insurance companies, electronics, and consumer products companies, just to mention a few. For example, *AskMe Enterprise* is used at CAN (insurance), Integra (European E-business Solutions), 3COM, and Procter & Gamble. *Remedy* is used by Knowledge Management Software, Trimble, and Printronix.

The knowledge-discovery *DigiMine Analytic Services* is used by Microsoft bCentral, shockwave.com, AT&T Wireless, Atom Films, and The .tv Corporation. Tacit's *Knowledge-mail*' extracts knowledge from e-mails at Texaco, Kaiser Permanente, Hewlett-Packard, Aventis, and Braas.

For knowledge organization, US Postal Service uses *Semio* integrated with *MS Sharepoint*.

Collaboration tools support a diversity of problems within an organization, as well as external relationships. For example, GroupSystems helps marketing (GTE, Nokia) and process analysis and design systems (Randolph Air Force Base, US Army, Y2K State and Federal Summit, US Army Technical Integration Center, MD Anderson Diagnostic Imaging Department); problem solving and crisis management (Eastman Chemical, WSU College of Nursing and Health, Luther College, Community Partnership for Youth); and human resource management (MD Anderson Cancer Center).

British Petroleum Exploration needed to reduce the number of direct face-to-face meetings and increase productivity[48]. They used Virtual Teamwork (VT), an in-house developed collaboration tool. Virtual Teamwork allowed people to meet on the net and write (share) documents simultaneously. They had measurable productivity improvements related to more efficient information searches and issue resolution, and less "miscommunication". One finding was that commitments made "face-to-face" using the VT stations were honored much more consistently than commitments made by phone or mail.

Buckman Laboratories' driver for management of knowledge is customer intimacy[49]. Cash flow is generated on the front line with the customer, and effective engagement on the frontline is the major initiative. The goal is to have 80% of all employees engaged on the frontline. This means the employees are only in the office 14% of the time. They, therefore, need a process and a system that allows people to solve problems anytime, anywhere. *K'Netix* is the tool for management of knowledge used by every person in Buckman. *K'Netix* is an interconnected system of knowledge that provides real-time access to solutions through electronic forums, bulletin boards, virtual conference rooms, libraries and e- mail. The key to its success is that every employee takes ownership for knowledge and sharing knowledge. There has been a major cultural shift in Buckman from hoarding of knowledge to gain power, to sharing of knowledge to gain power.

[48] http://www.k-solutions.com
[49] http://www.k-solutions.com

In the remainder of this section, we present in more detail implementations of knowledge management at Ernst & Young, Hewlett-Packard, Microsoft, Frito Lay, United Technologies, Sony, and Chevron. We show the problems that each organization tried to solve by knowledge management, the context and characteristics of each company that led to a problem or to a specific solution, and then identify the solution, the challenges and the results.

Ernst & Young[50]

Since consulting is a human and knowledge intensive business, the intellectual assets are of utmost important for companies like Ernst & Young (E & Y). This organization has highly geographically-distributed contracts, covering a large variety of domains and applications. For information management, they used multiple technologies and tools that were not integrated and could not interface with each other.

As a result, consultants were performing similar assignments without reusing material and knowledge previously employed in similar contracts because this material had not been collected. Even the knowledge that was captured was difficult to access. There was an obvious lack of taxonomy and of knowledge classification according to different areas of business.

Ernst & Young realized the importance of identifying sources of knowledge, capturing and organizing knowledge, and for document management and technology integration, such that access to knowledge would become easy, regardless of time or place of access. This is why the Center for Business Knowledge (CBK) was created. It included a library, a call center for answering consultant requests, and a database of consultant skills. The CBK spent considerable time identifying and tracking subject matter experts, and ensuring that they were present in sufficient number on industry and client teams.

A knowledge network was organized for each key domain within the consulting practice. There were 22 networks in the US practice based on industries (e.g., energy). Some involved particular consulting approaches (e.g., business process reengineering) and some involved key areas of technology in which the firm consulted (e.g., the SAP package). Some regions also had *knowledge focus groups* on narrower topics. Each network occasionally met face-to-face and had an on-line discussion and document database in Lotus Notes.

A group of facilitators was created to capture the knowledge from particular engagements, prompt consultants to add their own experiences, and edit and prune discussions and document databases. The consultants who performed these roles had expertise in the domains of the networks they facilitated. They rotated into the knowledge facilitator positions and then back into line consulting positions.

[50] http://www.bus.utexas.edu/kman/toc.htm

Another key task of the CBK was developing a knowledge architecture and taxonomy. The purpose of this architecture was to focus knowledge acquisition, organization, and retrieval efforts. The knowledge architecture would specify the categories and terms in which Ernst & Young needed to gather and store knowledge. The architecture would also be used by consultants and knowledge facilitators to search databases and document files.

Knowledge managers believed that knowledge primarily resided in people, not technology. However, the scope and geographical distribution of the knowledge base and its users meant that technology had to be used as an enabler wherever possible. Lotus Notes had been selected as the primary technological platform for capturing and disseminating internal knowledge. By early 1996, there were already 2000 different Notes databases, most of which were discussions in networks and focus groups. The CBK maintained a Notes database of key documents. By 1996 it was being accessed over 16,000 times a month. E &Y had allowed multiple technologies to proliferate in the early days of knowledge management. There were between 200 and 300 local applications and databases. Approximately 12 to 15 applications would eventually support knowledge management, including Notes, the Web, the skills database, and a few others. E&Y had also made major investments in technology infrastructure that were not undertaken solely for purposes of knowledge management, but certainly benefited that cause. Altogether, E&Y was spending 6% of its consulting practice revenues on knowledge management and technology. E&Y technologists at the Center for Business Technology were exploring the possibility of using Web-based technologies for knowledge management. A key focus was putting knowledge, models, tools and techniques into the Accelerated Solutions Environment (ASE). The ASE was how E&Y consultants would deliver many of their services in the future, and had already been used on several client engagements. Embedding knowledge in technology was an ongoing issue, with the technology options changing rapidly and support requirements growing with increased use.

But technology is not everything in implementing a knowledge management system. They also identified issues in terms of the culture for knowledge management and use. It was particularly difficult to use technology to support some types of consulting knowledge (e.g., building relationships with senior client executives) which were tacit in nature and difficult to extract from the minds of practitioners.

The perception that knowledge management led to increased performance was undoubtedly aided by E&Y's recent performance.

Hewlett-Packard[51]

Hewlett-Packard (HP) is a large, successful company with over $31 billion in 1995 revenues. The company competes in many markets, including computers and peripheral

[51] http://www.bus.utexas.edu/kman/toc.htm

equipment, test and measurement devices, electronic components, and medical devices. It has 110,000 employees and over 400 locations around the world. The company is known for its decentralized organizational structure and mode of operation.

Although HP managers felt that the strong business-specific focus brought by decentralization was a key factor in the firm's success, they also saw a problem in that there was little organized sharing of information, resources, or employees across units. HP is known for its relaxed and open culture where many employees are technically-oriented engineers who enjoy learning and sharing their knowledge. It is also common for employees to move from one business unit to another, making possible some degree of informal knowledge transfer within HP. However, this was considered insufficient and the need for some organized form of knowledge management was acknowledged.

In mid-1995 it became apparent that several knowledge-management initiatives were underway in various HP business units. Some had been in place for several years; others were just beginning. Noticing this phenomenon, HP's Chief Information Officer (CIO) Vice President (Bob Walker) and Manager of Information Systems Services and Technology (Chuck Sieloff) decided to facilitate knowledge management at HP by holding a series of workshops on this topic. Their idea was to bring together a diverse group of people within the company who were already doing knowledge management in some form, or who were interested in getting started. Key objectives for these workshops included the facilitation of knowledge-sharing through informal networking, and the establishment of common language and management frameworks for knowledge management. The first workshop was held in October 1995. From this discussion, a list of more than 20 HP sites was compiled where some form of proactive knowledge management was underway. Several of the initiatives are described below.

Trainer's Trading Post

This initiative addressed the HP educators' need to be aware of material developed for similar classes within the organization and to be able to reuse that material, tools and experience. The Corporate Education organization, part of HP's Personnel function, was comprised of more than 2,000 educators or trainers distributed around HP, most of whom worked within small groups and found it difficult to share knowledge.

Three knowledge bases were established using Lotus Notes:

- *Trainer's Trading Post* (a discussion database on training topics)
- *Training Library* (a collection of training documents),
- *Training Review* (a Consumer Reports collection of evaluations of training resources)

The library was later merged with the trading post, while the "review" was abandoned due to a lack of reward for contributions, and also the reluctance to opine on-line about the worth of course materials or providers.

To stimulate educators to submit to the knowledge bases, free Notes licenses were given out to prospective users and free airline miles for contributions, questions, and responses to questions. By early 1996, more than two-thirds of the identified educator community had read at least one posting, and more than a third had submitted a posting or comment themselves. However, this project had to be heavily and continually supported by an "evangelist".

Building a Network of Experts

Another knowledge project was initiated within HP Laboratories, the company's research arm. The goal of this project was to provide a guide to human knowledge resources in order to identify who knows what. They developed a directory of HP experts, called *Connex*, which used a Web browser as an interface to a relational database. The primary content of the database was a set of expert profiles, that is, guides to the background and expertise of individuals who were knowledgeable on particular topics, with links to the individuals' home pages. One problem with creating these profiles was the creation of a manageable list of knowledge categories that could be understood by all employees and accurately reflected the Labs' broad universe of knowledge. To define these categories, and also for populating the profiles for each person and maintaining these profiles, they planned to rely on the experts' contributions. Realizing that this would be a challenge, they planned to adopt an incentive system (for example, "a Dove Bar for each profile" that was submitted and maintained) and also, as a back-up, a "nag" feature built into the system to remind people to update their profiles.

Knowledge Management on Product Processes

HP's Product Processes Organization (PPO) is a corporate group with the mission of advancing product development and introduction. It includes diverse functions such as Corporate Quality, Procurement, Product Marketing, Safety and Environmental, and Organizational Change. PPO began to think about a knowledge management initiative, as its activities contained a lot of experience-based knowledge that should be shared.

The PPO knowledge management group developed Knowledge Links, a Web-based collection of product development knowledge from the various PPO functions. Knowledge Links contained knowledge contributed by "knowledge reporters and editors" who obtained it through interviews with experts. Unfortunately, the goal of summarizing knowledge across PPO proved overly ambitious, and the system was never built.

The PPO knowledge management group had three other projects. One involved competitor information for HP's Components group. The second project's goal was to create a Web-based interface to primary and secondary research information. The third system was supposed to manage international marketing intelligence.

There are a lot of open questions in HP relative to knowledge management. Two of them are (1) whether it makes sense to try to manage knowledge in a centralized manner in

such a decentralized organization, and (2) whether opening a chief knowledge officer (CKO) position is justified.

Microsoft[52]

Due to the fast changing nature of software and related technologies, one of the requirements (and, at the same time, one of the competitive advantages) in this industry is that personnel continuously acquire new skills, both technical and business-related. The importance of staff competence has been repeatedly stressed by Microsoft, which does not tolerate "legacy people", i.e., people whose skills have become obsolete. An organization must keep track of what its employees skills and expertise are for staffing projects and identifying training needs, to mention a couple of reasons.

Acknowledging the criticality of competence management, the Information Technology (IT) group within Microsoft (that consists of over 1000 employees who develop applications, build infrastructure, and operate computers and networks) started a project called Skills Planning "und" Development (*SPUD*). This initiative, once implemented and tested, will be extended to the entire company. The goals of SPUD were to:

- create an on-line competency profile both for employees and for jobs within Microsoft IT
- use the competency model to transfer and build knowledge
- identify skills gaps and training needs and match them with educational offerings within and outside Microsoft
- better match employees to jobs and work teams

The main tasks of SPUD were:

- development of a structure of competency types and levels
- definition of competencies required for particular jobs
- rating the performance of individual employees in particular jobs based on their competencies
- implementation of the knowledge competencies in an on-line system
- linkage of the competency model to learning offerings

To develop the structure of the competency model, SPUD used four types (foundation, local/unique, global, and universal) and four levels (basic, working, leadership and expert) of knowledge. Within each of the four foundation competencies were two different competency types: explicit and implicit. The implicit competencies involved knowledge of and experience with specific tools or methods. The implicit types involved more abstract thinking and reasoning skills. The implicit competencies were expected to remain quite stable over time, while explicit competencies were expected to change

[52] http://www.bus.utexas.edu/kman/toc.htm

frequently with rapid changes of particular languages and tools. Within all four competency types, there were 137 implicit competencies and 200 explicit ones.

The manager to whom the job would report typically defined the competencies required for particular jobs. There were 40 to 60 competencies identified in the average job template. Because identifying all of the competencies for a job was very time consuming, they decided to focus on those competencies requiring the highest skill levels.

To build competency profiles (unlike the case of Hewlett-Packard, where each employee would define his/her own profile) workers at Microsoft IT were evaluated by the employee and his or her supervisor in terms of the competencies they had exhibited in their current jobs.

To create an on-line system that contained the competency structure, the job rating system and ratings database, and the competency levels for employees, they started with a prototype for the pilot using Microsoft Access. They later switched to SQL Server, since the system needed greater performance and robustness. The system has a Web front-end for easy access around the world through the Microsoft's Intranet.

As SPUD spread to product-oriented software developers within Microsoft, it had to be integrated with existing systems, for example, with Framework, Microsoft's methodology for product development.

Though the technical implementation was fairly straightforward, there were human and cultural issues to be resolved, such as access and security issues to prevent inappropriate usage (for example, managers composing teams "raiding" existing teams for members with desired competencies).

Frito-Lay[53]

Within Frito Lay, the need for knowledge management was addressed for the first time by customer development at Frito-Lay, an $8.5 billion division of PepsiCo in Plano, Texas. Their main problem was that Frito-Lay's support staff ended up performing the same tasks over and over. They identified multiple causes for that. Knowledge was not captured and documented. It resided mostly with salespeople. Even when information was in files, they were scattered around the company in disparate systems, and there was no easy way for the geographically-dispersed sales force to access it. If that information lived in a central, easily accessible spot, the salespeople could access it as needed. The teams also needed a place for brainstorming and collaboration on-line. "If somebody got a piece of research and wanted to get input from account executives in Baltimore and Los Angeles, the ability to collaborate [on-line] just wasn't there," said Mike Marino, V.P. of Customer Development.

[53] http://www.cio.com/archive/050101/crunch.html

To address the need for having a single point of access to multiple sources of information and provide personalized access, they decided to build a knowledge-management portal on the corporate Intranet. A KM portal at Frito-Lay would give the sales department a central location for all sales-related customer and corporate information and cut down on the time it took to find and share research. In addition to different types of information about the team's customer (including sales, analysis and the latest news), the portal would contain profiles of employees, facilitating internal expert finding and setting the basis for competence management.

Marino chose this sales team as the portal pilot because it was working with a Frito-Lay client that Marino said was an industry leader in marketing, product promotion and merchandising. The sales team was dispersed across the country, making it ideal for determining whether the portal would succeed in bridging geographic boundaries when it came to sharing internal information. A prototype was built using *Lotus Domino*, *BusinessObjects' WebIntelligence*, *Java,* IBM's *DB2* database and *Autonomy.*

To populate the portal, the VP, together with *Navigator* (the consultant that implemented the KM technology), performed an audit within the company and created expertise profiles on the portal so that sales staff in the field would have an easy way to learn who's who at headquarters in Plano. Security was also a big concern because the pilot team would be working with confidential client information. This was resolved by having different sections of the portal-accessible information password-protected, ensuring that only pertinent users could access the confidential information.

The portal started to be used in January 2000. The results show that the test team doubled the growth rate of the customer's business in the salty snack category. Another important effect was its contribution to increased employee retention rates by increasing staff satisfaction due to reduced traveling; better communication and access to the desired information (including experiences and best practices); and reduced paper circulation (by fax, for example). The portal usage will soon be extended to three divisions.

United Technologies[54]

Although United Technologies is comprised of many companies with very diversified application domains, they still believe that sharing knowledge between engineers across the organization could be very beneficial. The problem is that the organization is large and hugely decentralized (142,000 employees and five major divisions worldwide).

As UTC grew increasingly global and added new companies through mergers and acquisitions, knowledge management was considered to be one avenue for increasing the business value through information sharing and brainstorming. To increase the United Technologies Corp.'s (UTC) effective use of information, the knowledge management group at the United Technologies Research Center (UTRC), the R&D arm of UTC, started a knowledge sharing initiative in November 1998.

[54] http://www.cio.com/archive/020100_km.html

The company spent about a year defining the project's goals and purposes before moving into implementation. Their strategic decision was to start small and build the effort incrementally. Also, they decided to build on top of the earlier similar efforts at UTC, even if these activities were not called "knowledge management" because the term had not been coined at the time they started.

The initial scope was to cover the engineering population, which already had a cross-functional group called the United Technology Engineering Coordination Activities (UTECA), a grassroots organization started in the '70s dedicated to transferring knowledge across business units. UTECA facilitated the informal exchange of information related to 18 different functional disciplines via channels such as e-mail or conversations. Another vehicle for knowledge-sharing was an annual conference. However, this was not enough. They realized the need to expand this to all engineers, and to incorporate greater structure and accountability into the system. To build that structure, the Knowledge Management (KM) group at UTRC read studies about how to build communities across an organization and concluded it was vital to get senior- and middle-level managers involved in the effort. The VPs (eight in all) analyzed the core technology areas that were critical to both products and customers, and also defined appropriate experts. They talked to UTECA members, brainstormed with their staff and other business units, and recommended topics and topic experts. The VPs proceeded to fine-tune the topics and recruit the identified experts.

While the VPs were working on gathering the content for the new competence management system, UTRC was defining the format of the program to go beyond a directory of experts and a list of best practices and lessons learned already existing since 1989. They have realized the need for structuring and organizing knowledge and knowledge sources and providing the right infrastructure for people to share.

Sony[55]

This case study combines solicitation of tacit knowledge and development of visualization-based web tools. Sony Entertainment has more than 200,000 master recordings that the company licenses to song licensees. The website, which is based on the *Thinkmap*[56] platform, allows potential licensees to search among the songs based on key words. Before the current system was implemented, the knowledge about the songs was tacit. Mainly, one person at Sony was in charge of recommending songs to potential licensees, according to their specific needs. The licensee would, for example, ask for songs to use with a commercial for a new truck. The Sony person would then go through his/her memory and recommend songs that were somehow related to trucks. Candidate songs could either have "truck" as a word in the lyrics, or the theme could be related to trucks. Related theme keywords could be, for example, "cowboys", "desert", and "wild life".

[55] http://www.sonymusic.com/licensing
[56] http://www.thinkmap.com

The first part of creating the website was to elicit the tacit knowledge and turn it into a keyword-based taxonomy that could be used by the program. The taxonomy was combined with a public taxonomy for songs that is updated yearly.

The final web solution allows potential licensees to search among songs based on a keyword. The application displays all songs related to the key word. All songs are displayed in a list showing the title, the artist and the year when the song was released, together with an audio clip of the song. More details for a song can be displayed by clicking on its title. A graphical display indicates how the searched keyword is related to other keywords. The size of the displayed circles (representing the keywords) indicates the number of songs that match that particular keyword. For example, a search for the word "Life" will find 394 songs. It will also return 13 other keywords related to "Life".

Chevron[57]

At Chevron, the chairman and CEO Ken Derr set a 15% annual growth in stockholder return target for the period 1994-98. By utilizing the Chevron knowledge base better, this target was reached. A core element in the overall approach was *best practice* sharing. Chevron formed a number of best practice teams, each one led by a "Master" chosen for strong technical expertise, knowledge management skills and high team leadership competencies. A "Chevron Knowledge Map" was developed and made accessible via the Chevron Intranet to guide Chevron employees in their search for best practices inside and outside the company. Chevron appointed 2000 facilitators to facilitate the operation of the best practice teams.

Concluding Remarks

After reviewing all above-mentioned case studies, we can draw some concluding notes:

1) Knowledge management is seen as a process of converting information into value for the corporation (reduce costs, increase employee productivity, improve products and services) (United Technologies).

2) In terms of results, knowledge managers felt that some sort of predicted success (in terms of statistical numbers) had to be shown as a direct result of a KM system before implementing it. Along with this predicted success, some level of faith was required, because it was impossible to fully justify knowledge management investments (E&Y).

[57] http://www.k-solutions.com

3) A fundamental question was related to the basic definition of knowledge, i.e., how different managing "knowledge" is from managing information, since the same fact could be data, information, or knowledge for different people (HP).

4) Regarding the technology to support KM, instead of first devising the applications and then imposing them on people and expecting people to adapt, it is better to look at how people are naturally sharing information and then build a system to support those activities. This is a critical success factor in the implementation of a KM system (United Technologies).

5) Knowledge Management will not be beneficial unless people feel they are getting something from it. It is critical for employees and supervisors to feel that they contributed to the KM system's implementation. Ultimately, the attempt to advance knowledge by focusing on individual knowledge competencies requires the active involvement of everyone in the organization (Microsoft).

Summary

This report focused on software tools for knowledge management. We have surveyed the commercial market for such tools, divided them into categories and described them from different perspectives. To illustrate the implementation of knowledge management, we provided a set of case studies. As background, we provided two models that we used when we described the tools. The first model distinguished between tacit and explicit knowledge and the conversions that can occur between these two knowledge formats. Tacit knowledge represents the expertise of the employees of the organization and explicit knowledge represents the recorded knowledge that exists in any organization. Due to the fact that all knowledge cannot be made explicit and recorded, a knowledge management solution must address both forms. Document and content management systems, knowledge and experience bases, and other techniques that support management of recorded material exemplify management of explicit knowledge. Management of tacit knowledge can be represented by competence management systems that keep track of who in the organization knows what.

The second model described the knowledge life cycle that acknowledges that knowledge is created, stored, organized, distributed, and applied. We saw, in the descriptions of the tools, that all repository-based software systems support a majority of the phases in the life cycle, while few systems actually deal with the analysis and synthesis of new knowledge.

We discussed a sample of tools that we think represent what the market has to offer. We do not claim to cover the entire market, which is large and growing. The material was compiled based on the vendors' own descriptions of the tools and systems. Impressions from the Knowledge Management World 2001 (KMWORLD 2001) Conference (which, according to the people in charge of the conference, is the largest Knowledge Management event in the world) indicate that the market is steadily growing. A growing number of tools are introduced to the market and organizations tend to acquire more and more tools. This is illustrated in the section of case studies where we describe how tools can be used to implement knowledge management.

It was stated during KMWORLD 2001 that knowledge management relies heavily on technology, which the authors of this report believe is true. It is important to state, however, that technology alone will never be the solution to knowledge management. Knowledge Management is a key enabler, but needs to be implemented properly and with support and commitment from the people in the organization.

Many case studies of successful implementations of knowledge management are mentioned in this report. One example is Xerox' Eureka success story that indicates that knowledge management is indeed possible to implement and that today's technology definitely makes the chances higher than ever to succeed with the effort.

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