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ABSTRACT

This paper discusses the use of mobile applications in knowledge management (mobile KM). Today more and more people leave (or have to leave) their fixed working environment in order to conduct their work at changing locations or while they are on the move. At the same time mobile work is getting more and more knowledge-intensive. However the issue of mobile work and knowledge management is an aspect which has largely been overlooked so far.

Based on requirements for mobile applications in KM an example for the implementation of a mobile KM portal at a German university is described. The presented solution offers various services for university staff (information access, colleague finder, campus navigator, collaboration support). The paper is concluded by outlining an important future issue in mobile KM: The consideration of location-based information in mobile KM portals.

Keywords

Mobile Knowledge Management, Portal, Knowledge Management, Location-Orientation

INTRODUCTION

Today many working environments and industries are considered as knowledge-intensive, i.e. consulting, software, pharmaceutics, financial services, etc. Knowledge Management (KM) has been introduced to overcome some of the problems knowledge workers are faced when handling knowledge, i.e. the problems of storing, organizing and distributing large amounts of knowledge and its corresponding problem of information overload etc. Hence, KM and its strategies aim at improving an organization's way of handling internal and external knowledge in order to improve organizational performance (Maier, 2004).

At the same time more and more people leave (or have to leave) their fixed working environment in order to conduct their work at changing locations or while they are on the move. Mobile Business tries to address these issues by providing (mobile) information and communication technologies (ICT) to support mobile business processes. However, compared to desktop PCs typical mobile ICT, like mobile devices such as PDAs and mobile phones have some disadvantages (Hansmann et al., 2001):

- Limited memory and CPU – Mobile devices are usually not equipped with the amount of memory and computational power in the CPU found in desktop computers.
- Small displays and limited input capabilities – for example entering a URL on a web-enabled mobile phone is cumbersome and slower than typing with a keyboard.
- Low bandwidth – in comparison to wired networks wireless networks have a lower bandwidth. This restricts the transfer of large data volumes
- Connection stability – due to fading, lost radio coverage, or deficient capacity, wireless networks are often inaccessible for periods of time.

Taking into account the aforementioned situation one must question whether current IT support is already sufficient in order to meet the requirement of today's knowledge-intensive mobile work environments. So far, most of the off-the-shelf

knowledge management systems are intended for the use on stationary desktop PCs and provide just simple access from mobile devices. As KMS are generally handling a huge amount of information (e.g. documents in various formats, multi media content, etc.) the management of the restrictions described above becomes even more crucial. In addition, neither an adaptation of existing knowledge services of stationary KMS nor the development of new knowledge services according to the needs of mobile knowledge workers are taking place.

The goals of this paper are to identify the main issues when mobile work is meeting knowledge management. In particular the focus lies on mobile knowledge portals, which are considered to be the main ICT to support mobile KM. Further on the applicability of these suggestions is shown with the help of a mobile knowledge portal that was implemented at a German university.

The paper is structured as follows: Section two will detail the understanding about mobile knowledge management and derive important requirements to be fulfilled. In section three mobile knowledge portals are then described as main ICT to support tasks in mobile KM. As an example the mobile KM portal of the University of Regensburg is presented (section four) whereas section five shows location-orientation as the next step in mobile KM. Finally, section six concludes this paper and gives an outlook on future research issues within the field of mobile KM.

KNOWLEDGE MANAGEMENT MEETS MOBILE WORK

A mobile working environment differs in many ways from desk work and presents the business traveller with a unique set of difficulties (Perry et al., 2001). Throughout the last years several studies have shown that mobile knowledge workers are confronted with problems that complicate the fulfilment of their job (Figure 1).
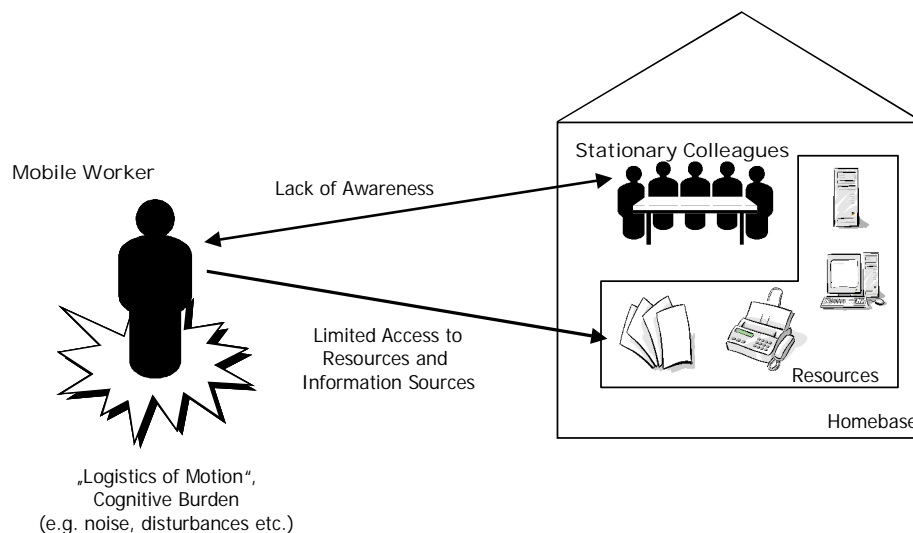

Figure 1. Problems related to mobile work.

Mobile workers working separated from their colleagues often have no access to the resources they would have in their offices. Instead, business travellers for example have to rely on faxes and messenger services to receive materials from their offices (Schulte, 1999). In case of time-critical data, this way of communication with the home base is insufficient. Bellotti and Bly (1996) show in their survey about knowledge exchange in a design consulting team that it is difficult for a mobile team to generally stay in touch. This is described as "Lack of Awareness". It means that a common background of common knowledge and shared understanding of current and past activities is missing. This constrains the exchange of knowledge in teams with mobile workers. In addition, mobile workers have to deal with different work settings, noise levels and they have to coordinate their travelling. These "Logistics of Motion" lowers their ability to deal with knowledge-intensive tasks (Salvador/Sherry 2001) while on the move. The danger of an information overflow increases.

Mobile Knowledge Management is an approach to overcome these problems. Rather than adding to the discussion of what actually is managed by KM – knowledge workers, knowledge or just information embedded into context – in this paper mobile KM is seen as KM focusing on the usage of mobile ICT in order to (Berger, 2004, p. 64):
- provide **mobile access** to Knowledge Management Systems (KMS) and other information resources.

- generate **awareness** between mobile and stationary workers by linking them to each other.
- realize **mobile KM services** that support knowledge workers in dealing with their tasks.

The next section reviews the state of the art of KMS and assesses if these requirements are met.

MOBILE KNOWLEDGE MANAGEMENT PORTALS

Currently, many knowledge management systems (KMS) are implemented as centralized client/server solutions (Maier, 2004) using the portal metaphor. Such Knowledge Portals provide a single point of access to many different information and knowledge sources on the desktop together with a bundle of KM services. Typically, the architecture of knowledge portals can be described with the help of layers (Maier, 2004).

The first layer includes data and knowledge sources of organizational-internal and external sources. Examples are database systems, data warehouses, enterprise resource planning systems, content and document management systems. The next layer provides intranet infrastructure and groupware services together with services to extract, transform and load content from different sources. On the next layer integration services are necessary to organize and structure knowledge elements according to a taxonomy or ontology.

The core of the KMS architecture consists of a set of knowledge services in order to support discovery, publication, collaboration and learning. Personalization services are important to provide a more effective access to the large amounts of content, i.e. to filter knowledge according to the knowledge needs in a specific situation and offer this content by a single point of entry (portal). In particular, personalization services together with mobile access services become crucial for the use of KMS in mobile environments.

Portals can be either developed individually or by using off-the-shelf portal packages, such as Bea WebLogic, IBM Portal Server, Plumtree Corporate Portal, Hyperwave Information Portal or SAP Enterprise Portal. Most of these commercial packages can be flexibly customized in order to build up more domain-specific portals by integrating specific portal components (so called *'portlets'*) into a portal platform. Portlets are more or less standardized software components that provide access to various applications and (KM) services, e.g. portlets to access ERP-systems, document management systems, personal information management and such like.

In order to realize mobile access to knowledge portals, portlets have to be implemented as mobile portlets. That means that they have to be adapted according to technical restrictions of mobile devices and the user's context. At the moment, commercial portal packages cannot sufficiently fulfil the needs of mobile KM. Most of the systems are enhanced by mobile components, which are rather providing mobile access to stationary KM services instead of implementing specific mobile KM services.

Hyperwave´s WAP (Wireless Application Protocol) Framework for example enables mobile users to browse the Hyperwave Information Portal with WAP-enabled devices. The Wireless Suite of Autonomy is a WAP-based solution with the focus on awareness-generating features such as 'people finder' and community support.

At present, the arguably most comprehensive support for mobile KM seems to be provided by the Livelink portal from Opentext Corporation. With the help of the Wireless Server users can access discussion boards, task lists, user directories (MS Exchange, LDAP, Livelink User Directory), E-Mails, Calendar and documents (Figure 2). In addition, it provides some KM services specially developed for mobile devices, e.g. automatic summarization of text. Hence even longer texts can be displayed on smaller screens (Figure 3).
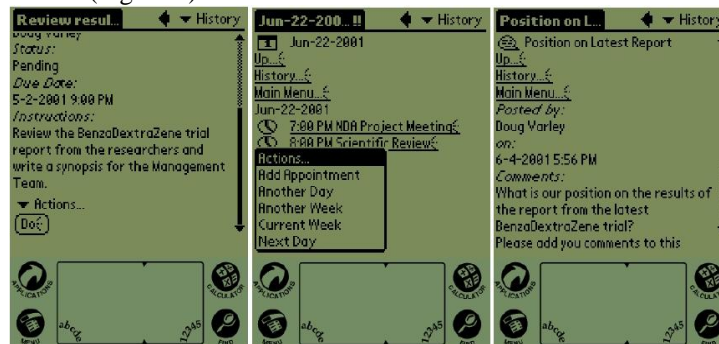

Figure 2. Tasklist, Calender and Discussion Board of Opentext´s Livelink Wireless (Opentext 2003, p. 12)

Figure 3. Automatic Text Summarization (Opentext 2003, p. 11)

EXAMPLE: A MOBILE KNOWLEDGE MANAGEMENT PORTAL AT THE UNIVERSITY OF REGENSBURG

In recent years the German universities, which are financed to a large extent by public authorities (federal states and federal government), have been severely affected by public saving measures. As a result lean, efficient administrative procedures are more important than ever. KM can help to achieve these objectives. One example is to provide easy access to expert directories, where staff members with certain skills, expertise and responsibilities can be located (e.g. "Person X is responsible for Third-Party-Funding") in order to support communication and collaboration.

However, there are several reasons why the access to information of this type is limited at the University of Regensburg. First, there is the hierarchical, but decentralized organizational structure. All together about 1.000 staff members are working in 12 different schools and about 15 research institutes at the university, serving for about 16.000 students. As most of the organization units are highly independent they have their own administrations and the exchange of knowledge with the central administration is reduced to a minimum. Likewise there is hardly an exchange of knowledge between different schools and departments. As a result knowledge, which would be useful throughout the whole university, is limited to some staff members ("unlinked knowledge", Figure 4).
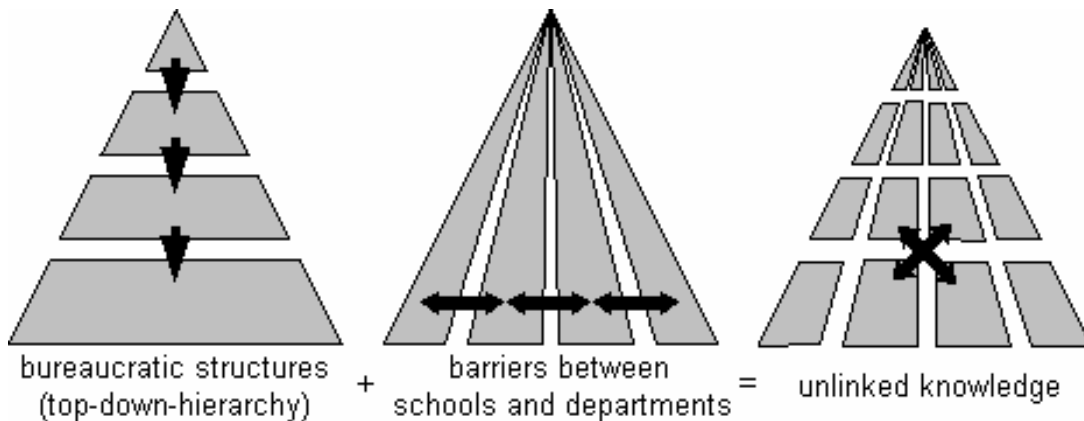

Figure 4. Unlinked knowledge because of independent organization structures

A second problem is that many scientific staff members work on the basis of (short-term) time contracts. This leads to an increasing annual labor turnover, comparable to the situation that consulting companies are facing. Important knowledge about past projects, courses and scientific results is lost very easily. Due to this fact a high proportion of (new) staff members are relatively inexperienced to cope with administration processes, which can be described as highly bureaucratic and cumbersome.

To overcome these problems – the lack of communication between departments and the need to provide specific knowledge (i.e. administrative knowledge) for staff members – the University of Regensburg decided to build up a Knowledge Portal called U-Know (Ubiquitous Knowledge). U-Know is meant to be a single point of access for all relevant information according to the knowledge needs described above. When conducting a knowledge audit it became obvious that a large amount of knowledge is needed when knowledge workers are on the move, i.e. working in a mobile work environment. Staff is frequently commuting between offices, meeting rooms, laboratories, home offices, they visit conferences, and sometimes they are doing field studies (e.g. biologists or geographers).

Hence the picture of one single resource rich office has to be extended towards different working locations, where a large number of knowledge-intensive tasks are carried out as well (Figure 5). Consequently the considered solution should meet these "ubiquitous" knowledge needs of current work practices at a university.
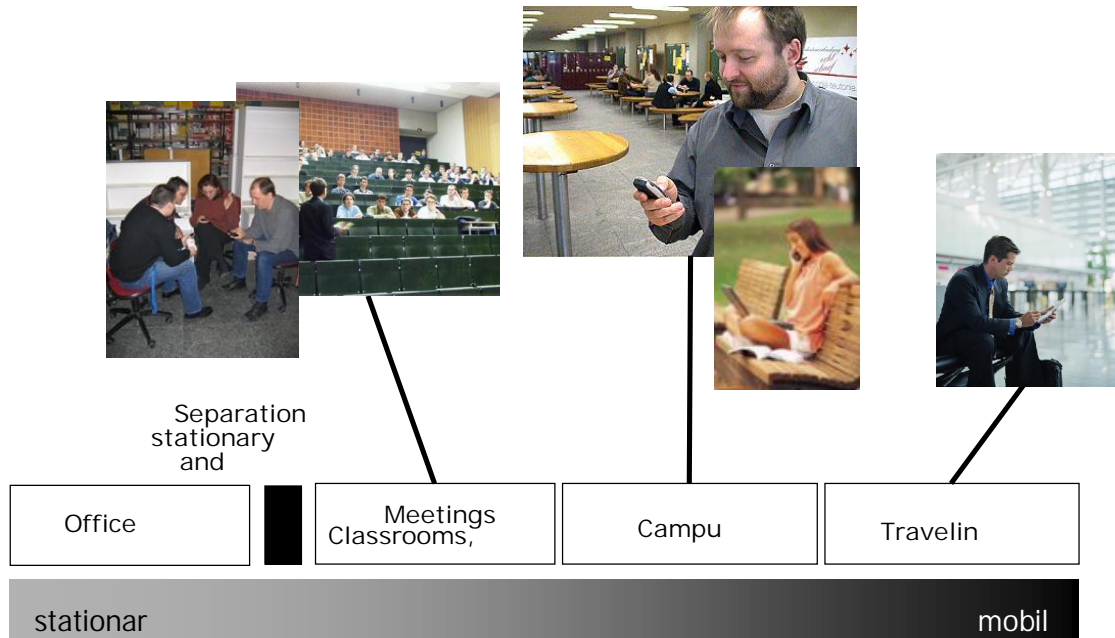

Figure 5. Knowledge Demand in "mobile" situations

The portal should support staff members by managing:
- **Documented knowledge**: A knowledge audit was conducted in order to get a better picture of knowledge demand and supply. This was mainly done with the help of questionnaires and workshops where staff members were asked to assess what kind of (out of office) information is considered as useful.
- **Tacit knowledge**: In order to support the exchange of tacit knowledge (which is hard to codify, due to the fact that this knowledge lies solely in the employees' heads, often embedded in work practices and processes) the considered KM solution should enable communication and cooperation between staff members.

In order to meet these requirements U-Know should offer the following KM services (Figure 6):
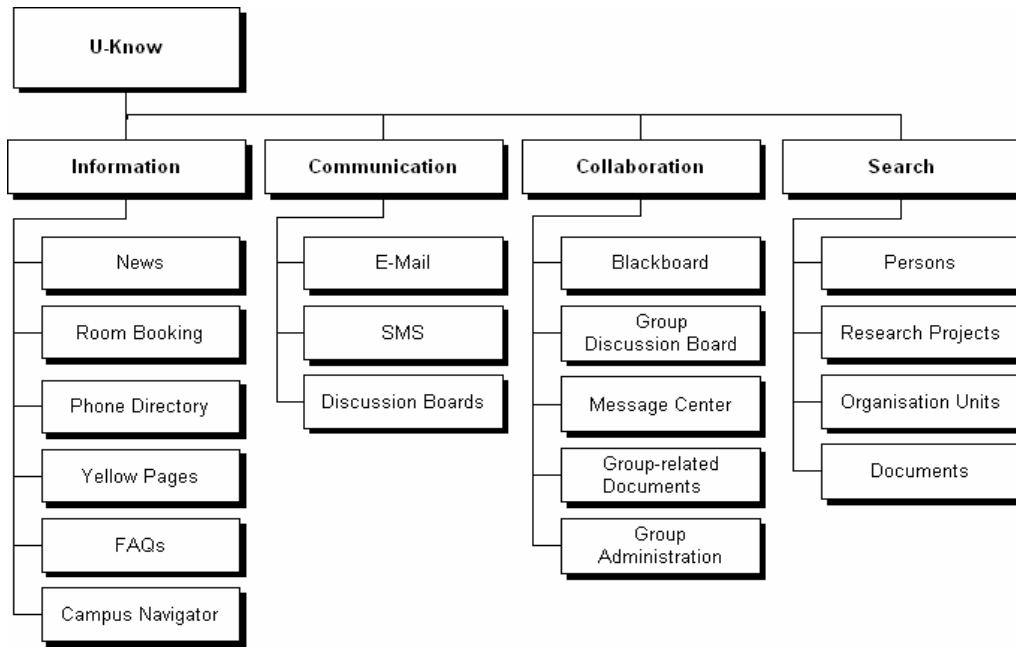
Figure 6. Features of U-Know

The services can be categorized into information, communication, collaboration and search. The first category comprises all services that are responsible to manage simple information in the knowledge base. By invoking these services staff members obtain the information they need to perform their daily tasks, e.g. news, notifications about changes in rooms or phone numbers. A very important part of this section are *'yellow pages'* (Figure 7) where all staff members are listed. This list can be browsed by names, departments, fields of research and responsibilities respectively.

Figure 7. U-Know 'Yellow Pages'

Frequently Asked Questions (FAQ) answer questions that are typically asked by new staff members. The Campus Navigator helps locating places and finding your way around the campus. Each room at the university carries a doorplate with a unique identifier. After entering a starting point in form of the identifier and a destination in form of the name of a person, of an office (e.g. "Office for Third-Party-Fundings", "Academic Exchange Service") or just another room number the shortest way to the destination is calculated and shown on maps of different sizes (Figure 8).
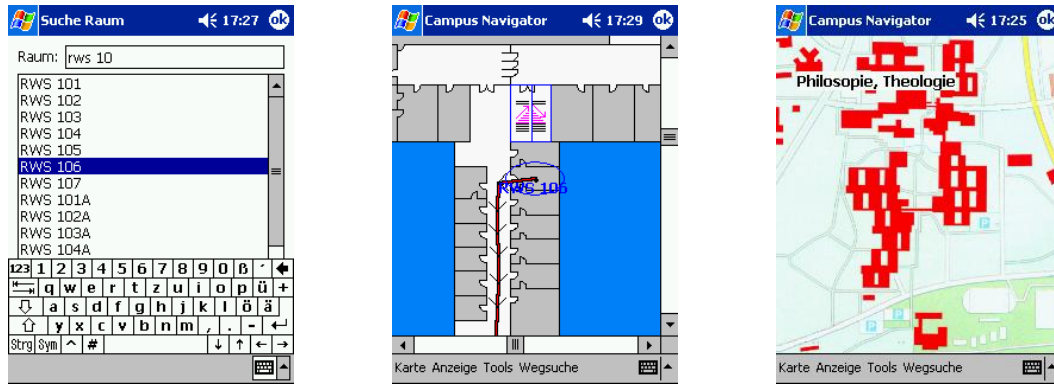
Figure 8. U-Know Campus Navigator

Communication-oriented features like E-Mail, Short Message Service (SMS) and Discussion Boards are intended to support the exchange of tacit knowledge between staff members.

To foster collaboration, e. g. in temporarily project groups, staff members can initiate workgroups by inviting colleagues via SMS or E-Mail to join a virtual teamspace. After forming a workgroup the participants can use their teamspace for (electronic) group discussions and sharing documents. The blackboard displays all recent events, including new group members, new files, discussion entries and administrative actions that are taken. In the search section queries can be limited to persons, research projects, organization units or documents.

To support different networks there are several ways to access the portal. University staff can use the campus-wide WiFi-network with WiFi-capable devices. Users can also deploy a mobile phone and access the portal via a GSM-network and the Wireless Application Protocol (WAP). Hence it is possible to use the portal even when users are outside the university, at a conference for instance. The phone directory or the yellow pages can be accessed via voice as the entry of longer words may be cumbersome in many situations. An integrated speech-recognition-system "translates" the user's spoken words into database requests and the results back into speech respectively.

LOCATION-ORIENTATION AS NEXT STEP IN MOBILE KNOWLEDGE MANAGEMENT

Generally, there is agreement about the distinction between human- and technology-oriented KM approaches which basically reflects the origin of the approaches. KM research should try to bridge the gap between human-oriented and technology-oriented KM. Many authors have propagated a so-called ''holistic'' approach to KM. However, so far these authors leave it to the interpretation of the reader what such an approach could look like. The examples in the last column of Table I should be seen as a step towards detailing this approach which is called ''bridging the gap'' KM. In Table I this classification (Maier, 2004, Maier/Remus, 2003) is enhanced towards the consideration of mobile KM. As mobile KM is mainly focusing on instruments and systems other dimensions like strategy, organization, and economics are not considered in this table.

In order to structure mobile KM one can distinguish two dimensions: mobile access and location-orientation. Mobile access is about accessing stationary KMS whereas location-orientation explicitly considers the location of the mobile worker. The field of location-oriented KM draws attention from research in mobile knowledge management, ubiquitous computing, location-based computing and context-aware computing (Lueg/Lichtenstein, 2003).

So far, the implemented solution provides mobile access to a broad range of different knowledge sources in a mobile work environment. University staff can use the KM services provided by U-Know in order to access information, to find colleagues, to navigate the campus, to collaborate, etc. These KM services mainly support the human-oriented KM approach. In fact, typical knowledge services were adapted with regard to the characteristics of mobile devices, i.e. small display, bandwidth, etc.

However, an adaptation of these services according to the user's location did not take place yet, whereas a customization of services according to the location of the user would enable a mobile Knowledge Portal to supply mobile knowledge workers with appropriate knowledge in a much more targeted way. At the same time, an information overload can be avoided, since only information relevant to the actual context and location is filtered and made available. Think of a researcher who is guided to books in a library according to his own references but also according to his actual location.

	Technology-oriented instruments and systems	Human-oriented instruments and systems	Bridging the Gap instruments and systems
Mobile Access	Mobile access to content, e.g. knowledge about organization (e. g. Campus Navigator), processes, products, internal studies, patents, online journals by using mobile devices focusing on services for presentation (e.g. summarization functions, navigation models) and visualization	Mobile access to employee yellow pages, skill directories, directories of communities, knowledge about business partners using mobile devices focusing on asynchronous E-Mail, Short Message Service (SMS) and synchronous communication (Chat), collaboration and cooperation, community support	Mobile access to ideas, proposals, lessons learned, best practices, community home spaces (mobile virtual team spaces), evaluations, comments, feedback to knowledge elements using mobile devices focusing on profiling, personalization, contextualization, recommendation, navigation from knowledge elements to people
Location-orientation	Adaptation of documented knowledge according to the user's current location	Locating people according to the user's location, e.g. locating colleagues, knowledge experts	Personalization, profiling according to the user's location and situation, providing proactive mobile KM services

Table 1: Mobile KM Approaches (grey highlighted cell is covered by U-Know)

Currently, common "stationary" Knowledge Portals are ill-suited to support these new aspects of KM derived form a location-oriented perspective (Berger, 2004). One reason is that the context, which is defined by the corresponding situation (tasks, goals, time, identity of the user) is still not extended by location-oriented context information (Abecker et al., 2002).

Location-oriented knowledge services could contribute to :
- **More efficient business processes**: shortcomings arising from mobility can be compensated by considering location-oriented information. Times for searching can be reduced due to the fact that information about the location might restrict the space of searching (e.g. an engineer might get information about a system that he is currently operating). Possibly, redundant ways between mobile and stationary work place are omitted when the information is already provided on the move.
- **Personalization**: When considering the user's location information can be delivered to the user in a much more customized and targeted way (Rao and Minakakis, 2003). For example an engineer in an production hall is seeking information about outstanding orders whereas close to machines he might need information about technical issues or repair services. In addition, location-oriented information might be helpful to locate other "mobile" colleagues that are nearby.
- **New application areas**: The integration of common knowledge services together with location-oriented mobile services may also extend the scope for new applications in KM, e.g. the use of contextual information for the continuous evolution of mobile services for mobile service providers (Amberg et al. 2003). One can also think of providing a more "intelligent" environment where information about the user's location combined with sophisticated knowledge services adds value to general information services (e.g. in museums, where customized information to exhibits can be provided according to the user's location).

To build up mobile Knowledge Portals that can support the scenario described above mobile portlets are needed that can realize location-oriented KM services. In case of being implemented as proactive services (in the way that a system is going to be active by itself) these portlets might be implemented as push services. In addition, portlets have to be responsible for the import of location-oriented information, the integration with other contextual information (contextualization) and the management and exploitation of the location-oriented information. Of course the underlying knowledge base should be refined in order to manage location-oriented information.

With respect to mobile devices one has to deal with the problem of locating the user and sending this information back to the Knowledge Portal. Mobile devices might be enhanced with systems that can automatically identify the user's location. Dependent on the current net infrastructure (personal, local or wide area networks), there are many possibilities to locate the user, e.g. WiFi, GPS or radio frequency tags (Rao and Minakakis, 2003) .

CONCLUSION AND OUTLOOK

The example of U-Know shows some important steps towards a comprehensive mobile KM solution. With the help of this system it is possible to provide users with KM services while being on the move. With its services like Yellow Pages, messaging features etc. it creates awareness among remote working colleagues and hence improves knowledge sharing within an organization.

With respect to the acceptance of U-Know two user groups can be distinguished. The first group is characterized by users who already own a mobile device, especially a PDA, in order to organize their appointments and contacts (Personal Information Management). They are the main users of the system because they perceive the additional KM-related services as an extension of the capabilities of their devices. In contrast, staff members that didn't use mobile devices for their Personal Information Management are more reluctant to adopt the new system.

The WiFi-access soon became the most popular way of accessing the system. This is because of several reasons. Most of the staff members are actually working on the campus and the WiFi-access is free of charge for university members. Another reason is probably the higher bandwidth (and therefore faster connections) of WiFi in comparison to a GSM-based access via WAP. Nevertheless, it can be assumed that decreasing connection fees and higher bandwidths of 3G-Networks (UMTS) would encourage staff to use the system from outside the university.

However, in order to fully meeting the requirements of mobile KM in the near future, mobile KM portals have to be enhanced with mobile knowledge services that consider location-oriented information. More applied research work is needed in the future to address the adaptation of mobile services, the consideration of the user and work context for KM and the design of highly context-aware knowledge portals.

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