# Infotop – An Information and Communication Infrastructure for Knowledge Work

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**Abstract**

The desktop metaphor has been helpful as long as the types, formats and amounts of contents to be administered were limited. Due to the increase in size and complexity of contents, much of the original desktop's functionality has moved into applications, replacing the desktop as the central view to collections of contents. We will outline an environment based on knowledge management (KM) concepts, that can better cope with the requirements of knowledge workers. We will analyze shortcomings of the desktop for supporting KM-related tasks and motivate its replacement by what we call infotop, a new metaphor to interact with personal knowledge environments.

**Keywords:** knowledge management, knowledge work, desktop metaphor, information and communication technologies

## 1 Introduction

The transformation of organizations into knowledge-intensive and knowledge-aware organizations takes place at an increasing pace. Knowledge workers have to be supported with an adequate organizational as well as an information and communication technological infrastructure. A knowledge management system (KMS) promises enhanced support for knowledge work through an integrated combination of a number of information and communication technologies (ICT) from the perspective of knowledge management (KM). So far, a KMS is rather technocratic and document-focused. It provides a corporate solution with little consideration of what ICT tools knowledge workers need in order to personally share in and benefit from a corporate KM initiative (Maier 2002). Thus, actual KMSs fail to convince users of their advantages.

Knowledge workers are the primary user group of personal computers. From an ICT infrastructure perspective, the desktop metaphor has been used for decades to administer small amounts of documents. This metaphor has been sufficient as long as the types, formats and amounts of contents to be administered were limited. Today, the desktop provides only a restricted view to the organizational knowledge base. Due to the increase in size and complexity of contents, much of the original desktop's functionality has moved into complex applications, e.g., web browser, messaging system, KMS. Thus, the desktop has been replaced in many situations as the central view to collections of contents. This has resulted in today's scenario where we have many applications with many isolated and incompatible views on parts of the data and with many categorizations of these data.

We will propose to replace the desktop with infotop, a new metaphor to interact with personal knowledge environments, what formerly was a personal computer. The term infotop covers the dynamic aspect of knowledge, the flow of knowledge, which is best described by the term information. Infotop thus means to be “on top of the information” that flows in and out of the personal knowledge environment. Consequently, the main aims of this paper are:

- to analyze requirements for a knowledge environment suited to support knowledge workers and enable corporate KM initiatives,
- to discuss the shortcomings of the desktop and review the literature on attempts to its replacement,
- to suggest infotop as a new metaphor to interact with personal knowledge environments taking into account the requirements extracted from KM.

Section 2 discusses the changed situation in which computers are used in today's knowledge-intensive organizations. Section 3 reviews the desktop metaphor and discusses its shortcomings in the light of the changed requirements distilled in Section 2. It also reviews an exemplary set of alternative solutions to the desktop scenario. Section 4 presents infotop. Section 5 summarizes the main findings and presents an outlook to possible future developments.

## 2 Knowledge work

Knowledge is the key resource in today's knowledge-intensive organizations. It changes production functions in organizations significantly. It represents the key concept to explain the increasing velocity of the transformation of social life in general and the way businesses and social institutions work in particular (Drucker 1994). Consequently, knowledge workers have to be supported with an organizational and ICT infrastructure in which knowledge work can be handled more effectively and efficiently.

### 2.1 Traditional Work Versus Knowledge Work

There is a trend towards more complex problem-solving services where the majority of employees are well educated and creative, self-motivated people. Employees' roles and their relationships to organizations have changed dramatically with knowledge workers replacing industrial workers as the largest group of the work force. Consequently, businesses should no longer be seen from an industrial, but from a knowledge perspective (Sveiby 1997, 26). This is reflected by a share of 60% of US organizations that think that between 60% and 100% of their employees are so-called knowledge workers (Delphi 1997, 10). Knowledge work can be characterized by a high degree of variety and exceptions and requires a high level of skill and expertise. Knowledge work requires that knowledge is continuously revised, and considered permanently improvable, not as truth, but as a resource (Willke 1998, 21). Knowledge workers gain more and more influence in organizations because businesses focus on knowledge and their holders as key competitive factors.

The increasing specialization means that knowledge workers have to work together in various kinds of groups and teams, which differ in their social structure and interactions. An organization provides the frame to bring together people holding specialized knowledge to be jointly applied to accomplish a task (Drucker 1994). This gives rise to organizational competency or, in other words, complex knowledge shared in intra- and inter-organizational networks of knowledge workers. Virtual teams, expert networks, best practice groups and communities complement traditional organizational forms such as work groups or project teams and aid collaboration between knowledge workers within and increasingly across organizations.

## 2.2 Knowledge Management

Success of an organization is dependent on taking these changed requirements into account. An organization has to create an effective environment for knowledge generation and application and depends on the knowledge and talent it can recruit, develop and retain in order to provide value innovation (Kim 1999, 41). Consequently, organizations need concepts and instruments that help them to establish such an environment. KM promises guidance in this matter and therefore has recently received increasing attention from a variety of fields and disciplines, see e.g. (Maier 2002).

KM can be defined as the management function responsible for regular selection, implementation and evaluation of goal-oriented knowledge strategies that aim at improving an organization's way of handling knowledge internal and external to the organization in order to improve organizational performance. The implementation of knowledge strategies comprises all person-oriented, organizational and technological instruments suitable to dynamically optimize the organization-wide level of collective competencies, education and ability to learn (Maier 2002, 48). KM initiatives can be described with the help of four levels of intervention:

- strategy: KM strategy and goals
- organization: roles, tasks and organizational culture
- contents and systems: KMS architecture, contents and functions
- economics: evaluation areas and evaluation categories

Moreover, recently process orientation has been viewed as a good starting point for formulating knowledge strategies and for redesigning the organizational and the ICT environment for KM (Maier 2002a). These levels of intervention can play a crucial role in the design of a knowledge environment for knowledge workers.

## 2.3 Knowledge Management Systems

Modern ICT tools and systems provide sophisticated functions for publication, organization, visualization, contextualization, search, retrieval and distribution of knowledge as well as functions supporting communication, cooperation and linking of individuals in networks. The situation as found in many organizations is that there is an advanced ICT infrastructure in place. This is regularly a solution based on a set of Internet technologies or based on a groupware platform like Lotus Notes. Consequently, knowledge workers are increasingly supported by advanced ICT systems. The ever-increasing pace of innovation in the field of ICT support for organizations has provided numerous technologies ready to be applied in organizations to support these approaches. Examples for information and communication technologies that are related to KM include Intranet infrastructures, document and content management systems, workflow management systems, business intelligence tools, visualization tools, groupware and e-learning systems.

A KMS promises significantly enhanced functionality through an integrated combination of a substantial portion of the information and communication systems from a KM perspective. It should not be seen as a voluminous centralized database, but rather as large networked collections of contextualized data and documents linked to directories of people, roles and skills. A KMS provides intelligence to analyze these documents, links, employees' interests and behavior, offers support for personalized

access to the knowledge base as well as advanced functions for knowledge sharing and collaboration. Figure 1 gives an overview of an ideal KMS architecture.

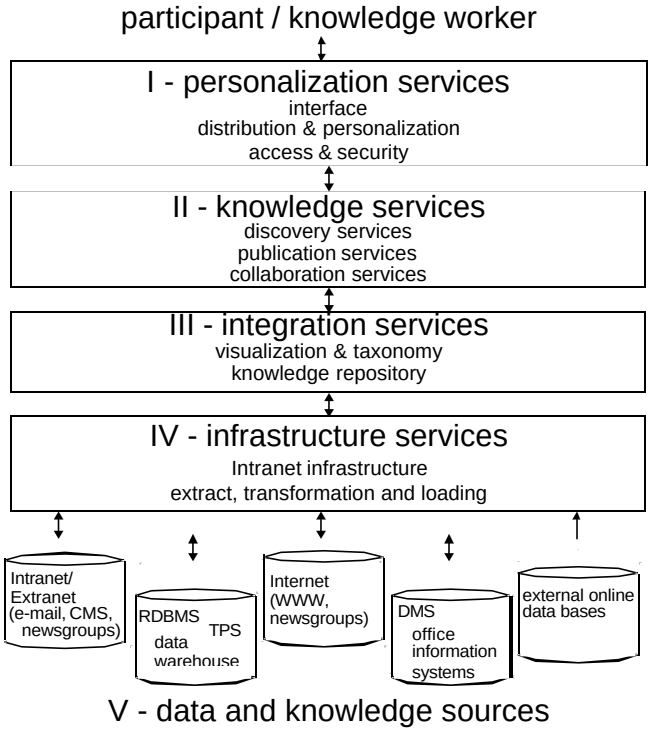


**Figure 1: KMS architecture, for details see (Maier 2002, 195)**

A knowledge worker accesses the organization's KMS with the help of personalization services (I), a variety of interfaces, such as a web browser, a personal digital assistant, or a mobile phone. The KMS has to be protected by access and security services. Knowledge workers have personalized access with interest profiles, personal category nets and personalized portals. The core knowledge processes—search and retrieval (discovery), publishing and collaboration—are supported by knowledge services (II) which are key components of the KMS architecture. Knowledge services work on the basis of integration services (III), e.g., a knowledge repository which handles the organization's knowledge elements and meta-knowledge as well as knowledge maps and directories that are required to visualize knowledge elements and relate them to knowledge workers. These layers are based on infrastructure services (IV), an Intranet infrastructure which provides basic functionality for messaging, teleconferencing, data (file server) and web content management as well as extract, transformation and loading tools which can be viewed in analogy to a data warehousing architecture. The data and knowledge sources (V) give some examples of the wide variety of electronic sources which have to be integrated into a KMS.

### 2.4 Enhanced Support for Knowledge Work

Current KMS implementations are rather technocratic and document-centered infrastructure-oriented solutions. Thus, they are limited to the lower levels of Figure 1.

Personalization services, easy access as well as integration into daily work practices are missing. Knowledge workers access knowledge services with the help of a number of isolated applications, such as a web browser, the desktop, a mailing system, office systems and a Groupware client.

The efficient and effective use of a KMS, which is smoothly integrated with an organization's (knowledge-intensive) business processes, requires a systematic redesign of personalization services, see Figure 1. Knowledge workers need a personalized knowledge environment that allows for an integrated multi-perspective view on knowledge services, on collections of contents and networked fellow knowledge workers as part of the organizational knowledge base. From the concept of a process-oriented strategic KM initiative we can derive some of the perspectives required, see (Maier 2002, 134):

- organization: structure, business, work and knowledge processes (and projects), people and roles, groups, teams and communities,
- contents: types of contents / media, topics, knowledge structures, ontologies,
- systems: formats, integration of document, messaging, personal information, office, Groupware and KMS applications.

In the following section, we will review the desktop metaphor as the prevalent paradigm used to design the workspace of a personal computer and challenge it by the requirements of knowledge work.

## 3 The Desktop Metaphor

A metaphor is one thing conceived as representing another. Using metaphors takes advantage of peoples' knowledge about them. For example, people in offices have been used to store paper documents in file folders. It makes sense to these people to store computer documents in folders on the computer, i.e., in containers that look and behave like folders. The desktop is the primary metaphor being used as interface on our computers. The desktop metaphor was introduced when computers were quite different to today's machines, see (Genter 1996). While computers, users and the environment have changed, interfaces and the basic handling of data have stayed the same. Today, the situation is quite different with professional users in addition to novices, a wide range of applications including web applications, rich resources, permanent network connections, and comprehensive communication features. The desktop has become an unmanageable mess (Tristram 2001). Countless files are stored on increasingly more capacious storage drives. This has resulted in big hierarchies of folders that make it hard to retrieve information.

### 3.1 Problems with the Desktop

In this section we describe several situations that we face in everyday knowledge work, but that are not supported well by the desktop metaphor, e.g., document handling, especially web documents, e-mail messages, and appointments. From these everyday situations, we infer basic shortcomings of the desktop that we will need to address for a better interface for knowledge workers: isolation, loss, and plurality.

### *3.1.1 Isolation*

Most people have different ways of working with a computer. They arrange items on the desktop differently, they build folder hierarchies according to different criteria, they use tools in different ways, and they use different tools simultaneously. When we work on our computer, we always have at least three applications running, i.e., a calendar, an e-mail tool, and a web browser. This helps us in accessing appointments, addresses, notes, e-mail messages, and documents on the Internet conveniently at any time, in addition to accessing the documents we have on our local computer. This habit seems to be quite usual, even though habits differ. Taking a closer look, it turns out that this habit compensates for an intrinsic deficit of the desktop. This deficit stems from the fact that we simply do not have a unified document model. Rather, we have different forms of documents that are treated differently and that do not have sufficient meta-information to allow for efficient archival and retrieval.

Additionally, we use different categorization mechanisms. We have various categories to organize our addresses and notes of our palmtop. We have different categories to organize incoming and outgoing e-mail messages. Yet another categorization is used for the organization of our favorite web sites. The folder hierarchy on our local disk provides an additional form of organizing our local files. These are four different, isolated categorization mechanisms with information that logically belongs together.

### *3.1.2 Loss*

The other day we came back home from a conference. A few days later we received an e-mail message from another conference attendee, a couple of images attached that she had taken at the conference with her digital camera. How are we going to handle this simple situation in case we do not want to delete this message and the attached images? Where are we going to keep the information? We can either keep the message in the mailing system or we can save both the message and the images in our local folder hierarchy. But where should we put it such that we will be able to find that information again later? The current desktop model does not offer a convenient solution to this simple situation, even if we constrain ourselves to a certain habit, for example to save all files in a folder, for this person/event/project/date. What we want is that existing associations will not be lost. Such associations exist among messages with the same subject, between messages and their attachments, between messages and senders/receivers, etc.

The situation with web documents is somewhat similar to local documents and messages in the e-mail system. Suppose we do a literature search, say at the digital library of ACM. We may find several papers that we are interested in and we can download them in PDF format. We may store them in a specific folder with names from the library that may not be useful in finding a specific article again, or we may cumbersomely create our own names. Anyway, we have to perform several activities by hand in order not to lose information.

### *3.1.3 Plurality*

When we created the first version of this paper, we added v0.0 to the name of the document and later increased this version number whenever we made substantial modifications. Typically, we increase the version number once a day, such that we have older versions available on a daily basis. When writing a paper, like this one,

there are usually 10 to 15 iterations until a first release version is ready. Later, for example when the paper has been accepted for publication, we delete earlier versions. We could use a program administrating different versions of our documents. However, we do not want to have yet another application involved, e.g., a document management system. Rather, we wish not to worry about versions and arbitrarily be able to step back in the modification history.

It is also quite common to have different representations of the same document. When we create a document we may use MsWord. Some figures may be included that were drawn with an application other than MsWord. When finished, a postscript version, a PDF version and an HTML version of the document may be created. These are different documents in our desktop folder hierarchy. Typically, all these documents will be kept in a single folder and named similarly to indicate their belonging together. Whenever the "root document" is changed, all the corresponding representations have or should be recreated. Thus, the original document, e.g., the MsWord document, is modified first and the other documents have to be created again with the new MsWord document as input.

### 3.2 Alternatives to the Desktop

Shortcomings of the desktop were discussed in the past section. In this section we will review some of the alternatives and enhancements that have been presented in the literature. These approaches do not necessarily tackle all the problems mentioned above, but provide important first steps in finding a solution to these problems.

*Lifestreams* uses a time-ordered stream of documents rather than conventional files and folders (Fertig 1996). Incoming information is organized, located, summarized and monitored by stream filters and software agents. Each document that is created is also stored in a lifestream which functions as a diary. *Time-Machine Computing* is another time-centric approach and has been proposed in (Rekimoto 1999). Four key features characterize time-machine computing, i.e., lifelong archival of information history, chronological navigation over archived information (time-traveling), visualization of time in different ways, and inter-application communication of time (time-casting). *Presto* is an approach to overcome hierarchical filing structures as the basis for organizing, storing and retrieving documents (Dourish 1999). It is a prototype document management system that provides rich interaction with documents through meaningful, user-level document attributes. A uniform document model is provided for arbitrary kinds of documents to which attributes with arbitrary names and values can be attached.

*Hyperbolic browsers* provide a three-dimensional visualization of knowledge as networks of knowledge elements, e.g., TheBrain (www.thebrain.com). TheBrain is an associative information organization system, in which any piece of information can be linked to any other piece. The power lies in the flexibility of these links. Each item triggers related items and brings relevant information together. Items represent files, web pages or database records. *Data Mountain* uses spatial memory for document management (Robertson 1998). It had been used to serve as an alternative to the favorites mechanism of the Microsoft Internet Explorer. *DLITE* is a system with a user interface to a digital library based on a metaphor called ‚workcenters' (Cousins 1997). *TopicShop* is an interface that helps users to evaluate and to organize collections of web sites (Amento 2000). The result is an interface that is based on language, a rich representation of objects, expert users, and shared control.

### 3.3 Résumé

We have used the terms isolation, loss and plurality in order to categorize problems we face with the traditional desktop metaphor. Among other things, these problems are derived from the facts that

- we have a hierarchical folder structure on our desktop rather than a flexible means of categorization,
- we have trivial and multiple categorization mechanisms in various applications, e.g., Palm Desktop, Netscape Messenger, Internet Explorer,
- we have information that is only accessible via specific applications, e.g., e-mail messages, appointments, addresses,
- we have versioning information available only with specific applications,
- we have multiple documents that are different representations of the same contents, and that
- we have insufficient meta-information about local and remote documents.

Desktop alternatives have shown that time is an important facet in organizing information and in overcoming inflexible, hierarchical filing structures. We argue that additional, uniform categorization mechanisms as well as multiple hierarchies are needed for efficient information retrieval. Additionally, we identify the facets topic, location, person, process and type as being essential for the provision of an effective environment for knowledge workers.

## 4 Infotop – Desktop of the Future

Rather than having a desktop with a hierarchic folder view, we propose infotop with multiple views on documents and a much more powerful way of accessing information. Infotop can be implemented on top of today's file systems, but in this paper we will refrain from implementation aspects and concentrate on the concepts. Two perspectives have to be considered.

- *Island approach*: can be applied to a single computer and a single knowledge worker. This computer may be connected to other machines, but there is no extra communication in support of the island approach.
- *General approach*: comprises many knowledge workers who use infotop and, thus, can benefit from advanced features and shared context when communicating and working together.

In a first step, we will concentrate on the island approach, as this is the only practical way of making improvements to our imperfect world. In addition, upward compatibility is a necessity in order to consider a shift to our proposed approach. Therefore, today's desktop metaphor with files and folders should be a special case or view of infotop. Subsequently, we will describe the island approach of infotop.

### 4.1 Dimensions

Business intelligence software allows users to quickly analyze data that has been transformed into a subject-oriented, multidimensional data warehouse (Inmon 1992). Online analytical processing (OLAP) tools are used to perform trend analysis and

statistics on e.g., sales and financial information in an interactive question-answer way. As mentioned before, we identify time, topic, location, person, process and type as the essential dimensions for effective categorization, visualization and navigation of collections of contents. In analogy to OLAP techniques, we suggest using these dimensions for slicing, dicing, drilling down, rolling up, and ranging operations on contents of a personal knowledge environment:

- *time*: any representations with a timed order
- *topic*: any topics a user is interested in
- *location*: any geographic location like a city or country; local vs. lan vs. web
- *person*: any person, physical or not, e.g., a company
- *process*: any project or process, e.g., a conference, a paper writing process, an administrative task with many steps
- *type*: any type of document, e.g., text document, MsWord document

Figure 2 shows a simple one-dimensional view, where documents are shown that belong to various topics. On the right side there are six buttons that can be used to switch to different dimensions and to select sets of documents that are displayed in these dimensions. The pile metaphor (Mander 1992) can be used to display information about sets of documents. Additionally, the numbers of documents are indicated for each displayed topic. Visualization techniques like the well-known icons, thumbnails or lists are useful when displaying sets of documents. We can arbitrarily define several hierarchies of any of these dimensions and use them for display, e.g., in case of the dimension person the three hierarchies author, sender, receiver. One simple hierarchy for topics can be seen in Figure 2. Views may be restricted to documents with specific attributes, e.g., documents of a specific process or documents of a specific age. In Figure 2, only documents of type html are displayed.

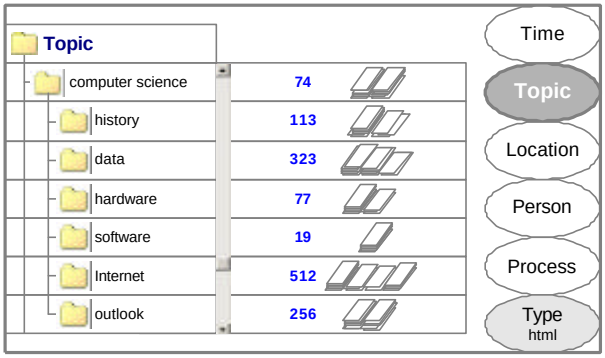


**Figure 2: One-dimensional View**

### 4.2 Time

Time is one of the most crucial attributes of documents, e.g., time of creation, time of last modification, time of last read only access. Usage statistics may also be useful, such that frequently used documents can stand out. Figure 3 shows documents assigned to the topic knowledge management that have a relation with the ECKM 2002 conference in a calendar view. The time of last modification is considered for the dis-

play. Clicking one of the days will bring up information about all documents, i.e., icons or a list with detailed information.

Apart from the usual appointments it is useful to have e-mail messages, text documents and other forms of documents, e.g., comments, yellow stickers, displayed in calendars. It is also useful to display a selection of documents, e.g., we may want to see all documents related to a project displayed in the calendar, or all documents of a person, i.e., all e-mail messages from and to that person, all files exchanged with that person, all web documents about that person that we have visited, etc.

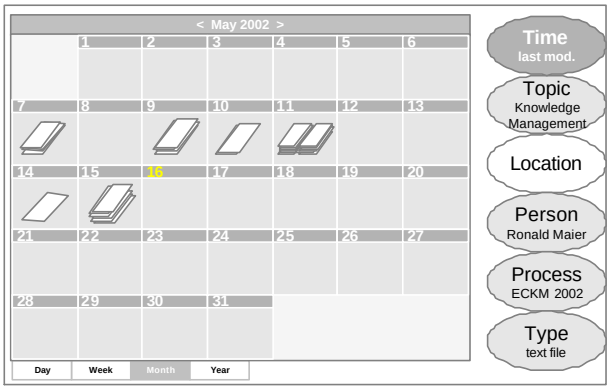


**Figure 3: Calendar view of documents**

### 4.3 Multi-dimensional views

We have mentioned that OLAP tools, for example, enable users to interact with multitudes of statistics in order to isolate specific items. We intend to use similar mechanisms to browse, navigate and filter information. The hierarchies can be used for this purpose. For example, we can select the two dimensions *process* and *person* for viewing, see Figure 4. Six dimensions enable us to select documents in one hierarchy and display this selection in another hierarchy. For example, we may want to select all Austrian documents, i.e., documents with location= Vienna, location= Linz, or location= any other Austrian location, and then display the documents according to a hierarchy based on persons. We should see associations of persons to locations.

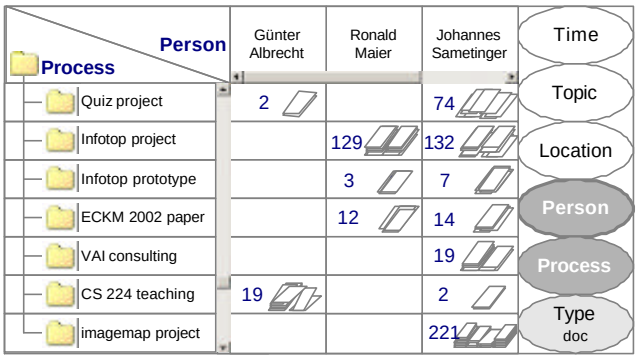


**Figure 4: two-dimensional view**

### 4.4 Meta-Data

For efficient document retrieval and for grouping of documents, categories have to be associated with documents. Attributes have to be assigned with documents. This can become a nuisance to the user, because she may not want to manually categorize each incoming and outgoing e-mail message, or each web page that she has visited. Therefore, we need an automated, or at least a semi-automated approach for this task. We imagine different attributes that should be defined for each document, e.g., title, author, date, event, location, person, process. Each attribute of a document has an undefined or a defined value, e.g., location= Dublin, date= 9/25/2002. We define one or more value sets, which we can easily switch when working on different processes. The meta-data can easily be extracted from context that comes with a document or the activities that are performed on a document, e.g. in the case of an e-mail message we can derive sender, receiver (person, location), date (time), subject (topic, process) and type of attached file (type).

## 5 Conclusion

We have discussed the changed requirements that knowledge workers have on their personal knowledge environment and motivated to replace the desktop metaphor by infotop, a multi-dimensional view to knowledge-in-flow. Infotop consists of the six dimensions time, topic, location, person, process and type. They were derived as essential perspectives on collections of contents of organizational knowledge bases.

Currently, we work on the implementation of a prototype that will show the look and feel of such an environment. It is important to include multiple ways to visualize the structure of elements in the dimensions, such as hierarchies, networks (knowledge maps) and geographical information systems in order to meet individual visualization needs. Another promising direction for future research is how to integrate personal KM techniques, e.g., portfolios, visualization of an individual knowledge worker's knowledge status, learning and networking needs, with corporate KM instruments, e.g., content management, yellow pages, communities, project staffing or competence development programs. We see infotop's role as an enabler and catalyst to spark usage of corporate KMS solutions and start a positive, reinforcing cycle of more and more active, motivated participants handling knowledge in organizations.

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