MOBILE E-LEARNING
Support Services Case Study

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Abstract: Currently mobile devices and wireless communications are present in the daily tasks of our lives. m-Learning extends the e-Learning concept by the use of mobile computation and communication technological resources. Mobile computing focuses the paradigm of "anytime, anywhere access" that offers resources for distance education via mobile devices. This paradigm, allow that information is made available to users with greater flexibility and diversity, supporting learning in non conventional places and time schedules. The need for learning throughout life and flexibility of education profiles requires the support and development of new approaches in the educational context and tools to support learning.
This paper presents a distance learning case study at Polytechnic Institute of Leiria. The main objective is the utilization of mobile devices as support tools for course information/contents resources access available in Learning Management Systems (in the presented case study - *Moodle*).

1 INTRODUCTION

The increasing of the computing power for mobile devices such as PDAs and mobile phones, mobile learning (m-Learning) be presented as supporting tools in teaching process. m-Learning complements the benefits of e-Learning in terms of access to information anytime anywhere - "anytime anywhere learning" (Perry2001). It allows for students new freedom, which comes with a choice of where and how they want to access the information.

The main function of mobile devices is to provide immediate communication. In this perspective, the present work represents one contribution for the problematic regarding the availability of contents from the LMS (Learning Management Systems) in mobile devices. The main goal consists in the definition of an architecture using mobile devices to access both administrative information associated to the courses and collaboration/communication information. An implementation of the prototype *mBoard* according to the architecture defined was implemented and presented in this paper.

mboard acceptance tests were performed by the students of Institute Polytechnic of Leiria (IPLeiria) - Informatics Engineering Department (DEI).

This paper is organized as follows. In section 2 we present an overview of applications using mobile devices in the educational area. Section 3 describes the supporting architecture for IPLeiria m-Learning case study. *mboard* prototype and acceptance tests results are presented in section 4 and 5 respectively. Finally, conclusions and future work directions are presented.

2 STATE OF THE ART

There are many researches regarding the applicability of the mobile devices as supporting tools in the educational scope. In this context, it will be presented some of those studies.

Applications to Perform Knowledge Tests. (Ally2007) uses the mobile devices in teaching English as a second language for adults. The contents used in the learning process are interactive,

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allowing students to practice using different types of questions. Indeed, four different types of questions were used in the creation of more interactive grammar exercises. They were easily accessible on mobile devices to test the ability of students. The type of questions were true/false, multiple choice, ordering and correspondence. (Matthee2007) has conducted the study on the use of mobile devices applied to the teaching of mathematics in South Africa. In this country there are low PC penetrations in the country, but that is about three million young people with mobile phones with Java. The MOBI client application is developed in tests on mathematics through mobile devices.

Games as Study Objects. (Liao2008) has developed the mini-My-Pet game that is inserted into the theme of creation/education of animals for PDA. It was developed as having three components: emotional bonding, controlled learning and exposure. The project Programming Mobile Games for Learners (MobiGP) was developed in order to teach the programming language object-oriented C++ to students through mobile games (Hamid2007). The project originated three games to test student's knowledge in C++: SpaceOut, Doggy and Snail. The Wireless Crossword Fan-Tan Game (WiCFG) was designed has an attempt to increase the vocabulary of English students (Lin2008). The game WiCFG represents a type of competition between groups through co-operation between the members of groups.

Learning a Language and also Foreign Language. The Mobile Adaptive CALL (MAC) application - (Uther2005), was designed to help the Japanese people to distinguish phonetic contrasts in the English language through audio. In this application students have to select the correct word from a presented list, and the next word is selected, based on the error rate of the student. Another system was developed for oral practice and assessment of English for students to be used with mobile devices with wireless in the classroom (Yang2005). Another study was presented by (Joseph2005) and describes the photoStudy that serves to support students in learning new words through pictures and collaboration among students. Other example is the PALLAS system (Petersen2008), which is based on real life scenarios and provides access to personalized and contextualized data associated with the teaching of languages through mobile devices.

Mobile Applications Adapted from Desktop/Web Application. (Kainulainen2004) has developed an extension of the application Problem Processing Assistant (PPA) which is a web tool for learning. This tool combines the features of digital portfolios with the functionality of problem. The adaptation of this tool for web access via mobile devices was implemented in two phases, where not all features were included. At first it only took into account the adaptation of digital portfolios and the second phase, was focused on the pre-research of contents. Another example is the study of (Marcelino2008), who had developed the H-SICAS application (Handheld - SICAS) which is the adaptation of SICAS application for mobile devices. The H-SICAS has all the features of the parent application, which is the creation and simulation of algorithms. The application also allows for the creation of the solution by the algorithm flowchart and automatic generation of pseudo-code. It also permits to run the solution in order to validate the correct definition of the algorithm.

These studies differ in technologies and approach to the use of wireless networks, mobile technologies, equipment integrated into devices (camera and video, mp3 players, calendar, browser, etc.). While some choose to create their own resources for learning, others are concerned about the reuse of existing content. Others are theoretical, with emphasis on educational research by the use of mobile devices as a tool to support learning.

While most m-Learning approaches presented are focused on the learning process and resources, the approach presented in this paper is specially focused on academic community communication and interaction processes (professors, students, school coordination, direction boards, etc.).

3 ACHITECTURE

This study is centred in the use of mobile devices as tools to support the education process, specially – availability of administrative information of the courses. Analysis of the overall information related to courses and the learning supporting process lead us to conclude for the need of a specific tool to manage the diversity of information and interactions involved in university level learning. The mobile devices are used as tools for easy obtaining of information about the existing courses without the need of accessing the LMS.

3.1 Considerations

Before the definition of the architecture has been done, the following considerations for the *mBoard* application were assessed:

Platform: the objective is the use of application to be adopted by the greatest number of students. Therefore, we choose to implement the application in Java ME;

Get Information: Web Services are used for communication between the application and the LMS;

Contextualized and Personalized Access: Users should be able to set the terms for the application to use, ensuring an application for adjustment of terms used by the LMS platform and also the ability to configure what types of content should be displayed;

LMS: the architecture should not depend on any data model of a specific LMS.

The contents to be displayed by the *mBoard* application are events; news since the last access; grade notes (marks); new posts in forums and blogs; new messages and activity reports.

3.2 Steps in Designing the Architecture

The definition of technical functional and non functional requirements for the *mBoard* system were done using UML (Unified Modelling Language) notation. For the sake of simplicity only a few diagrams of structural level and representative features are presented. Class Diagram is presented in Figure 1, Authentication and data retrieval functions are implemented by the use of Web Services provided by the LMS system and are depicted in the Activity Diagrams of Figure 2 and Figure 3 respectively.

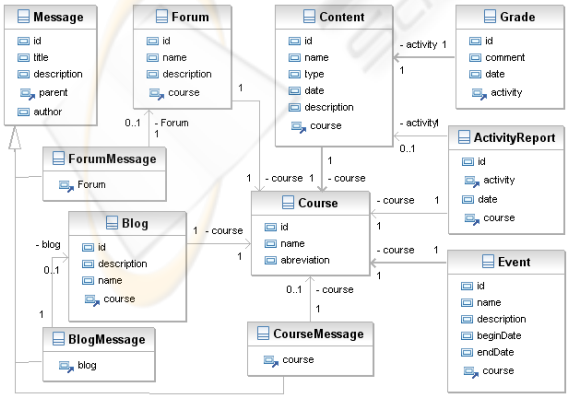

Figure 1: Class diagram of *mBoard* architecture.

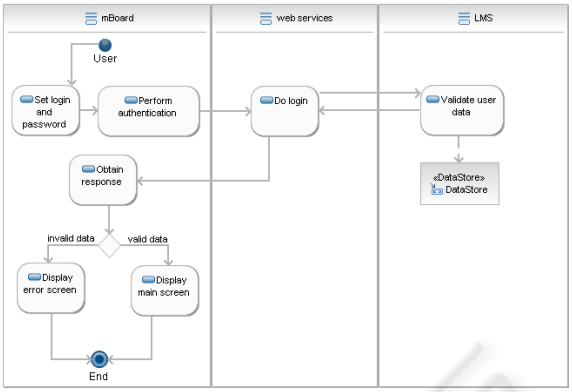

Figure 2: Authentication activity diagram.

The users to authenticate on the *mBoard* application must provide the same authentication data they use to login in the LMS.

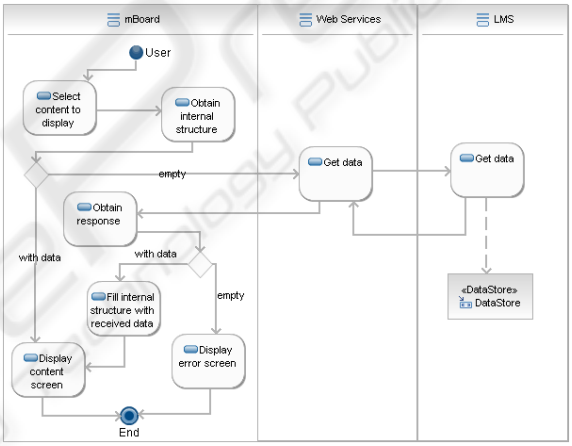

Figure 3: Data retrieval from LMS activity diagram.

The architecture we propose is derived from a key generic reference architecture defined by (Trifonova2003). In our proposal, we are going to improve some aspects that were not very well defined in the generic architecture. The architecture presented in the above study consisted in delegate to the mobile device the responsibility of the adaptation/conversion of the information to be displayed. Due to the limited processing power and memory of mobile devices, it was chosen to not include the adaptation/conversion of the LMS data in the application. Instead, it was included in the services that the LMS should provide. A new module was introduced for this specific purpose, consisting in preferences configuration by the user.

The architecture, shown in Figure 4, contains three layers: the upper layer - represents the client mobile application; the intermediate layer - is composed by the web services need for the *mBoard*

application; and the lower layer - represents the LMS, that is going to contain all the information need by the application, corresponding to the logical layer of the architecture.

The most important advantage of this architecture is that by isolating the implementation of the Web Services need for *mboard* application, it enables the use of different types of LMS, not requiring the adoption of any specific LMS.

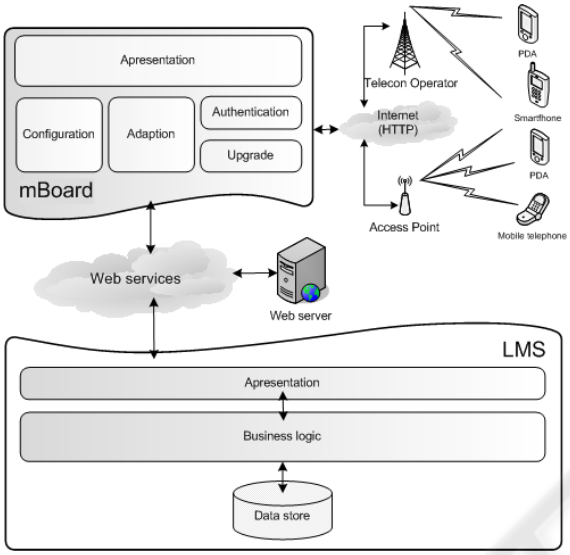

Figure 4: Architecture of *mBoard* system.

3.3 Upper Layer

In this architecture, the upper layer is the application *mBoard*, which will be installed in the mobile devices.

The application contains five modules:
Authentication Module: for *mboard* end user identification in the LMS, using the same authentication data used in the LMS.

Configuration Module: is constituted by two types of configurations. One consists in the definition of the connection to the LMS, i.e the address of the Web Services provided by the LMS. The other is related to the customization of the application, like the terms used and types of contents that must be displayed in the *mBoard* application.

Module for the Adaption: is responsible for the adaptation of contents in HTML format to text format. When it is detected that some attribute of the received content is in HTML, this module is responsible for its transformation into text.

Module for the Presentation of the Information: is the main module of *mBoard*, it is responsible for the information retrieval from LMS and let it available for *mboard* users. This module invokes the Web Services provided by the LMS and presents it to the users.

Upgrade Module: is responsible to ensure automatic upgrades for the *mBoard* application, i.e. this module minimizes user interactions in *mboard* versioning and configuring tasks.

3.4 Intermediate Layer

This layer represents how *mBoard* application is going to obtain the contents existing in the LMS and how contents will be then displayed to the users, through Web Services. It is also constituted by a Web Server responsible to provide data about existing versions of *mBoard* and to perform upgrades.

3.5 Lower Layer

The lower layer represents the LMS. This layer is responsible by the creation and maintenance of all the necessary information for the application *mBoard*, acting as a provider for the application.

4 MBOARD SYSTEM

4.1 Used Technologies

For the *mboard* core application development, Java ME framework was chosen, because of its wide adoption by mobile devices suppliers and users. Therefore, our application can be used by a high share of mobile device users.

For the designing of the user interface, Lightweight UI Toolkit – LWUIT was used. This toolkit makes very easy the process of creating and compelling UI's that will look and behave the same on all devices using a programming paradigm similar to Java Swing. To invoke the Web Services we used the KSOAP package.

4.2 Implementation

Before moving into the application programming, it was necessary to create a draft of the screens to be implemented in the *mBoard* application.
In the development of the draft we took into consideration some rules related to the orientation of the interfaces for mobile applications (Keogh2003, Gong2004): simplification of the interface; use of

diverse screens and each should only present relevant information (Figure 5, Figure 6, Figure 7 and Figure 8); always provide feedback to the user (middle screen of Figure 5 and right screen of Figure 7), because the mobile user is more impatient with the mobile than the user of a desktop application; consistency: in the "look and feel" uniformity in all of the screens in all of the elements of the interface (ex. names, plan of colors, appearance of the boxes), create methodologies of input/output independent of the device and reuse the same components used in several screens (e.g. commands).

In the login screen, it is displayed the menu option. However, the menu only allows the configuration of the address of the Web Services provided by the LMS, because the authentication involve the LMS through the Web Services. The first time the user accesses the application he must configure this address, otherwise it will not have access to the information.

Figure 5: Authentication screens.

In the setting setup screen, users can select which type of contents they want to be available, as well as defining the term to be displayed.

Figure 6: configuration screen.

On the main menu screen, users can choose the information they want to see. A process bar was added as feedback for the user when the application is performing some processing (e.g., invocation of Web Services). With this feedback the user gets to know that the application is running and not blocked.

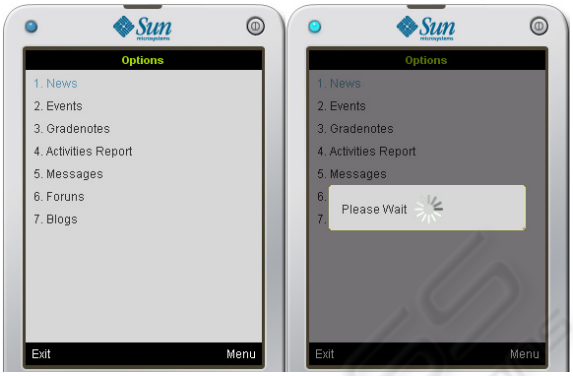

Figure 7: Menu screens.

For the screens presenting the contents of the courses associated to an user, two screens are required: one with the resume of all new information about the type of selected content by the user and the other with the details of the content. The right screen displays a warning message when there is no new information available about the selected content.

Figure 8: Contents screens.

4.3 Tests

This chapter discusses the several tests performed to validate the prototype implementation/functionality.

4.3.1 Tests in the Emulators

Several tests were performed in different emulators available from several suppliers. Table 1 presents a summary of those tests.

4.3.2 Acceptance Tests

To validate the prototype, a group of undergraduate Computer Science students at IPLeiria were chosen to perform the first *mboard* assessment and acceptance tests.

Table 1: Resume of tests performed with emulators.

Brands/ Model		Autentication	Settings	Contens	Comments
Samsung	SGH-B2700	✓	✓	✓	
	F480	✓	✓	✓	
	SGH-E250	✓	✓	✓	
	SGH-J800	✓	✓	✓	
	SGH-M8800	✓	✓	✓	
	SGH - F700	✓	✓	✓	
LG	GD900	✓	✓	✓	
	BL20	✓	✓	✓	
	LX600	✓	✓	✓	
Nokia	N97	✓	✓	✓	
	S40 5rd edition	✓	✓	✓	
Motorola	Qwerty	✓	✓	✓	
	Candy bar	✓	✓	✓	
	G24 - JHMI	✓	✓	✓	
	Touch	✗	✗	✗	Only has the virtual keyboard and I could not access it, so it was possible to test the application
Sonny Ericsson	K750	✓	✓	✓	
	W200	✓	✓	✓	
	W700	✓	✓	✓	
	W950	✓	✗	✓	I could not access the menu, in order to perform the settings
	M600	✓	✗	✓	I could not access the menu, in order to perform the settings
	V800	✓	✓	✓	
	Z550	✓	✓	✓	
	Z800	✓	✓	✓	

In order to gather necessary data to evaluate the *mBoard* prototype developed, it was created an inquiry composed by 14 questions, organised in three sections: the first section was essentially concerned with the installation of the application on the mobile device, the second on the usability and functionality of the application and the last section on the motivation for the use of such a mobile application.

The grades (marks) of the students were published in the LMS and made available only by the *mBoard* application. In a 93 potential users (students) group 15 answers were obtained for analysis. The statistical analysis of the data collected follows.

In Table 2 is presented the success rate obtained about the application installation in mobile devices.

Table 2: Answers percentage of question if application was successeful installed.

Answer	Response (%)
Yes	53.33
No	46.67

In Table 3 is indentified the mobile device suppliers where the application was installed.

Table 3: Answers percentage of question to identity the mobile devise.

Brand	Response (%)
LG	6.67
HTC	13.33
Nokia	46.67
Sony-Ericsson	33.33
Other	6.67

Due to a high rate of application setup failures, a more detailed analysis was made by mobile device models (Table 4).

Table 4: Mobile devices witch student could not install application.

Brand	Model
HTC	TYTN II
	P3600i
Nokia	9130
	E66
	E51
	5610
Sony-Ericsson	W880I

The technical requirements for each of these mobile devices were checked and the analysis confirmed that all devices had the necessary requirements. However, it was noticed that all devices supported applications with the MIDP 2.0 version of Java, and the required information about the application was

defined the version 2.1 for MIDP. This definition in fact was the cause of installation failures.

The results of users classification for application usability (in 1 to 5 scale, where 1 is bad and 5 very Good) are listed in Table 5.

Table 5: Answers percentage of question to classify the application in terms of application usability.

Item	1	2	3	4	5
Authentication	0	0	25	25	50
Navigation	0	0	12.5	75	12.5
Information visualization	12.5	0	75	12.5	0
Usability	0	0	12.5	75	12.5
Screens	0	0	50	37.5	12.5

The results of user classification for application feedback (in 1 to 5 scale, where 1 is bad and 5 very Good) are listed in Table 6.

Table 6: Answers percentage of question to classify the application in terms of application feedback.

Item	1	2	3	4	5
Progress messages	0	0	25	50	25
Error messages			25	62.5	12.5
Response time			12.5	25	62.5

For the question "How do you classify the application functionalities? (in 1 to 5 scale, where 1 is bad and 5 very Good)" the answers are present in Table 7.

Table 7: Answers percentage of question to classify the application in global.

Item	1	2	3	4	5
Functionality	0	0	25	50	25

Table 8 presents the answers for the question "Do you think that is beneficial to access information present in LMS via mobile devices?"

Table 8: Answers percentage of question about the beneficial of use this kind of application.

Answer	Response (%)
Yes	93.33
No	0
Without opinion	1 6.67

The answers for the "Identify the main cause to not use the application" question are listed in Table 9.

Table 9: Answers percentage of question to identify the main cause to not use the application.

Answer	Response (%)
Price	80
Device limitation	13.33
Limited information visualization	6.67

5 CONCLUSIONS

In this paper we presented a new method to make traditional e-Learning content available to mobile devices users, with no need to extra work of content adaption from LMS in mobile devices.

In the case study, we observed a good acceptance of students to this new approach for educational information access. According to the preliminary results from the acceptance tests we also conclude that mobile devices configuration and versioning management is one of the critical success factors for m-Learning applications deployment. In addition to configuration and versioning management improvements we also need to assess the core functions of m-Learning applications from the point of view of professors, student and staff. Other future working directions related to communication models, economical cost analysis, etc. were identified.

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