MODULAR PERSONAL KNOWLEDGE MANAGEMENT SYSTEM AND MOBILE TECHNOLOGY CROSS-PLATFORM SOLUTION TOWARDS LEARNING ENVIRONMENT SUPPORT

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ABSTRACT

It is frequently noted that nowadays is the age of information. Despite vast amounts of information knowledge becomes the most important asset for individuals and organizations. Thus knowledge more increasingly has been seen as an active area of research. Accordingly there is a need for highly qualified knowledge workers, which in this paper are represented by instructors or regular students in university environment. That in turn leads to a necessity for on an effective technology based education environment adaptable to each individual. Thus existing personal knowledge management (PKM) tools and systems are explored. Working and education environments are developing and encompassing new technologies such as mobile and agent technologies. Mobile technologies are developing with an accelerating speed. They are providing new opportunities for different type of learning and for different learning environment support. In the market there are a wide variety of mobile devices such as mobile phones, personal digital assistants, smart phones, netbooks, tablet personal computers and laptops. This poses a challenge for common application development for these devices. Many mobile devices have a built-in support for Java applications. Also agent technology is ready to be deployed on mobile devices. Both points can be used as a key unifying factor for cross platform mobile device application development. Thus the central point of the paper is a conceptual modular personal knowledge management system (PKMS) based on mobile technology cross-platform solution. This work includes a case study at Vidzeme University of Applied Sciences to develop a prototype for enhancing learning environment support and a course grading system.

INTRODUCTION

In several previous decades one can observe a historic transition from the industrial age to the information age. Usage of fixed procedures, following standardized information routines, and creation of material goods and consumption of them are characteristic elements of industrial age. In opposite creation and consumption of information, usage of ad-hoc approaches and non-standardized information for decision making describes information age. The Web has developed very rapidly. The same has happened with the growth of information amounts, which has led to information overload. Workspace equipment and environment is turning to be more sophisticated. Also learning environment is becoming more information and technology dense. That requires additional skills and knowledge to handle it. In turn that leads to recognize that knowledge has become a very important asset, which more increasingly has been viewed as an active area of research. Notions of knowledge work and thus a knowledge worker have followed out of the shift from information to knowledge.

In addition of transition to information age and development of the Web and the Internet have appeared new technological solutions such as mobile technology and accordingly different types of mobile devices. These devices have influenced people habits and their ways of consuming, storing and sharing information. A large variety of mobile devices and several new forms of communication have been developed to accommodate individual's expanding needs. Thus, for example, based on i2SMS (2008) almost every second person uses a mobile phone. However that has its draw back by making it difficult to develop services and applications accommodating different mobile devices and their platforms. Accordant innovative services are lacking a momentum of development and are still mainly based on

rather old technologies such as text messaging despite this wide acceptance of mobile phones. As follows there are needed new developments and technologies in the area of mobile device service and application creation. Per Koch and Rahwan (2004) agent technology proposes to be as such within this domain. In particular Java agent development environment (JADE) besides other possibilities proposes a way to develop mobile device based cross-platform applications. Taking this into account the main focus of this paper is designing a conceptual modular PKMS utilizing mobile-cross platform solution based on JADE. In particular m-learning conceptual module of PKMS is described in details, which involves a case study at Vidzeme University of Applied Sciences to enhance a course grading system at Faculty of Engineering as a learning environment supportive effort.

This paper has the following goals: to summarize existing PKM tools and systems, their development approaches and to propose a conceptually new approach for developing more well-rounded PKMS. As one area of usage of such PKMS is proposed a learning environment support, which is looked at in more details. The paper is organized as follows. First PKM skills and tools are overviewed, which is followed by introduction to PKM system as such. Then PKM tools and systems current development approaches are summarized. Next is proposed a new conceptual PKMS consisting of several modules. One of these modules is m-learning module, which leads to overview of mobile devices and main elements of mobile Java environment. That is followed by a description of a case study at Vidzeme University of Applied Sciences and by proposing conceptual system architecture from m-learning module perspective up to the main PKMS. Finally it is followed by concise conclusions and accordant references.

PKM SKILLS AND TOOLS

Before taking a look at PKM skills and tools one has to be familiarize himself or herself with the notion of knowledge as such and with knowledge management (KM) and as follows with PKM. Per Davenport (2000) knowledge is “a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms”. KM usually is looked at in the prism of an organization. Thus by Quintas (1999) KM enables creation, sharing and utilization of knowledge in order to achieve business goals. PKM is rather overlooked area within KM despite that recently it gains a momentum again. By Tsui (2002) PKM is “a collection of processes that an individual needs to carry out in order to gather, classify, store, search and retrieve knowledge in his/her daily activities”. In addition he points out that “activities are not confined to business/work-related tasks but also include personal interests, hobbies, home, family and leisure activities”.

As mentioned above along with appearance of knowledge work there got introduced a notion of knowledge workers. They are a target audience of PKM. Per Davenport (2007) a large part of their time knowledge workers spend for creation of necessary documents for their duties, for communication with colleagues, for searching for information and knowledge elements. More than a decade has passed since KM is an active area of research. Though still in most cases knowledge workers are trying on they own to find and customize tools (i.e. also PKM tools), which helps to successfully carry out a knowledge work they do. Frequently these tools (be they technologies or physical equipment for processing personal knowledge or information) are not integrated with each other. Thus knowledge worker himself or herself functions as an integrating element within a set of fragmented equipment and technologies. This set includes such still used technologies as paper based to do list, task calendar, also land line phone and mobile devices such as mobile phone, smart phone, personal digital assistant (PDA), tablet personal computer and netbook. The list can go on. In addition personal information management (PIM) tools can be considered as part of PKM tools. Only few knowledge workers are accustomed with the broad variety of these tools and technologies. In order to do their tasks successfully and with good quality knowledge workers must be well informed about available PKM tools and should have accordant PKM skills.

PKM tools are divided in several groups accordingly to specifics of their usage in order to make it easier to get familiar with them and to decide which tool is best suited for which task. During development PKM area there have been used several more or less robust PKM tools division. We chose to use the most detailed one and adopted it from Dorsey (2000) and Barth (2005). This division has seven categories for information and ideas, which appropriately used potentially leads to obtaining accordant knowledge elements. The division is as follows: retrieving, evaluation, organization, analysis, presenting, collaborating and securing. Based on this division the summary of PKM skills, tools and representatives of these tools are given in Table 1 (see below). Summarized PKM skills and tools division into seven categories gives a concise overview of the broad set of different tools available for knowledge workers for solving current tasks and problems. However it is also important to point out the significance of knowledge workers appropriate skill level as not all tasks can be solved just by the help of a particular tool (even though it

Table 1: Overview of PKM tools and skills (adopted from Dorsey (2000) and Barth (2005)).

Type of processing of information, ideas and knowledge elements	**Skills**	**Tools**	**Tools representatives**
1. Retrieving	Asking questions, Ability to get around, Searching techniques, Summarizing basic ideas	Desktop searching	Spotlight
		Web meta-browsers	Choosy
		Push/pull services	IgentaConnect
		Contact databases	www.zl.lv
		Web, e-mail	MS Outlook
		Dictaphone, smart phone	Nokia E71
2. Evaluation	Source identification, Qualification, Validation, Judgment, Intuition	Rating services	www.reitingi.lv
		Trusted recommendations	blinklist
3. Organization	Finding common interconnections, E-mail filtering, Outlining, Discarding (carefully)	Voice recognition	LumenVox
		Character recognition	ReadSoft
		Data bases & Indexers	Oracle
		Journals & calendars	Mozilla Sunbird
		Links, bookmarks	BookMark Master
		Personal portals, Mind maps	TheBrain
4. Analysis	Testing hypothesis, Analytical techniques; Specific skills for particular task	Spreadsheets	MS Excel
		Summarizers	Copernic Summarizer
		Visualization tools	Adobe Fireworks
		Relevance or rule searching tools	Find In Context
5. Presenting	Spoken word, Written word, What's left unspoken	Word processing	MS Word
		Spreadsheets	OpenOffice Calc
		Presentation tools	MS PowerPoint
		HTML editors	Adobe Dreamweaver
		Data bases, Personal wiki	WikiPad
		Document libraries	MS SharePoint, Knorg
		Web blogs	TypePad, Blogger
		Public bookmarks	Delicious, Diigo
		Bulletin boards	vBulletin
6. Collaborating	Leadership, Emotional intelligence, Playing ability, Facilitation, Networking, Relationship management, Social skills, Political skills	Collaboration software	Skype
		Coffee machines	Siemens
		Forums, Social networks	sdn.sap.com, LinkedIn
		Messaging	SMS
		Micro-blogs	Twitter, Jaiku, Yammer
		Shared desktops	Copernic Desktop Search
		Discussion and chatting software	Skype
		Brain storm support tools	MindGenius
		Video conferences	Skype
		Whiteboards	SmartBoard
7. Securing	Attention, Self-discipline, Order, Threat awareness	Lockable places & safes	Safe
		Passwords & Biometric data readers	Finger print reader in notebook
		Access controls	Passwords
		Anti-virus software	Kaspersky Lab
		Tunnelling, Firewalls & IP filtering	ZoneAlarm
		Encryption tools and techniques	TrueCrypt

fits the case). A notable value for successful completion of knowledge work rests within the mix of individual's level of education, social skills, culture and intuition.

PKM SYSTEMS

The interest about personal knowledge management systems and their research has begun rather recently. As per Pauleen (2009) so far PKMS is not a frequently researched area. That also can be double checked by searching the internet directly for PKMS information (i.e. by using Google), or by searching research related data bases such as SpringerLink, Emerald, IEEE, ACM, and EBSCO. The amount of information found is rather small. However there is a tendency that in recent years the research interest about this area grows. PKMS is a complex system and it contains social, psychological and technological aspects (see Apshvalka and Grundspenkis 2005). The performance of PKMS is closely tied with knowledge worker's perceptions, emotions, beliefs, surrounding society, environment, wishes and goals. Technology in the context of PKMS has an important role as well. PKMS goal is to support and help its owner to make decisions and to do actions as good as it can. PKMS supports knowledge elements finding, retrieving, creation and sharing; it supports decision making and creating an environment where individual can share his or her knowledge with other knowledge workers or with acquaintances at communities of practice (CoP). Per Miller (2005) PKMS from practical point of view contains how individual can find personal information sources in his or her personal computer (PC) or in a mobile device, and how to adjust this information to current situation to create intellectual and knowledge values for enhancing success at work or in daily life. In addition PKMS is focusing not just on individual's personal information sources, but on other sources as well. Also PKMS has to foster knowledge worker's individual independence and has not to ignore that (see Li 2009). So far PKMS research directions can be divided into two parts. One explores PKMS as separate subsystems (see Völkel and Abecker 2008) of an organizations whole knowledge management system (KMS) and how they interact with each other. Second approach focuses on PKMS or PKM tools usage in the context of individual and not so much looking at organization KMS factor (see Jarche 2006 and Li 2009).

PKM TOOLS AND SYSTEMS DEVELOPMENT APPROACHES

PKMS and PKM tools can be divided into several groups based on the way how they are built. So far many of them are based on the desktop approach (see Doong and Wang 2009) or on web technologies related approaches such as wiki and blog spaces (see Li 2009). There are some attempts to combine these approaches (see Kim et. al. 2007) in order to avoid duplicated information on desktop and in wiki place.

As one of first desktop based PKM tool can be named Google Desktop, which is available for public use since 2004. It does indexing and makes sure that knowledge workers can search information by using Google resources or by searching individual's files in his or her computer, e-mail, as well as by searching individual's visited web pages and chat rooms (see Google Desktop 2011). In addition it provides possibility to undelete files, offers several utilities such a clock, a calendar, Google Reader, to do list and others. Google Desktop is available free of charge. Similar tools are Windows Search by Microsoft and Spotlight by Apple, which are available in accordant operating systems developed by the same companies. A commercial tool similar to the ones above is Copernic Desktop Search (see Copernic Inc. 2011). This tool offers free of charge its version called "Home" with a limited functionality. Even though the main version of this tool is not free of charge, still it has gained individuals attention – more 4 millions are using it. Latter mention tools (i.e. such as Google Desktop) are focusing on different type of searching functionality. Doong and Wang (2009) positions Google Desktop as one of most popular PKMS in the Web. However such PKMS is more a tool as a system because it provides limited functionality (i.e. mainly based just on searching).

There is one more group of PKM tools and partial PKMS, which have gained knowledge workers acceptance. They are ones based on wiki and blog spaces. One example of them is personal wiki places. Such tools tend to contain a free form data base, try to be a personal information management tool or to serve as a personal journal. They can be accessed by using a web browser (see TiddlyWiki 2011), or can be located on an individual's PC as ConnectedText (2011) or on a mobile device as WikiPad (see Jera Design 2011). These tools may provide also an additional functionality, which is not typical for regular personal wiki place functionality. One more type of PKMS is based on blog spaces. That makes them more user-friendly because blog spaces as such are rather well known and frequently used. Thus there is no need to learn how to use them as it is rather straight forward (i.e. as a regular web browsing). Such system or tool is accessible in any time and in any place. It supports communication, knowledge sharing and free form knowledge structures. Li (2009) proposes three level blog based PKMS development approach. These three levels are: personal level, system or tool level, and source level. Such tool supports user centred knowledge and information organization.

In addition to latter mentioned PKMS and PKM tools can be named some more conceptual PKMS development approaches, for example, Smedley (2009). It uses

Nonaka SECI (i.e. Socialization, Externalization, Combination, and Internalization) model approach and the concept of Ba (see Nonaka and Konno 1999), which comes from Japan and is about a creating friendly communication environment for individuals. SECI model is about transition and interaction between tacit and explicit knowledge within four states: socialization, externalization, combination, and internalization. Smedley approach uses both of these two concepts and includes experts, knowledge workers as a central point and CoP. The main idea of this approach is that accordant area expert provides knowledge worker with initial bits of knowledge (i.e. provides a direction for solving a task), but CoP provides a support for creating personal knowledge. A very important point for this approach mentioned by Smedley (2009) is the factor of trust within a knowledge sharing process.

Another conceptual approach is given by Wright (2005, 2008) and contains four interconnected areas: analytical, information, social, and learning. Several skills are assigned to each of these areas, which knowledge worker should posses in order to be fluent in an accordant area. Wright has proposed a set of questions for each area so that knowledge workers could test themselves and the work they do. Thus weaknesses could be discovered, which in turn would also suggest the areas of improvement. For this approach a very important point is to maintain a good collaboration and networking level.

MODULAR PKMS CONCEPTION

Per Jefferson (2006) currently available PKMS are just a bit more than just productivity tools. He suggests that there is a necessity for systems with ability to adjust to individual (see Jefferson 2006). In the same time it is important to develop a structure for fostering knowledge acquisition and usage of existing knowledge. However Li (2009) believes that for knowledge management in personal level it is impossible to create a standardized or strictly fixed knowledge structure for each individual as they tend to create their own knowledge structures. One can agree to such point of view. However that does not exclude possibility to search for other PKMS development approaches (i.e. not just to follow the web blogs based PKMS development track). We propose to develop a robust framework for PKMS development and future enhancement. Thus PKMS foundation is created as a rather fixed structure. However in the same it can be adjusted to particular knowledge worker in several levels. This approach is based on modularity concept by developing system consisting from different modules. In the core of the system is a compact and fixed *Basis* module. This module is surrounded by a number of other *Supplemental* modules depending on each particular knowledge worker case. These Supplemental modules can be added by developer or by configuration consultant of particular PKMS or by knowledge worker himself or herself. Thus system can be customized to specific group of knowledge workers.

Such system adjustment is 1st level configuration. Each of these Supplemental modules is developed before hand by taking into account also a specific PKMS social and psychological approach developed by authors of this paper. However it is out of scope of this paper to discuss them in more details. Supplemental modules can be further customized to a certain level by knowledge worker (i.e. system user). This adjustment is 2nd configuration level. However it has to be pointed out that this configuration level provides more narrow PKMS structure changing possibilities than the 1st one. Instead these tend to be more of a visual type of adjustments than structural. Such limited possibility of adjustments in 2nd level of configuration is designed on purpose so that the system would not be too complicated from the perspective of knowledge worker. Thus broader 1st level system configuration possibilities compensates 2nd level limited configurations options.

The Basis module of proposed system provides basic functionality of PKMS. This module includes also individual's knowledge profile and user profile. Knowledge profile contains information about PKMS user's knowledge level to a certain extent, knowledge specifics, and information about the knowledge individual is eager to acquire. User profile contains individual's personal information. PKMS uses both profiles when it is collaborating with other knowledge workers and accordingly with their PKMS.

FREQUENTLY USED MODULES AND SPECIFIC AREA MODULE M-LEARNING

Supplemental modules are divided into two groups. One group represents frequently used modules. Other group contains specific area modules. Frequently used modules are used to create a small size PKMS while in the same time supporting system's further growth towards different specific areas. However not necessarily all frequently used modules have to be incorporated within PKMS in order to make this system functional.

The following frequently used modules are identified:

- Goal and task management module,
- Time management module,
- Personal knowledge audit module,
- Collaboration management module.

Goal and task management module provides possibility for knowledge worker to set his or her personal goals. To do that system offers ready-made goal-setting templates depending on type or specifics of chosen goal. Specifics of chosen goal are linked with one of available modules either frequently used ones or specific area ones. Thus

there are available ready-made goal-setting templates only in correspondence to currently available PKMS modules. In addition this module provides knowledge worker with possibility to manage his or her tasks. Tasks can be very simple ones taking just couple minutes or more complex ones taking more time and involving several steps to complete. Such steps may also require collaboration with other knowledge workers by using PKMS (i.e. technological) functionality or bypassing it. *Time management module* supports knowledge workers in performing his or her tasks in a timely fashion. However as there is concept of compact module development, then time management module is designed to basic and medium complexity time related functionality. It does not contain, for example, complex project time management functionality. *Personal knowledge audit module* provides simplified individual's knowledge (i.e. both explicit knowledge and also partially codified user's tacit knowledge). Accordingly this module helps to identify basic knowledge of a certain area, possible knowledge gaps and some other knowledge related information necessary for completing a particular task. *Collaboration management module* supports individual in fostering communication and collaboration ties with other knowledge workers. This module helps to find best communication type and channel in accordance of current environment of knowledge worker (i.e. of current environment of PKMS as well). Among others there are such communications options offered as short text messaging, making phone call, and chatting using the Internet.

Proposed PKMS can contain also one or more specific area modules. Each such module is designed for a specific area with a concrete functionality. We chose m-learning module as a representative of specific area modules. Such module is designed to provide learning environment support functionality both for adult learners and for regular university students. In addition in our case it supports specific functionality in relation with course grading system. As the name of module suggests it is based on mobile devices. A short overview of this environment is provided in the following chapter.

MOBILE DEVICES AND MAIN ELEMENTS OF MOBILE JAVA ENVIRONMENT

The United States based Annual gadgets survey states that 59% of adults now access the internet wirelessly using a laptop or cell phone (see Smith 2010). E-communications household survey states that in European Union 89% of all people use mobile phones (see TNS Opinion & Social 2010). As one can assume mobile devices are very popular among younger generation of people as well. In fact young adults lead the way in the use of mobile applications (see Smith 2010). They use their mobile phones, PDA-s, and laptops for sending and receiving text messages or e-mails, playing games, taking pictures, recording and watching videos, accessing the internet for latest news, listening favourite music or radio, making a purchase and getting maps or directions.

Not only there is available a wide variety of mobile applications, but also there is a large diversity among mobile devices in general. First of all there are different types of mobile devices such as camera mobile phones, smart phones, PDA-s, portable media players (PMP-s), mobile gaming devices, netbooks, tablet PC-s, wearable mobile devices and laptops. There are many options how to get mobile and many connection types (i.e. WI-FI hot spots, Bluetooth, broadband air card, GSM, OnStar system used in the United States made cars for the internet connection, 3G and 4G mobile phones represent another type of wireless network usage), applications, and services to use. Despite that individuals still have rather negative experience with mobile web and mobile device applications. Based on i2SMS (see i2SMS 2008), it is because that there are over 1,500 different handsets available around the world with over 450 different configurations. There are different screen sizes, operating systems (see i2SMS 2008) (Symbian, Android, Windows Mobile, iPhone, Blackberry, Linux, Maemo, Palm, Brew), and carriers choosing differing settings on a cafeteria type selection platform for the same phones. That is making havoc on mobile web and application developers. The iPhone browser will not run applications developed in Flash or Java. It cannot be expected that consumers will embrace a mobile browsing, application and service experience with convoluted and confusing content.

As a uniting element and a cross platform unification solution for many mobile devices can serve Java programming language even though these devices might operate on different operating systems (OS). Also within mobile Java execution environment there are several differences based on mobile device technical specifications. A short overview of main elements of Java execution environment follows.

Mobile Java execution environment includes such elements as configurations and profiles. Configurations define the minimal requirements for the hardware of the device and what kind of Java virtual machine is included in the system. In turn profiles define the programming infrastructure available for applications intended to be run on top of particular configuration (see Mikkonen 2007).

There are two important configurations: Connected Limited Device Configuration (CLDC) and Connected Device Configuration (CDC). Each of them sets requirements for underlying virtual machines which in turn are hosted on each particular mobile device

operating system. CLDC is the simplest mobile Java configuration and it is available on low-end and middle-class mobile phones and smart phones. This configuration is based on simplified Java virtual machine. CDC configuration lays on standard-featured Java virtual machine even though it does not require all the libraries as in the case of desktop environment (see Mikkonen 2007). Thus such configuration usually is available on most powerful mobile devices like communicators, tablet PC-s, and PDA-s.

Each configuration has profiles, which can be seen as a connecting element between Java environment creators and mobile application developers. CLDC has two closely related profiles: Mobile Information Device Profile (MIDP) and Information Module Profile (IMP). The first one is meant for mobile devices with small screens, as a minimum limited connectivity and a simple keyboard. Thus MIDP profile actually is the most widespread one available. IMP profile is geared for similar devices but lacking screen features like operate-able sensors. CDC configuration has three profiles: Foundation Profile (FP) being a simplest profile among the three, Personal Basis Profile (PBP) extends the FP and Personal Profile (PP) basically mimicking standard Java running on desktop environment.

In market currently CLDC configuration dominates among mobile phones and also among smart phones. Only few smart phones with CDC configuration were in the market in the beginning years of this century such as Nokia 9500 (see Forum.Nokia 2010). They were upper level smart phones with a very expensive price tag. As a result it turned out that there is not really a business case for CDC configuration environment within a smart phone market. Also PDA-s (which are dominantly based on CDC configuration) tend to disappear from market as smart phones are taking over their niche and offering even a wider variety of functionality. However the future of CDC can not be painted just in dark colours. Thus, for example, Amazon Kindle e-Reader is taking over the run for CDC configuration support. A Kindle software development kit (SDK) (see Amazon Kindle 2010) has been made available since spring 2010. However for time being it is still available only for Amazon chosen or approved developers.

A CASE STUDY – SITUATION DESCRIPTION

For study purposes it was decided to develop m-learning specific area module of PKMS based on mobile devices. This module is particularly focused on learning environment support. A partial description of Basis module of this PKMS is also available at (see Osis and Grundspenkis 2009). The goal for this module was to support a course grading system.

There were evaluated a number undergraduate level courses within Faculty of Engineering in Vidzeme University of Applied Sciences. Grading systems of these courses were of particular interest as some courses had rather simple grading, but others had more complex grading approach. Thus "Accounting / resource-planning systems" course grading approach was chosen for this case study purposes. It has the following items:

- home works – 250 points,
- short quizzes – 40 points,
- research paper – 110 points,
- research paper presentation – 25 points,
- active participation in class – 75 points,
- final exam – 250 points.

In total a student can receive 750 points. The further grading is done based on accumulated points. Next these points are turned into percentages and then accordant percentage intervals are assigned to a final mark (see Table 2).

Table 2: Point percentage alignment with final mark

Percentage	Mark	Percentage	Mark
>= 93% (697 p.)	= 10	>= 78% (585 p.)	= 6
>= 90% (675 p.)	= 9	>= 74% (555 p.)	= 5
>= 87% (652 p.)	= 8	>= 70% (525 p.)	= 4
>= 82% (615 p.)	= 7	< 70% (525 p.)	= 3

Evaluation item called "active participation in class" means collecting "pluses" for each constructive activity such as asking questions, solving exercises on the blackboard, and so on during a time frame of whole semester. Then these "pluses" are summarized and a curving is performed – meaning that the student who has received most of all "pluses" receives 75 points, the next highest amount receives accordingly less points based on percentage difference, and so on. So far during the course all records are kept in an Excel file by an instructor. Thus student on his own even can not know his or her current standing. Instead instructor has to be approached in person to this find out. It is especially so because item "Active participation in class" can be calculated just by knowing the "pluses" of all students and thus it can not be calculated by a student himself or herself. Another feature of course grading system for all courses is that students can appeal the received marks. Especially it is so for the final mark. An appeal can be done only within certain amount of days after the mark has been set. After the time has passed and a student wishes to appeal or to enhance a mark, then he or she first has such option. But before that a processing fee to university has to be paid in order, for example, to re-take a final exam. This turned out to be a problem. Some students missed these deadlines and they had to pay a processing fee. Also it seemed to be rather difficult for some students to follow their own status during a course at a given time. Thus this module was designed to provide a support for these activities.

SYSTEM ARCHITECTURE

As described in (see Osis and Grundspenkis 2010) this module utilizes software agents. In Figure 1 below is depicted m-learning module architecture from software agent perspective.

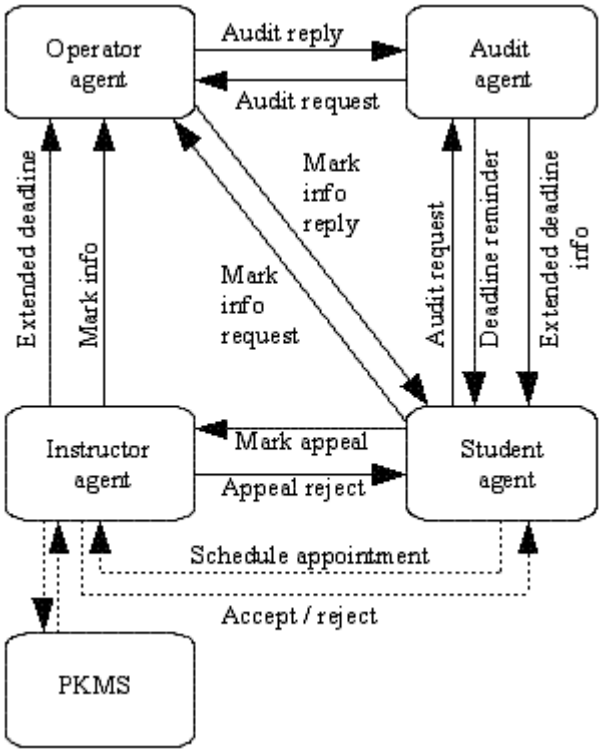

Figure 1. M-learning module architecture from agent perspective (adopted from Osis and Grundspenkis 2010).

The solid lines depict agents' communication within the m-learning module. The fine dashed lines depict the communication with the PKMS.

This module has four main types of agents:

- instructor agent;
- operator agent;
- student agent;
- audit agent.

Particularly system deploys Java agent development framework (JADE), which supports Foundation for Intelligent Physical Agents (FIPA) based standards for agent systems development.

Thus it also involves several FIPA standard management agents such as Directory Facilitator (DF). Each agent lives in a container. It is the Java process which provides the JADE run-time and all accordant services required for hosting and executing agents.

Main container is the bootstrap point and is launched first to be followed by all other containers which must connect to a main container by accordingly registering with it. Mainly JADE is geared towards agent system development on PC-s or servers.

However this environment also has Lightweight Extensive Agent Platform (LEAP) add-on, which is an extension of previously mentioned JADE framework. Starting from recent JADE 4.0 version this LEAP add-on has been integrated into JADE platform itself (see JADE 2010).

JADE-LEAP can be used in three different ways corresponding to the three types of Java environments depending on type of device it is being applied: PC-s and servers – Java 2 Standard Edition (J2SE), mobile devices supporting CDC configuration – Java 2 Micro Edition (J2ME), and mobile devices supporting CLDC configuration and MIPD profile.

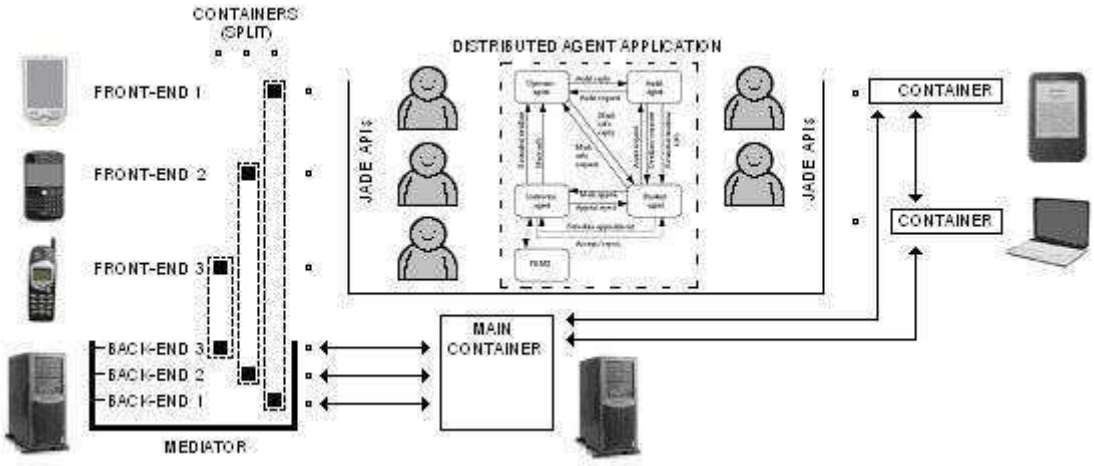

Figure 2. M-learning module architecture from – mobile technology perspective.

Even though different internally, the three versions of JADE-LEAP provide the same API subset (with few exceptions in MIDP case) to developers, thus offering a homogeneous layer over a diversity of devices and network types (see Bellifemine 2007).

Thus by combining these approaches we have worked out a mobile device cross-platform solution for m-learning module. This mobile device integrating cross-platform approach applies also for the whole PKMS as well.

In Figure 2 is depicted a proposed m-learning module architecture from mobile technology perspective. It is combining different types of mobile devices such regular mobile phones, smart phones, PDA, netbooks, laptops and tablet PC-s as a system backbone forming devices.

Even e-reader such as Amzon Kindle can be used. Such wide representation of mobile devices within m-learning module architecture ensures accessibility to this software solution by as many students as possible as they tend to posses different type of mobile devices.

This m-learning module has several scenarios. They are as follows: setting a mark, extending a deadline, appealing, and scheduling an appointment.

Setting a mark scenario begins when instructor has corrected, for example, a home work and assigns points. Instructor agent provides option to create a batch collection of the student ID, a single item of points, and the exercise ID. Next it sends this batch collection to operator agent. Then operator agent saves that information. It uses help of DF agent (i.e. it is a JADE framework internal agent) and broadcasts this information accordingly to each student agent.

In addition if student agents specifically request then they can receive a total summary status of assigned points at a given time. Meanwhile audit agent keeps track of done and not-yet-done exercises. It informs student agent accordingly based on deadline proximity property value. This value can be set by student agent.

Appealing scenario is started by a student. Then it is taken over by student agent. It sends an appeal directly to instructor agent. If it is too late and the appeal deadline is passed then instructor agent on its own rejects this appeal. If that is not the case, then instructor is informed.

Extending deadline scenario begins when instructor decides to extend a deadline for a given exercise. Then that information is transferred to operator agent. There it is saved and communicated further with audit agent and then student agents are informed.

Scheduling an appointment scenario provides possibility for a student agent to send a request directly to an instructor agent to schedule an appointment. If such request is received by instructor agent then it consults with its PKMS time management module agent (i.e. if it is available). The latter one on its own decides if to accept or reject particular appointment request.

CONCLUSIONS

There are many PKM tools available for knowledge worker use. However they are not integrated with each other. Also currently available PKM systems can provide only a partial support to knowledge workers.

Proposed modular PKMS development approach promises to be much more flexible and more able to provide the necessary support in many cases of knowledge workers work or daily life situations. PKMS specific area module "m-learning" demonstrates the adjustment possibilities of PKMS system (i.e. in this case to serve as a learning environment support provider).

In future there could be added several m-learning modules into this PKMS in order to provide broader learning support functionality. Proposed mobile-device cross-platform approach ensures that this m-learning module and the whole PKMS is available practically in every moment of individual's life as nowadays people tend to have their mobile devices all the time by themselves.

There are two next following steps towards designing this PKMS development approach. One is to work out a more detailed Basis module architecture from agents' perspective. Other one is to fine-tune a designed PKMS social/psychological aspects development approach before integrating it with the technological aspect development of PKMS.

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