Experiences in Applying Mobile Technologies in an E-learning Environment*

ROBERTO BARCHINO, JOSÉ M. GUTIÉRREZ, SALVADOR OTÓN and LOURDES JIMÉNEZ
Computer Science Department. University of Alcalá,Technical School of Computer Science Engineering, 28871. Alcalá de Henare, Madrid, Spain. E-mail: roberto.barchino@uah.es

The present paper introduces two computer science projects related to experiences in the use of mobile technologies in higher education and training, particularly in e-learning systems. The first project, called 'Learning Messages Notification System', is a new communication tool that can be added to any learning management system. With this tool the students will receive educational messages in their mobile devices: phone or PDA. The second project is the 'Mobile Assessment System', which can help us in the assessment process of the knowledge acquired by the student in a virtual environment.

Keywords: mobile technologies; PDA; learning management system; mobile assessment

INTRODUCTION

HIGHLIGHTING THE CONSTRUCTION of a Learning Management System called EDVI [1] and emphasizing the organization of relevant events such as the *I International Conference on Ubiquitous Computing: Applications, Technology and Social Issues* [2] and *V Jornadas sobre Programación de Dispositivos Móviles- MobiGame* [3] are what we want to do.

According to the Commissioner of Education, Training, Culture and Multilingualism of the European Commission, Ján Figel, globalization, new technologies and demographic developments constitute an enormous challenge, one of the answers to which is access to lifelong learning [4]. Moreover, the emerging technologies and mobile systems are priority areas for the European Commission: Education and Culture. These issues are essential learning for development of the new knowledge-based society.

On the other hand, the increasing use of mobile devices is spreading. Nowadays, we cannot imagine any professional in any working environment without a mobile telephone or PDA—Personal Digital Assistant. Since the late 1990s, mobile devices have been used in education. This is the reason why a new kind of learning, called 'mobile learning', was created. Briefly, mobile learning is learning that is mediated via mobile technologies such as mobile phones, personal data assistants, handhelds, wearable devices or laptops [5].

The Computer Science Department of the University of Alcalá has been working in e-learning system environments since the year 2000. Since then, we have designed and implemented two different systems using mobile device technologies. The first one is a passive project in which the information flows only one way to inform the students; the second one is an active project that conjures an exchange of information between the Learning Management System—LMS—and the user.

LEARNING MESSAGES NOTIFICATION SYSTEM

This system is an extension of the communication tools which are incorporated in all LMSs. The main idea is to inform everyone—students or professors—engaged in a virtual course, of any change of interest, for example, a change in the contents of the course, publication of examination dates, new tutorial schedules, results of an exam, proposals for new exercises, etc. In other words, any events related to the virtual course that can be notified by a message.

Those who want to use the system will first need to activate it by downloading a java application called midlet from the LMS, which is based on the J2ME (Java 2 MicroEdition) technology, and then transfer it to a mobile device. The midlet is a java application that conforms to the Mobile Information Device Profile (MIDP) standard; it activates the Learning Messages Notification System for that mobile device.

The activation process has three steps: first, the user connects to the LMS server through the mobile device, then downloads the midlet from the LMS and, finally, the downloaded midlet is executed. The midlet then asks for some information and the answers are sent to the LMS server. Figure 1 shows the activation protocol.

Fig. 1. Activation protocol.

The messages are SMS (Short Message Service), a wireless service in the mobile digital network. It is used in the Wireless Messaging Application Programming Interface (WMAPI) from Java for the activation process. This API has an access path to the applications for receiving and sending messages. It is based on the Generic Connection Framework (GFI), therefore the work environments will be J2ME and Java 2 Micro Edition Wireless Toolkit. The messages are sent through a PC wireless modem card with access to the Global System for Mobile Communications (GSM) and to the General Packet Radio Service (GPRS), two international standards that allow wireless mobile communications.

The traditional architecture of the LMS is spread through the addition of elements that register mobile users into the system and can send SMSs to them. Figure 2 represents this architecture.

The modem allows sending and receiving quick text messages. The modem used in the system is the Sony Ericsson GT47/GT48 [6]. It is an intelligent and versatile GSM/GPRS control terminal that encapsulates everything needed for wireless M2M—Machine to Machine—capability in a compact unit. Alternatively, it can be used as a stand-alone and powerful GPRS modem with its intrinsic TCP/IP stack. The basic functions are:

- Dual Band EGSM 900/1800 MHz (GT47) or GSM 850/1900 MHz (GT48);
- Data, Fax, SMS and Voice;
- HSCSD (2+1), up to 19.2 kbps;
- Wide and useful range of I/Os;
- Tricodec (HR/FR/EFR)—GT48 supports AMR;
- MS Class B, GPRS Class 8 & P Channels;
- Integrated TCP/IP stack;
- Type Approved for GSM Phase 2+ standards (GT47)/FCC/PTCRB (GT48).
- Easy and cost-effective application development using M2mpower, including GT47/GT48 Developer's Kit;
- $-30°C$ to $+75°C$ operation.

Once it is activated, and depending on the profile—professor or student—the system can work and send different types of messages. The system will inform the students about the following
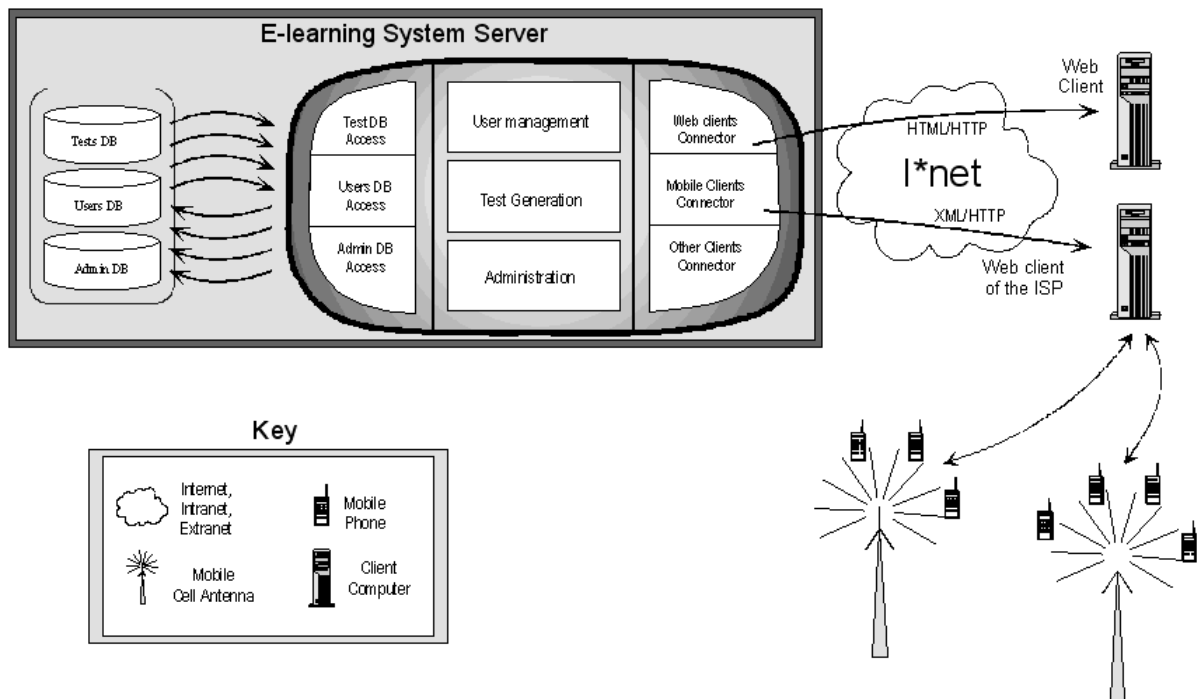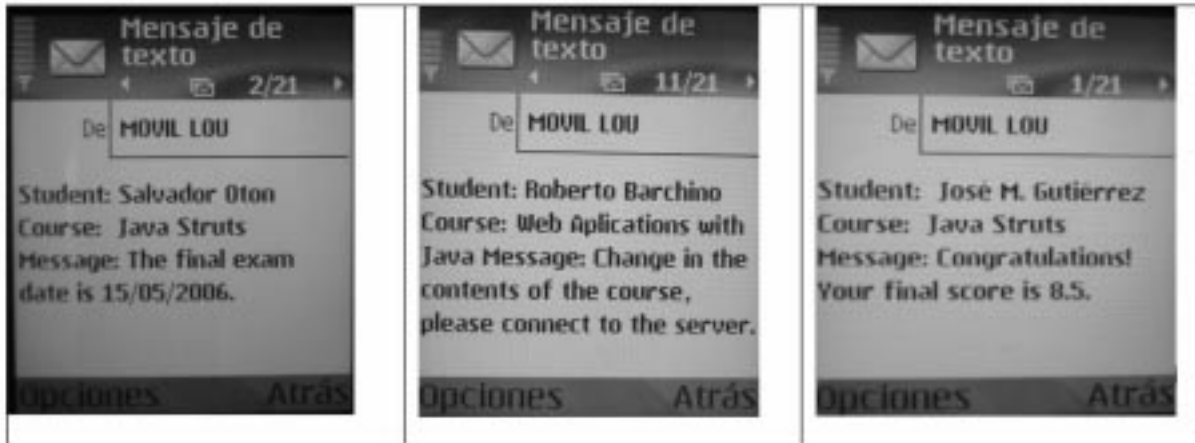

Fig. 2. System architecture.

Fig. 3. Examples of SMSs.

situations: new educational contents, change in the educational contents, final exam data, grades of an exam, timetables, etc. The professor will receive the following messages: tutorial timetables, assessment statistics, i.e. percentages of students who have failed or passed, e-mails without response in the LMS, etc.

MOBILE ASSESSMENT SYSTEM

The second implemented system is the Mobile Assessment System (MAS). This system helps us assess the knowledge acquired by the student in a particular virtual course. It allows the execution of multiple-choice exams through a mobile device. Once the student downloads the application—midlet—to the mobile device, it displays a list of the subjects/courses where the identified student is registered in the LMS.

The tools used to design and implement the MAS were:

- J2ME—Java 2 Micro Edition. J2ME is a reduced version of JAVA for the development of applications on mobile devices. J2ME has been used to create the midlets which are executed on the mobile devices;
- The Java Servlets technology. It allows the execution of applications in web servers and is used to read the questions in the exams from an XML file;
- Apache Tomcat. It is the servlet container used for the execution of the Java Servlet and the JavaServer Pages technologies.

The thought mechanism for the development of an exam is based on the Item Response Theory (IRT)[7]. The exam is answered in phases; by default it is composed of five phases plus two additional ones. In each MAS phase a random question is generated and sent, along with the possible answers, to the mobile device. A bank of questions (repository) should exist so that the evaluation is as efficient as possible. The repository has been implemented with XML language follow-

```
<choiceInteraction    responseIdentifier="RESPONSE"    shuffle="false"
maxChoices="1">
    <prompt>What layers belong to the protocols TCP and IP?</prompt>
    <simpleChoice             identifier="ChoiceA">TCP->transporte,IP-
>red</simpleChoice>
    <simpleChoice                identifier="ChoiceB">TCP->red,IP-
>transporte</simpleChoice>
    <simpleChoice             identifier="ChoiceC">TCP->red,IP->link
</simpleChoice>
    <simpleChoice                identifier="ChoiceD">TCP->link,IP-
>red</simpleChoice>
</choiceInteraction>
```

Fig. 4. QTI-XML question fragment.

Fig. 5. MAS interface.

ing the standard of the IMS Global Learning Consortium called Question and Test Interoperability (QTI) [8] [9], which describes a basic model for the representation of questions and test data and their corresponding result reports using XML (see Fig. 4) [10].

Once the question is answered through the mobile device, MAS evaluates it and generates the next question paying attention to the evaluation of the prior question, repeating this four more times. By default, MAS will randomly provide the students with exams of twenty multiple-choice questions. Finally, the system has to calculate and send the student the assessment score. A new scoring algorithm denominated ALgorithm EValuation INtelligence (ALEVIN) [11] has been proposed to get the final score.

Some screens are shown in Fig. 5. They are part of the MAS interface system: Presentation screen, question screen and score screen. These screens have been generated through the Java 2 Micro Edition Wireless Toolkit.

The exams that use ALEVIN algorithm can be represented in a matrix—Fig. 6—where the following concepts can be identified graphically:

- *Phase*: corresponds with the first columns of the matrix. All the exams have a number of fixed phases; this number can change depending on the configuration of the algorithm. Figure 6 shows an exam with five phases;
- *Additional phases*: correspond with the last columns of the matrix. They are phases that can or cannot be used depending on the student's needs. They can or cannot exist depending on the configuration of the algorithm, and their number can also vary depending on the configuration of the algorithm. Figure 6 shows a configuration with two additional phases;
- *Question blocks*: correspond with the rows of the matrix and their number can be configurable;
- *Questions*: in each position of the matrix a question will be asked. If at the end of a block of questions, some have not been filled out, this means that the student did not need the additional phases;
- *Level*: all the questions are classified by levels. The number that appears in each position of the matrix indicates the level which corresponds to that question. The number of levels can be changed for each user. Figure 6 shows a matrix with five levels where the number of phases is the same as the number of levels;
- *Non-answered question*: is indicated in the matrix with the NC characters, and the level of that question is shown in front of these characters;
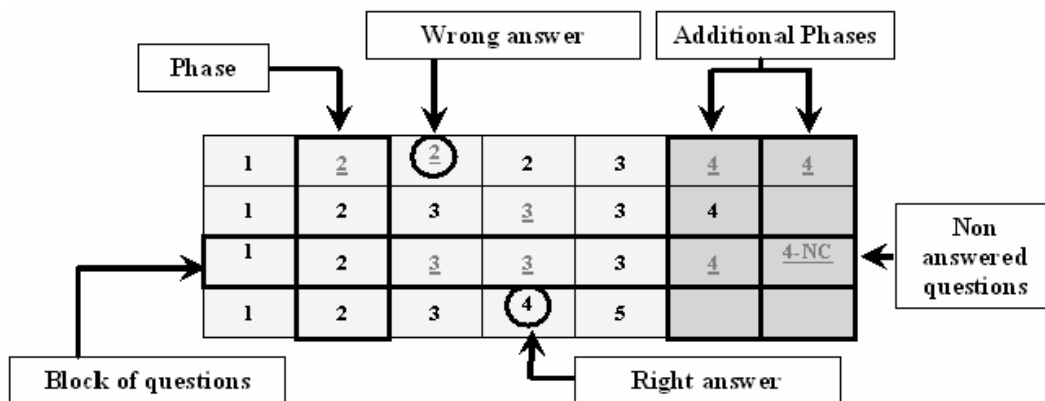

Fig. 6. ALEVIN matrix.

$$\sum_{n=1}^{m} \frac{\dfrac{E \bullet P_n}{100}}{\max(B, C_n)} \bullet A_n$$

B = Number of question blocks.
C_n = Questions answered in level n.
A_n = Wise questions of level n.
P_n = Percentage of the questions in level n
E = Maximum score in the exam. (usually 10)
m = Number of levels (the value in the standard configuration is 4)

Fig. 7. Score formula.

- *Right answer*: is indicated in the matrix with its corresponding number of the level of the correct answered question in black;
- *Wrong answer*: is indicated in the matrix with the corresponding number of the level of the wrong answered question in red.

The exam will consist of questions from all four levels (see Fig. 6); each level has a percentage weight in the final score. The sum of the scores of the four levels will be equivalent to the maximum score of the exam, usually being 10 points. Once the student has answered all the questions on the exam, the next formula (Fig. 7) is used to get the final score.

The ALEVIN algorithm can be used in several ways: ascending, descending and mixed. It can be configured under six different parameters: number of levels, number of additional phases, number of question blocks, modality of the algorithm, percentages of the levels and maximum score in the exam:

- *Ascending way*: the modality in charge of carrying out the exam questions beginning with those in level 1. Depending on the students' answers it increases the level of the questions step by step. Figure 6 shows a classification of questions in five levels: the ascending sequence is the following: $(1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5)$;
- *Descending way*: the modality in charge of carrying out the exam questions beginning with those from the last level. Depending on the students' answers, it decreases the level of the questions. Figure 6 shows the descending sequence: $(5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1)$;
- *Mixed way*: a variant of the previous two: a block of questions follows the ascending modality, another block the descending modality. The number of question blocks has to be even to be able to carry out this modality successfully.

This system allows the students to verify their degree of assimilation of the contents of a course with auto evaluations whenever and wherever they want. This system can also be used to detect possible defects in the learning process.

CONCLUSIONS

In today's knowledge-based society, the use of mobile devices is very common. Thus, the experiences and studies carried out by different institutions (universities and other organizations) incorporate mobile technologies into their curriculum.

Communication tools are basic in the dialogue among the participants of a virtual course in e-learning systems. Why not extend the communication tools to mobile devices? Using these in the formative process can prompt more interaction in course communications. Since the assessment must be one of the strategic objectives of the e-learning systems, this study has shown that the Mobile Assessment System can be used in different Learning Management Systems to check students' knowledge. Both systems must help in motivating students, specifically those who do not leave the formative process and continue with it until the end.

At present, these systems are being used in some virtual courses provided for technical computer science engineering degrees at the University of Alcalá; their use is at its testing-stage. When they are shown to improve the quality of learning, they will be implemented in all of the virtual subjects of our Department. The evaluation plan will consist in verifying the different aspects by carrying out surveys and statistical studies with the students. We emphasize the following among the information that will be handled in the future:

- Percentage of students that have really used these systems;
- To determine the reasons why it has not been used;
- Students' evaluation of the system (positive, neutral, negative);
- To compare academic results with those from previous years.

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Roberto Barchino has a computer sciences engineering degree from the polytechnic university of Madrid. Currently, he is an associate professor in the computer science department of the University of Alcalá and a tutor professor in the national open university, Spain (uned). He has been a visiting professor in the Dipartimento di Informatica e Automatica, university of Rome tre, rome, italy, for five months. He is the author and/or co-author of more than 60 scientific studies (books, articles, papers and investigation projects), some of them directly related to learning technology. He is also a member of the group for the standardization of learning technology in the Spanish official body for standardization (aenor).

José María Gutiérrez has a computer sciences engineering degree from the University of Murcia. He is a Professor in the Computer Science Department of the University of Alcalá, and has been working as a Professor at the Nebrija University. He has participated in many e-learning and b-learning initiatives. He has been co-chair of the IADIS CIAWI Conference for three years and is currently organizing the First International Conference on Ubiquitous Computing to be held in Madrid. Also, he is the author and/or co-author of more than 65 scientific papers and has written a book about mobile devices programming using J2ME (in Spanish) to be used in the MogiGame contest organized each year.

Salvador Otón has a computer sciences engineering degree from the University of Murcia. He is a Professor in the Computer Science Department of the University of Alcalá. He is author and/or co-author of more than 40 scientific papers (books, articles, papers and research projects), some of them related to the use of learning-objects and repositories.

Lourdes Jiménez has a mathematics degree from the Complutense University of Madrid. Currently, she is an Associate Professor in the Computer Science Department of the University of Alcalá and a Tutor Professor in the National Open University, Spain (UNED). She has been a visiting professor in the Dipartimento di Matematicas, University of Rome Tre, Rome, Italy, for five months.