Position Paper for Knowledge Technologies in FP 6 -
Organizational Memory, Knowledge Retrieval, Knowledge Visualization and Knowledge Transfer

Klaus Tochtermann
Know-Center
Inffeldgasse 16c, 8010 Graz, Austria, Email: ktochter@know-center.at, Internet: www.know-center.at

1. Introduction

Many future-oriented thinking companies have recognized that the management of intellectual capital and knowledge will be vital for a sustained competitiveness in a new business landscape which is often referred to as the New Economy. In the New Economy the value of an enterprise is much more based on intellectual assets rather than on material assets. For example, General Motors (GM) is a traditional industrial company with many material assets, such as land, buildings, equipment etc., with US $168 billion in sales in 1996. The market value of GM was US $50 billion in 1997, while the market value of Microsoft, a company with many intellectual assets, such as copyright on Windows operating systems, was US $120 billion. The difference is quiet impressive if one takes into account that Microsoft had "only" US $9 billion in sales in 1996. This example between a pioneering company in the Old Economy and a pioneering company in the New Economy shows that the successful management of invisible assets will be playing an increasingly important role to improve the performance and, thus, to increase the value of almost any type of organization.

Often the terms intellectual capital management and knowledge management are used as synonyms, even though a fundamental difference exists. According to Wiig [Wiig 1997] intellectual capital management focuses on building and governing intellectual assets from a strategic perspective. This includes to renew and maximize the human capital (e.g., competence of employees), customer capital (e.g., value of relationships with customers), or process capital (e.g., organizational structure). In contrast, knowledge management places the emphasis on an operative perspective. It is concerned with creating, capturing, extending and transferring knowledge within an organization. The focus of this position paper is primarily on management of knowledge rather than intellectual capital. For a study about measures for intellectual capital the interested reader is referred to [Bontis et al. 1999].

To implement knowledge management in an organization, different aspects from different disciplines have to be taken into account. Organizational aspects are required to define which knowledge should be captured and the way it is captured. Often a new knowledge-friendly culture has to be implemented within an organization. Such a culture is necessary to support knowledge sharing and to overcome the employees' fear that sharing of knowledge means losing power. Additionally, information technologies (IT) have to be introduced widely as the enabling technology for knowledge management. A general lesson learned is that using IT for knowledge management often meets resistance. Therefore, organizational and cultural change have to be taken place first. The introduction of IT afterwards will then be considered a help rather than a burden.

The purpose of this position paper is to present an integrated four-dimensional view on knowledge management from an IT perspective. This view has its origins from two sources: First, it evolved in the course of extensive discussions with the Know-Center's partner companies which are planning to develop or introduce a knowledge management system or components of a such a system within the next four years. Second, some ideas from sections 3 and 4 are based on a contribution the author made to the study "Knowledge Management – Learning more from Nature" which was commissioned by the German Ministry for Education and Research.

Against this background, this position paper reflects broadly the needs of European companies and research institutions and may serve as valuable input for the research agenda on “knowledge technologies” within the European Commissions 6th Framework Program (FP6).

The remainder of the position paper is structured as follows. Section 2 gives an overview of the knowledge management approach pursued by the Know-Center. Section 3 focuses on organizational memories, Section 4 on knowledge retrieval, Section 5 on knowledge visualization, and Section 6 on knowledge transfer. Each section closes with a recommendation for research topics for knowledge technologies to be covered in FP 6. The position paper closes with a brief suggestion for how the research can be organized within FP6.
2. IT-based Knowledge Management - And the role of humans

Often IT-based knowledge management places too much emphasis on the IT-component and, thus, tends to neglect the role of humans in knowledge management processes. Our point of view is that every IT-based knowledge management system should serve humans and their needs rather than humans serving the system. This leads to our cycle of IT-based knowledge management:

Arrow 1 in figure 1 shows that one of the most important ways to capture, disseminate and share knowledge is human-to-human interaction. Three ways exist to derive computerized knowledge from human knowledge (2): a) users explicitly input knowledge, b) users implicitly create computerized knowledge as by-product of processes they are carrying out anyway, and c) users input implicit knowledge without being aware of it. Systemic actions, i.e. actions which are triggered by the system, are needed to make this implicit knowledge explicit to the system and to create computerized knowledge (3). Examples for systemic actions are known from artificial intelligence where inference mechanisms derive new knowledge from already existing knowledge. Two ways exist how computerized knowledge flows back to humans to create human knowledge (4): a) by explicit queries for individual pieces of knowledge and b) by systemic actions, which become active according to user behavior patterns or user profiles. Often such actions are referred to as push-technologies, i.e. the system pushes knowledge pieces to the user rather than the user becomes active and pulls the knowledge from the system.

This model rises the question of how these knowledge flows can be supported best with IT-based components. The recommendation for FP 6 is to promote an integrated view on knowledge management by taking four dimensions into account: An organizational memory is imperative for storing and maintaining the knowledge available. Knowledge retrieval supports primarily users in retrieving knowledge in the system. In addition, knowledge retrieval holds a great potential for analyzing the needs of users and for assessing the quality and completeness of an organizational memory. Knowledge retrieval can be supported with knowledge visualization concepts which help make visible the otherwise invisible. Once knowledge is retrieved it has to be transferred from the system to the user (and vice versa). The main challenge for the knowledge transfer is to avoid that transfer processes change the meaning of the knowledge or put the knowledge in a wrong context.

3. Organizational Memory - An analogy to the human memory

In literature an organizational memory is often explained as the systematically archived collection of all explicit knowledge available in an organization. Considered from this perspective, an organizational memory consists of many heterogeneous, distributed knowledge bases, multimedia, relational or object-oriented databases, information systems etc. It is imperative for an organizational memory to hide this complexity to the users. This is why portal solutions (e.g., enterprise information portals), often referred to as “single point of access”, have attracted increased attention. Many of today’s solutions are very technology driven in that they apply Internet-technologies for a very clever integration of heterogeneous platforms. Or they provide very user-friendly interfaces to facilitate search for and retrieval of knowledge pieces. For example, in digital libraries, much research was conducted to optimize search and retrieval. And in the Internet it is much easier for users to search and
retrieve data than to add new data to a web server. Authoring functionality was and often still is a privilege for some authorized users. The strict separation between authors and readers may be appropriate for digital libraries and common Internet information systems, but it is certainly not for knowledge management purposes. What can the value of an organizational memory be if knowledge sharing between the users is not supported? What can the value of an organizational memory be if users cannot add their own knowledge? What can the value of generic access to knowledge be if users cannot get knowledge customized to their specific needs? Instead of a "single point of knowledge access" an organizational memory should be understood as a "single point of knowledge sharing". This leads to a slightly different notion of an organizational memory.

In our notion an organizational memory is, like a human memory, a complex system which provides features supporting knowledge sharing, knowledge authoring and knowledge customizing. To continue the analogy to nature, knowledge sharing corresponds to the neuronal network of a human memory which connects arbitrary neurons directly or indirectly to one another and let them "share their knowledge". For example, in an organizational memory yellow pages and communities of practices can bring together people with special knowledge. An authoring component is inherent in every human memory as nobody can consciously "switch off" his perception. An interesting phenomenon of nature is the "natural quality assurance" which ensures that people memorize important knowledge much better than useless knowledge. Similar to this, knowledge authoring allows everybody to extend an organizational memory. But the quality assurance must be integrated as a special process to separate knowledge which is useful and relevant from irrelevant knowledge. Knowledge customizing has its analogy in the phenomenon of the human memory to provide a person exactly with knowledge which is relevant to best perform a specific task in a specific context at a specific point in time. Therefore, customization ensures that knowledge is meaningful (content), relevant (context) and accurate (timely and trustworthy).

Finally, the term "organizational memory" implies that such a memory covers primarily the needs of an organization. Often personal and personalizable knowledge management at an individual level is not taken into account. The main reason is that knowledge management at the organizational level has different objectives which can be in conflict with objectives of personal and personalizable knowledge management. User acceptance can only be reached if personal knowledge management is embedded as an integral component in a knowledge management system.

Research topics for FP6:
- Development of generic portal solutions which support knowledge sharing
- Support of customization and personalization of knowledge management systems
- Development of meta-knowledge approaches (i.e. knowledge about knowledge), development of standards for meta-knowledge management according to MPEG-7, Dublicn Core etc.;
- Integration of knowledge management at different levels (e.g., the corporate and personal level)
- Integration of knowledge management with other eTechnologies (eGovernment, eCommerce etc.)
- Application of phenomenons known from nature to enhance knowledge technologies (e.g. automatic quality assurance, tools which allow organizational memories to “unlearn” knowledge)

4. Knowledge Retrieval - Exploring and enriching an organizational memory

Knowledge at your finger-tips is certainly one of the most attractive visions IT-based knowledge management can offer to its users. Knowledge retrieval faces numerous challenges in helping users find what they need. Many well-established approaches from the areas of information retrieval, digital libraries, hypertext, and artificial intelligence can be applied to knowledge retrieval. For example, the separation between the two different retrieval paradigms searching and browsing also applies to knowledge retrieval; conceptual navigation narrows the scope of a user’s interest by forming strategic sequences on why?, how?, when?, where?, who? and what? [Veltman 1997]; and finally ontologies are crucial for knowledge retrieval as they can give a unique semantic to complex objects [Fensel et al. 1998]. Implicitly, typical search strategies, search forms and query languages for information retrieval are based upon the assumption that users are familiar with the topic about which they need information and the terminology which is specific to the topic. For example, if users want to find information about document description languages which separate between a document's layout, structure and content, they formulate a query such as "Find all documents dealing with XML or SGML". A full-text search retrieves documents which contain the terms XML or SGML. Alternatively, a metadata search returns those documents which are cataloged...
with XML and SGML as thematic metadata. Such a query implies that users have already heard about XML and SGML. Even though most of the above mentioned approaches can be applied for knowledge retrieval, there is a significant added value of knowledge retrieval. Knowledge retrieval should support users in describing their "problem" with the knowledge they have about the problem and without being required to be familiar with a specific terminology. To take the above example, instead of formulating a query "Find all documents dealing with XML or SGML" users describe that they are interested in "possibilities to separate a document's layout, structure and content". Such descriptive approaches for knowledge retrieval require much more sophisticated search strategies and new approaches to store and catalog knowledge.

In the near future digital video/audio will emerge as an important representation form for knowledge. Organizational memories will include video and audio archives with recorded speeches, multimedia learning and training courses etc. Another example is the professional movie sector, where huge treasures of mostly analog audio and video material are waiting for getting digitized and supplemented with appropriate metadata. To this end new methods for knowledge retrieval which go beyond today’s annotation concepts are required. The current approaches for video annotation are either based on general and flat textual annotations, or propose complex languages for video annotation (e.g., Media Streams from MIT Media Lab). Annotation is a broad concept which ranges from the registry of physical characteristics (e.g., color or special effect) to content related aspects (e.g., outdoor scene, person speaking). New metadata standards such as MPEG-7 will allow fast and efficient search for digital audios/videos. Different levels of abstraction have to be developed. A low level of abstraction would be a metadata description of shape, size, texture, movement and position for digital videos and for audios mood, tempo, tempo changes etc. The highest level of abstraction would give semantic information: "This is a scene with an airplane on the right and a laughing children in the front". The level of abstraction is related to the way the metadata can be extracted. Many low-level features can be extracted in fully automatic ways, whereas high level features will need much more human interaction. From the perspective of knowledge retrieval, high-level abstraction would significantly improve a user’s possibility to search for knowledge pieces in an organizational memory. The most intuitive form are descriptive queries such as "Find the video with a chirping bird in a tree".

Another perspective of knowledge retrieval which is currently only poorly developed deals with the question of how knowledge retrieval can be used to enrich an organizational memory. This idea originates from the observation that every query contains a lot of knowledge about how users work with an organizational memory, which knowledge users are most interested in etc. Analyzing the queries users submit to the system is the key to identify missing knowledge. Such an analysis can indicate that something is wrong with how the knowledge is presented and explained in an organizational memory. Or, it can point to missing intellectual assets in an organization. Such an identification is of great importance for an organization: From the perspective of intellectual capital management, skills and know-how for the missing knowledge area can be integrated in an organization’s strategy to build up future intellectual assets. From the perspective of knowledge management, the organizational memory can be improved with the provision of the respective knowledge. In this context, further research is required to bridge the gap between intellectual capital management and knowledge management.

**Research topics for FP6:**

- Development of descriptive query languages for knowledge retrieval
- Development of different semantic levels for metadata to be used for knowledge retrieval
- Analysis of user behavior (e.g. queries) to automatically extend organizational memories
- Integration of knowledge management which is at the operative level with management of intellectual capital which is at the strategic level

**5. Knowledge Visualization - Making visible the invisible**

Visualization of knowledge pieces stored in organizational memories can help contextualize knowledge and can significantly make visible the otherwise invisible [Tochtermann et al. 2000b]. Two-dimensional visualizations with meaningful axes are an effective visualization strategy because thousands of knowledge pieces and the relationships between them can be shown at once. Generalized hierarchies as a special form of two-dimensional visualization concepts will be of particular importance since they have the potential to reduce the complexity by organizing related knowledge into comprehensible structures. Such hierarchies allow multiple classifications of
the same object (solving the old “library dilemma”: where to put a book on biochemistry? In chemistry or biology?) While this is a difficult problem in real life, it is not a problem in a knowledge management system since it allows to have one copy of a document but many pointers to it. The user does not see the pointers, but has the feeling that many copies exist. Carried further this means that an organizational memory can be accessed using arbitrary many paths. In addition, innovative three-dimensional structure visualization mechanisms, such as “information pyramids” or “NewsMaps” allow users to have different views on and perspectives of the content of an organizational memory. For example, the concept of NewsMap is an promising visualization approach for contextualizing knowledge [NewsMap 2000]. NewsMaps look like topographical maps of mountains and valleys. Documents with similar content are placed closer together, and peaks appear where there is a concentration of closely related documents. The valleys between peaks are interesting for two reasons: First, they contain fewer documents and more unique content. Second, they make visible the otherwise invisible as they indicate that the organizational memory is lacking knowledge in certain areas.

Conceptual navigation can be improved by sophisticated visualization components which interactively guide knowledge workers through an organizational memory. Even though a number of pioneers are assuming that two-dimensional navigation will soon be discarded as a thing of the past and everyone will use three-dimensional knowledge spaces for navigation, we want to focus on both two-dimensional and three-dimensional visualization concepts. A reason for this decision is that two-dimensional visualizations require less complex user interfaces and are thus easier to handle. Another reason is that many tests have shown that three-dimensional visualization is cute, but not necessarily helpful. We want to investigate whether three-dimensional navigation is indeed as helpful as some people seem to think. The usual argument is that nature is three-dimensional, hence it is clear that navigation should also be three-dimensional. We believe that this kind of argument is not always valid. In nature birds fly by flapping their wings, but airplanes don’t. In nature, animals walk but fastest transportation is on wheels. Just because something in good in nature does not mean that it is the best technical solution.

Research topics for FP6:

- Development of knowledge classification algorithms (particularly in combination with knowledge visualization)
- Development sophisticated knowledge visualization techniques to put knowledge in context
- Validation of visualization techniques (many approaches exist but only very few have proven beneficial for knowledge management systems)

6. Knowledge Transfer - Bringing the right knowledge to the right people

In the emerging information (knowledge) society, the dominating strategy for organizations to become more profitable and competitive is to increase the innovation speed hoping that better technical solutions will solve many of the current problems. However, an increased innovation speed also leads to problems because many employees cannot keep pace and thus can no longer be sufficiently involved in the economic process. To overcome this hurdle support for education and life-long learning is imperative for organizations if they want to stay successful and competitive in the long run. What is required are means for organizations to build up an organizational memory and to utilize this knowledge to its maximum potential with support of methodologies and tools specifically designed for life-long learning, long-distance education etc. Educational programs require methodologies which support the mapping from computerized knowledge back onto human knowledge. In addition, it is crucial that the process of internalization of knowledge (e.g., understanding the information, putting it into context with existing knowledge) is well supported. Against this background knowledge transfer covers a broad spectrum including support for employees to exchange knowledge, feedback mechanisms, evaluation and certification mechanisms, support to design courseware, and learning strategies.

Knowledge transfer between people can take place outside but with support of a knowledge management system. Often finding people is more valuable than finding knowledge. That is, instead of making available the knowledge a person has in a specific subject domain, yellow pages can be used to make available the information about which person is an expert in which domain.

Traditionally, questionnaires are used to get feedback from users about the quality of a course or the value of a knowledge piece. However, questionnaires are often considered as an additional burden and are filled in with very little care only. Therefore one aim is to find alternatives for unobtrusive feedback, i.e. without molesting
users. An idea for future research is to distribute the questions as "questionnaire-lets" among the courseware instead of asking them all at once in a single questionnaire. For example, questionnaire-lets can be combined with navigational buttons in that users have two buttons to continue their navigation: one of those could say "I like the way how the material was presented, please continue" while the other button could say "I did not like the way how the material was presented, please continue". A problem users may encounter with this concept is that they get distracted when they have to decide if they liked the presentation of the courseware or not. Due to this distraction users might even forget what they have just learned. Psychologists explain this phenomenon with the three existing types of memories (i.e., short-term, medium-term and long-term memory). The migration of the knowledge from the short-term memory to the medium-term memory can be disturbed or even interrupted by taking the decision about which button to press.

The design of courseware is coined by two trends: first, the Internet emerges as the primary medium for courseware distribution and use; second, the use of multimedia is almost a must to increase the degree of interaction in courseware. Using the Internet as platform for knowledge transfer helps overcome the "tunnel syndrome" which is an obstacle well-known from Computer Based Training (CBT). The tunnel syndrome is the users' impression that there is only one direction in which they can go to accomplish a course. A methodology to solve this problem is to provide multiple ways each of which leading to the same target. At least four different possibilities exist: 1) A knowledge transfer system can offer background libraries a user can visit whenever necessary; 2) To change the path through the courseware a user can always jump back to the table of content; 3) A user can ask questions to the system which will be answered from an expert (or directly from the documents themselves); 4) Communication features allow users to contact others to discuss questions [Maurer 1998].

Multimedia standards such as SMIL or MPEG-4 are well suited for designing Internet-compliant multimedia courseware. Interaction is possible in that users can click with a pointing device on objects in a scene to jump to another scene or to follow another path of the courseware. Today, however, the design of such interactive courseware requires authors to program the interaction using some kind of scripting language (e.g., Lingo for Macromedia Director). We consider the need to program just as a intermediate molestation for the author which will be replaced in the near future by more sophisticated authoring tools.

Finally, today's multimedia documents are often too concrete and no high-level abstraction mechanisms exist. This can be explained best by taking an analogy from books and movies: Often people are so enthusiastic about a book they have read that they also want to watch a movie about the story of the book. Often, however, people do not like the movie and are disappointed about it. The reason for this phenomenon is that the book and the movie are at different levels of abstraction. While the movie is very concrete (e.g., the main character is middle-aged, small and almost bold) the book is at a higher level and thus allows the readers to have their own imaginations about how the main character may look like (e.g., the main character is young, tall and with black hair). Similar to this new document types for multimedia documents should allow to compose scenes in a movie using abstract symbols instead of concrete objects. These abstract scenes can then be instantiated to produce concrete scenes with concrete objects. Of course, the level of abstraction has a direct impact on how queries must look like to efficiently retrieve abstract movies or parts thereof [Lennon et al. 1994].

Research topics for FP6:
- Development of mapping mechanisms between computerized and human knowledge (to ensure that the right knowledge is brought to the right people at the right time)
- Development of generic tools to create ontologies which support knowledge transfer
- Development of user-friendly knowledge transfer technologies to support knowledge exchange and transfer in thematic networks in various fields (e.g. environment, medicine etc.)
- Development user-friendly feedback mechanisms for knowledge transfer
- Development of tools for creation of interactive multimedia content
- Support of multimedia creation at high levels of abstraction
7. Recommendations for the organization

The EC should differentiate between pre-competitive research and strategic research.

**Pre-competitive research**: The objective of pre-competitive research is

- to provide the European industry with funding to stay competitive in a global world market. pre-competitive research should bring together research institutions with industry companies to reduce the time which is normally needed to bridge the gap between research solutions and “real world” applications.
- to provide incentives for the European industry to develop and apply leading edge technologies,
- not to support the development of products; this means this kind of research is always pre-competitive.

Pre-competitive research projects should not last longer than two to three years.

**Strategic research**: The objective of strategic research is

- the accompany and supplement pre-competitive research on demand, that is whenever a strategic research question appears it should be possible to apply for a strategic research project. The strategic research project the helps to gain insights in the complexity of the question and to decide whether this problem can be solved within a pre-competitive research project or not,
- to capitalize on already existing thematic networks in Europe so improve the efficiency with which strategic research questions can be solved,
- not to replace or supplement the national funding programs for basic research (e.g., at Universities) in the EU member states.

The budget for strategic research projects should not be bound to dates for a call of proposals.
Instead, it should be possible to continuously submit proposals on demand.

8. References


Acknowledgements
The Know-Center is a Competence Center funded within the Austrian Competence Center Program K plus under the auspices of the Austrian Ministry of Transport, Innovation and Technology (www.kplus.at).