Mobile Knowledge Management Toolkit

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Abstract: The transition towards a knowledge-based society triggers the need and pressure to learn continuously, yet the time available for learning is getting shorter and the knowledge gaps are widening. Knowledge management-enabling tools play a useful role in learning organizations, especially in an era when information overload is plaguing most organizations with an Intranet, enterprise resource planning, or business intelligence system. Mobile and wireless technologies and associated infrastructures improve significantly the access to knowledge at any time from any place through diverse and capable hand-held devices. The rapid development of mobile knowledge supports robust contributions to the development of knowledge communities. Building adaptive learning resources reconfigurable based on the device attributes and users' preferences represent a key research issue of mobile learning within organizations. The contribution of this paper consists in describing the similarities, differences and challenges recorded during the development process of a mobile knowledge management system that provides secure access to learning content for users situated in various mobile settings. In this respect, we shall present the implementation settings of the MOBNET-Learning Project developed by "Carol I" National Defence University in Bucharest in partnership with Advanced Technology Systems, the Research Institute for Artificial Intelligence of the Romanian Academy and two other private companies. The research domain of the project is advanced information systems for education and it has been financed through the "Partnership" national funding scheme. The MOBNET project aims to identify new opportunities to extend the lifelong learning arena of the educational and training systems through advanced information and communication technologies. This project addresses specific learning needs in terms of content, availability, and flexibility, with a stress on security due to the fact that it is implemented within the "Carol I" National Defence University. The authors propose a framework for an integrated mobile learning system that provides access to various mobile users, within formal or vocational educational systems, to knowledge databases in support of the Anyone, Anytime, Anywhere (AAA) paradigm. This mobile knowledge management system aims to capture and integrate the learner's feedback and to create the framework for an optimised virtual learning environment. The paper also takes into consideration the challenges and the limitations implied by the mobile world in terms of hand-held devices and mobile user interface design.

Keywords: Mobile knowledge management, hand-held devices, mobile user interface design, semantic web, HTTPS

1. Context and aims of the MOBNET-learning project

Developments in the information and communication landscape facilitate new strategies, optimised creation of knowledge, teaching with new methods and implementation of technology-rich projects. Recent studies carried out in regard to the use of information technologies in learning (Noveanu and Potolea, 2008; Istrate, 2009; Toma, Gabureanu, Fat and Novak, 2009; Tuncay, Stanescu and Uzunboylu, 2009) have reflected the interest of the Romanian teachers in implementing eLearning technologies in their teaching activities and in participating at training courses that can provide support for interacting with the new technologies. One of the studies (Tuncay, Stanescu and Uzunboylu, 2009) showed that 66% of the Romanian teachers that answered the questionnaire stated that their training needs refer to "mobile technology" and "wireless technologies". To meet these needs, developers have to provide teachers mobile content and software, as well as guidelines that facilitate the assimilation process.

MOBNET-Learning Project is developed in partnership by "Carol I" National Defence University in Bucharest, Advanced Technology Systems, the Research Institute for Artificial Intelligence of the Romanian Academy and two other private companies. The Project is entitled "Research regarding the design of an experimental model of a mobile learning-type virtual network with real time access to knowledge and learning, using communication technologies and wireless terminal devices" and aims

to provide flexible access to content and knowledge based on the translation of business approaches into the learning environment and the promotion of the concept of "*just-in-time knowledge*". One of the aims of the project is to develop a mobile knowledge management system, as a framework of practice for teachers and trainers that would like to integrate mobile technologies in their course environment.

Figure 1: The project's website

The aim of this paper is to present the development process of such a system, in order to make it more accessible, more user-friendly and adapted to the mobile arena. The paper is based on the findings of the main analyses carried out within the MOBNET Project that refer to fundamental research on the mobile learning and the net-centric concepts, and also on their applications in education and knowledge management; research on the virtual educational network based on mobile technologies; scientific research on standardised digital content for multi-usage; the report between learning object and learning management system; study on the current state of mobile Web services development; the European market of services based on mobile technologies; study on the domain of applicability of mobile services in an information and knowledge society; restrictions and perspectives. The research was carried out to support the demo version of the mobile knowledge management system, where users will be able to practice and share their feedback on their mobile experiences. This approach is based on Awareness – Acceptance – Action (AAA) paradigm, through which the results of the MOBNET Project can be adapted to the users' expectations and requirements. The paper includes a comparison of the similarities and the differences between a desktop web-based knowledge management system and a mobile knowledge management system, and points out the opportunities and challenges of the mobile life in terms of content delivery and security.

2. The transition to the mobile web experience

The analyse on the market potential of mobile devices showed that the number of personal portable devices sold each year has increased rapidly in the last decade; cell phones are ubiquitous and industry analysts indicate that cellular phones are outpacing personal computers at a rate of 5 to 1 (Stănescu and Ştefan, 2008). Research shows that the abilities, the knowledge and the preferences of mobile users are extremely diverse and mobile users keep wanting new features on their phone, from texting, browsing, multimedia and even knowledge, because they like these things in their pocket and the phone is already there (Shearer, 2007; Stănescu and Ştefan, 2009). This reality requires new approaches that facilitate and sustain the implementation of the potential of advances in technology.

Mobile phones represent a controversial part of the educational landscape. Research (Smith, 2007; Stănescu and Ştefan, 2008; Istrate, 2009; Toma, Gabureanu, Fat and Novak, 2009;) shows that most teachers and trainers are becoming aware of their learning potential The computing power of mobile devices is rapidly growing, whilst the hardware becomes cheaper and more portable in comparison to desktop computers. This means that mobile phones are easily available on learning activities from field trips or collaborative learning. Other teachers questioned on the potential of mobile technologies in education commented that it is unlikely to use mobile devices for learning due to the limitations in regard to keyboard and screen dimension, memory available, processing power and range of content supported. The conclusions of researches was that some of the teachers consider mobile devices in the strict sense of a very small portable device and that there is a lack of correspondence between theory and practice because the mobile devices are already, more and more, part of our life, work and learning. The research recommended the promotion of an enriched and broader definition of mobile

technologies and devices among teachers especially because education plays a double role in approaching the mobile arena: one to teach and the other to use. The recommendations of the researches stressed on the importance of updating the knowledge and the skills of the actors that operate in the education environment and also on the necessity to integrate new advances in teaching activities, in order to be able to use the potential of the mobile technologies.

2.1 Capabilities of mobile devices for enriched user experience

The MOBNET-Learning Project focuses on improving the experience of the mobile user by identifying a flexible blend of devices, technologies and skills required for a better performance. In accessing the mobile environment, the devices represent a key performance factor. The mobile world includes a large range of devices from mobile phones, smart phones, XDAs, PDAs, Media Players, and even notebooks or laptops that present a variety of characteristics. The purpose of the Project is to provide access to specific content and develop optimised knowledge delivery for devices that present significant restrictions in terms of screen size, keyboard access and processing power.

In order to obtain an enriched user experience when accessing mobile knowledge, the users need to understand *the capabilities* and the technology that their mobile device provides. The large range of mobile devices available on the market today implies that it is basically impossible for developers to target each and every one of them. This requires future mobile users to consider certain features when purchasing a mobile device. When users intend to access web content on their mobile device, they will benefit most if they choose a device with a web browser based on the same libraries as a desktop browser. For example, iPhone OS uses Mobile Safari, which is based on the same WebKit libraries as Safari and Google Chrome. The same applies to the Series 60 3rd Edition web browser, which is also based on WebKit.

Mobile devices have such a precious screen estate, and developers need to follow the best practices recommended by the World Wide Web Consortium (W3C) and avoid adding extra user interface elements. Given the same URL, one can easily observe the difference between:

- Mobile browser configured in mobile view mode;
- Mobile browser configured in desktop view mode;
- Mobile browser configured in one column mobile view mode with full screen.

Figure 2: Different configurations of mobile browsers

The best experience can be obtained by removing the application's title bars and adapting the content to just one column to allow users to scroll in just one direction.

2.2 Limitations of content delivery to mobile devices

Developers need to consider the limitations and usability of mobile applications in regard to the capabilities of mobile technologies and also of the users. General limitations of mobile devices refer to:

- Keyboard and screen dimension;
- Limited memory available;
- Limited processing power;
- The range of content supported is limited

and represent a barrier that can be overcome only at the pace of the advance of technology. For example, reduced keyboard and screen dimensions can be compensated by voice functions.

Research show that most mobile applications are miniaturized versions of similar desktop applications and incorporate all the limitations of the desktop applications, all the limitations of the mobile devices, and typically some extra limitations due to the 'sacrifices' designers and developers make as they move applications from desktop to mobile devices (Stănescu and Ştefan, 2009; Roceanu et al., 2009). Practice has shown that desktop web sites do not work well on mobile devices; people are not willing to read long documents on tiny screens; and most users will not pay for a service that provides text freely available elsewhere. The design and the development of our mobile knowledge management system tried to break the "miniaturized" trend and provide sound customization, under the consideration that mobile learning requires more than a "copy" & "paste" operation.

Delivery of content to mobile devices requires solid customization in the attempt to encourage users to become mobile. Bets practices (Rabin and McCathieNevile, 2008, Stănescu, Hamza-Lup and Tuncay, 2009) stress upon the following issues:

- *Maintenance of thematic experience for content accessed from different devices:* content should be kept similar, no matter if it is accessed from desktop or mobile devices.
- *Exploitation of device capabilities for an enhanced user experience*: mobile devices provide different functions, and these should be exploited to a maximum in order to provide the best possible experience for the mobile user. Adapting the system and/or the content to support specific functions of a device or group of devices allows the user to obtain a better experience.
- *Provide solutions for deficient implementations:* This refers to differences in interpretation between browsers and also deficiencies in implementation caused by non-support of mandatory features. The system should be able to adapt itself in case it encounters clients that do not respect defined standards, or lack part of the standard implementation. Most of the time, there are workarounds that can be used in order to obtain the same result as in standard browsers.
- *Tests on actual devices:* because of the vast number of differences between mobile devices, it is best to test the website of as many different phone models as possible. Sometimes the browser implementation can differ greatly for the same phone model, depending of the firmware version installed.
- *Keep the URIs of site entry points short:* The web site should be designed with quick URIs that can take the user to a specific page based on a content ID. For example, the user can access the address http://news.mobi/45123 and be automatically taken to the article with ID 45123.
- *Provide minimal navigation at the top of the page:* The navigation menu should be designed to occupy little space but at the same time provide links to the most important pages. It is probably best if content is structured hierarchically to provide the content hierarchy leading to the current page.
- *Provide a balance structure:* it is not recommended to include a large number of linked at the top of thee mobile web site; users become mobile as they need to access as much content as possible, as quickly as possible.
- *Provide consistent navigation mechanisms*: it is important to preserve the same navigation mechanism across a service to allow users to identify them easier.

- *Assign access keys to links in navigational menus and frequently accessed functionality*: easy access is a top priority in the mobile world; users would enjoy the mobile experience, if they can access information with just 'a single click'.
- *Avoid pop-ups*: pop-ups or other informative windows can affect the quality of the interaction, reducing the attractiveness of the web site.
- *Use clear and simple language*. Users in a mobile environment expect specific and accurate pieces of information, rather than browsing. They usually access mobile knowledge when they really would like to find specific information, at a specific moment, maybe even for an urgent matter. Extensive reading will discourage the user and make them give up on the experience.
- *Provide correspondence between size of page and device capabilities*: the reduced memory of mobile devices can limit access to content from a various range of mobile devices.
- *One direction scrolling*: Users can improve the comprehension of a text and eagerness to use mobile browsers, if they don't have to scroll in all directions and loose coherence.
- *Avoid large or high resolution images:* As mobile devices present limited storage capacity, images should be resized at the server, to avoid unwelcomed experiences
- *Avoid using tables or frames:* Due to screen limitation, tables and frames rarely fit. To avoid incomprehensible display, it is better to avoid tables that contain many rows and columns, or frames; otherwise the information cannot be accesses properly.
- *Error handling*: when errors occur, users need to be able to understand what has happened and also how they deal with the problem; otherwise they might get reluctant and give up on the experience.
- *Avoid free text entry and provide pre-selected default values:* To compensate the reduced size of most mobile devices, users need to be able to use access keys for an easier navigation in a mobile browser. Also, in designing for small devices, speech input is a viable alternative for devices too small for extra buttons.

The design and the development for the mobile world requires sound adaptation to the basic environmental conditions that restrict wide usage, in order to provide enriched user experience.

2.3 Building a secure mobile World Wide Web connection

At the core of every web application is the fact that all of its functionalities is communicated using Hypertext Transfer Protocol (HTTP), and its results are typically formatted in HyperText Markup Language (HTML). The only difference between HTTP and Hypertext Transfer Protocol Secure (HTTPS) is that an HTTPS connection has extra setup at the beginning. It negotiates a secure channel, and then it sends normal HTTP over that channel (Hope and Walther, 2008).

Security objectives in general terms fall into one or more of the following objectives (MacGregor et al., 1996):

- *access control*: to assure that the person or the computer at the other end of the session is permitted to do what he asks for;
- *authentication*: to assure that the resource (human or machine) at the other end of the session really is what it claims to be;
- integrity: to assure that the information that arrives is the same as when it was sent;
- *accountability*: to assure that any transaction that takes place can subsequently be proved to have taken place. Both the sender and the receiver agree that the exchange took place (also called non-repudiation);
- *privacy*: to assure that sensitive information is not visible, usually carried out by encryption.

The security objectives remained the same along years, but their environment has expanded with the advanced of technology to more complex circumstances and interactions, bringing forth new challenges. Today, users expect to be able to access data securely no matter where they are and remote connections require extra qualifications (Hope and Walther, 2008). Although, in recent years, in terms of Internet access the developments of the mobile technologies have begun to fill the gap between mobile devices and the desktop computers, there are still many differences between how content is rendered in mobile web browsers and on desktop computers due to hardware, software

and physical device constraints. With this in mind, the best way to create a friendly web experience for the mobile users is to create customized context, specially adapted to the device specifications.

Mobile content developers have to take into account the wide variety of mobile browsers and operating systems that are available on the market today. While high-end devices with operating systems such as iPhone OS, Windows Mobile, Android, and Symbian are better equipped to handle Rich Internet Applications (RIA), they only comprise a small number of the mobile device market mostly due to the high costs of such devices. In order to make the make the content accessible to as many users as possible, designers of mobile web applications need to maintain a delicate balance between the features that they provide to end users and the features that they require from the device.

In order to access data using a mobile web interface, the developers have used an *encryption data connection*. In this way, no third party is able to intercept the communication between the client and the server. HTTPS is a protocol that encrypts and encapsulates normal HTTP traffic using SSL (Secure Sockets Layer). Data encryption and client authentication are done through the use of PKI certificates issued to each client and installed in the SIM card of the mobile device. Besides the normal data encryption application, issuing self-owned client certificates allows developers to embed them into the SIM cards and therefore, they can prevent any attempts to copy the private key and allows them to easily revoke client certificates in case a mobile device is stolen or lost.

2.4 Semantic web technologies

The World Wide Web (WWW) is the ultimate source of information (Yu, 2007), regardless if the device used to access it is a mobile or a desktop computer. Anyone with a server can publish documents for the rest of the world to see, and one can hyperlink to any other document. Even more, it does not matter if the page you are browsing is being served up by someone in Bucharest, Romania, from a Unix server, or whether your Web browser is running on a Machintosh machine in New York, USA. People use the WWW for searching, integration and Web mining and when using mobile devices they present the same limitations as the device itself. The introduction of mobile and embedded computer devices, referred as pervasive systems, brings forth enlarged possibilities and sets the base for the future development of the Web. The problem with the majority of data on the Web is that in this form at the moment it is difficult to use on a large scale because there is no global system for publishing data in such a way as to make it easily processed by anyone. The Semantic Web (SW) combines the descriptive languages RDF (Resource Description Framework) and OWL (Web Ontology Language), with the data-centric, customizable XML (eXtensible Mark-up Language) to provide description of the content of Web documents. These machine-interpretable descriptions allow the development of more intelligent systems, automating the analysis and exploitation of web-based information. Ontologies, generally defined as a representation of a shared conceptualisation of a particular domain, represent a major component of the Semantic Web. It is anticipated that Ontologies and Semantic Web technologies will influence the next generation of e-learning systems and applications (Sampson, Lytras, Wagner and Diaz, 2004).

The MOBNET Project uses semantic web technologies to increase efficiency of knowledge processing. The Semantic Web is the main direction of the future Web development and semantic technologies are a rapidly emerging element of the web infrastructure, which enables rapid, large-scale integration, identification and linking of web documents and data.

2.5 Mobile knowledge management system

Mobile contextual learning requires specific knowledge and, at the same time, generates valuable input data, which generally is lost due to the lack of adequate input collection systems. An important goal of the MOBNET Project is to develop a knowledge acquisition and retrieval system that operates as a mobile learning assistant, allowing users to access mobile knowledge when they need it. The system will help mobile learners to fulfil their tasks more efficiently, as it exploits the learner's context in order to filter information, which is of special interest in a specific circumstance.

The system provides advanced searching options: by *keyword*, *full text search*, by *topic* and by *similar articles*, to target the preferences of a larger group of mobile users. For a better user experience, the mobile knowledge management system allows the users to further refine search results by applying search criteria progressively, against the current result set (i.e. a search within a search). For example

users could do a search for the term “engine” and if they are not satisfied with the results, they could further narrow down the list by search for “boat”. This would be the equivalent of searching “boat engine” from the very beginning and would prevent the user from writing extra keywords. To achieve this functionality, the system temporary stores search results in the database and performs further searches based on this list rather than on the whole database.

While reading an article, users are provided with links for terms on which the system can provide further information. This feature is valuable especially for mobile users which are constrained with regards to the input methods that their device provides. At the end of an article, users are also provided with links to other related articles and information on where to obtain further data.

Over time, users are likely to refer to the same articles multiple times. This is particularly valid for articles that include mathematic formulae and large tables that are impractical or hard to memorize. To speed up access for these articles, users are provided with a complete history of previously visited articles as well as with the possibility of creating multiple article favourite lists based on topics of interest.

The system developed also allows learners to capture new information by providing different forms of input such as text, sketches, recording of messages or photos. To use the potential of this data collection process, the system allows the user attach feedback to existing articles and also to create new articles. The user also has the option to automatically attach relevant information such as localisation, or a history of the most recently accessed articles. Articles are published in the system, but to endure data consistency, all articles uploaded by mobile users must go through a peer review process. This method supports knowledge creation and diversity, but also provides knowledge certification.

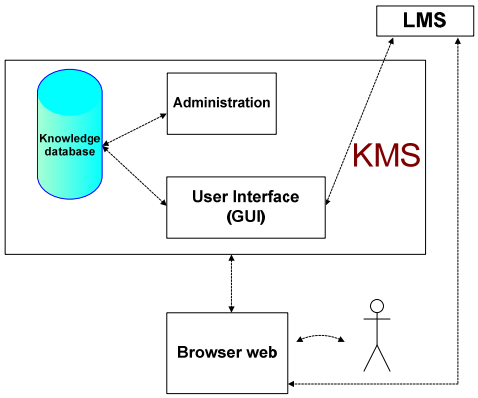

Figure 3: Mobile knowledge management system – MOBNET Project

The system uses a common database for both the knowledge management system and the learning management system. This improves the results of the search and allows an easy administration of knowledge and learning objects and a unified access from the users’ standpoint. The knowledge is accessed via a mobile Graphical User Interface that follows the above-mention recommendations. The mobile website is developed based on the Microsoft .NET Framework using ASP.NET and C#. For the backend, the developers have used Microsoft SQL Server 2008 as the database engine. These are a few of the key features of the mobile knowledge management system that is developed by the MOBNET Project. The system aims to build adaptive learning resources reconfigurable based on the device attributes and users’ preferences and to provide mobile learners with knowledge in the Romanian language, becoming a start-up project in this domain.

3. Conclusions

The learning environment is rapidly advancing within the mobile arena and it is necessary to consider the active processes of building up and structuring knowledge, in the perspective of how they impact abilities, behaviour, attitude, values, cognitive structures and social dimensions. This paper presents the challenge of change that the mobile world brings in the learning environment.

The MOBNET Project develops and promotes the opportunity and the values that the mobile technologies implement in the learning and knowledge community. The Project represents an innovative practice-driven approach in the Romanian research area and aims to become a significant

contribution to the implementation of mobile knowledge management both in mobile learning and mobile business environments. .

The MOBNET Project develops a mobile content management system that teachers/ trainers and students/ trainees will use to supplement and improve formal or informal learning activities. To achieve this objective and sustain the successful implementation of the project, the researchers have developed a practice-based framework to improve the overall performance of the mobile knowledge management system.

The paper details the concepts and the steps that assist the actors of the mobile learning environment in the assimilation and implementation of mobile technologies. To better the results of the Project, a demo version of the m-KMS shall be available online at the completion of the second phase of the project and it will be used to collect feedback from the active actors on their mobile experience, especially in regard to the limitations of the mobile world and security-related aspects, as the resulting application shall be implemented within "Carol I" National Defence University in Bucharest. The MOBNET Project will impact also the mobile business environment. Additional developments of the project will include the extension of the use of the m-KMS to support decision-making systems. Such an extension will complement the basic functions of business intelligence solutions with tools that capture and reuse experience as a competitive advantage.

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