Implementation of Location-Aware M-Learning System

Joel J. P. C. Rodrigues\textsuperscript{1,2}, Iúri D. C. Veiga\textsuperscript{2}, and Binod Vaidya\textsuperscript{1}

\textsuperscript{1}Instituto de Telecomunicações, Covilhã, Portugal
\textsuperscript{2}Department of Informatics, University of Beira Interior
Rua Marquês d’Ávila e Bolama, 6201-001 Covilhã, Portugal
Phone: +351 275 319 891; Fax: +351 275 319 899
joeljr@ieee.org, iuridavid@gmail.com, bnvaidya@co.it.pt

Abstract—Mobile learning (m-learning) is a technology with a huge potential to be used in distance learning. This technology is developed for mobile devices. This paper describes the proposal of a location aware m-learning system for personal digital assistants (PDA) with global positioning system (GPS) receivers incorporated. Location-aware support is provided using GPS. This application was designed and developed taking into consideration the advantages and disadvantages of mobile devices. M-Learning application uses GPS to trigger contents associated to pre-established geographical coordinates and to evaluate students in those pre-established locations. The main contribution of the M-learning application described in this paper is the possibility to evaluate students in pre-defined locations and to integrate the evaluation results into a learning management system (LMS). The proposed solution was evaluated and validated with success, and it is ready for use with the Aulanet learning management system, from EduWeb.

Index Terms—Mobile learning, location-aware computing, mobile computing, global positioning system.

I. INTRODUCTION

N owadays there is a successful usage of mobile technologies in learning environments. One of the reasons of this success is the fact that mobile devices such as mobile phones, smart phones, and personal digital assistants (PDAs) have a huge technological development. The development in the mobile computing has changed the way we communicate and work. The new generations of these devices not only are becoming increasingly more powerful in terms of processing speed, storage capacity and operating time but also have essential functionalities such as short message service (SMS), multimedia message service (MMS), web browsing and integrated components such as GPS receivers or card readers. These technologies enable the construction of applications of mobile learning (m-learning). In fact, with the advances in emerging wireless and mobile computing technologies and superior learning theories, mobile learning has been widely popular in various domains in the modern world, which is considered as a rudimentary learning style in the future.

M-learning [1-3] is a technology with a huge potential to be used in distance learning. There are various interpretations for the meaning of m-learning in the academic community. M-learning can be defined as a form of learning that occurs when the learner takes advantage of learning opportunities offered by mobile technologies (like mobile phones, smart phones, PDAs or laptops) or any form of learning that occurs when the learner is not in a predetermined and fixed location.

M-learning is used to provide a learning environment without space and time restrictions. Students may learn according to their wishes and are able to manage their own studies without impositions to be in a classroom with rigid learning schedules.

M-learning paradigm can be categorized into many different categories, according to its main characteristics such as portable devices used, mobility, location and context. In this paper, we basically deal with mobile learning according to its relation with the location. Thus, learning activities with m-learning may be focused on the student’s location. With this type of m-learning, students may learn historical events in the same localities where these events happen or also may learn new subjects in outdoor activities, such as team spirit, leadership, creativity and innovation, among others.

Location-aware computation refers to the applications with capacity to recognize and adapt their actions according to the current locations [4]. It is not possible to create learning content for activities that take place in environments without computers or network connections and assessment for learning management system (LMS) [5].

The prime objective of this work is to propose and create a location-aware m-learning application for PDAs that uses GPS to trigger contents associated to pre-established geographical coordinates and to evaluate the students in those pre-established locations. The evaluation results will be further integrated into a LMS. With these features, it will be possible to develop training actions integrated in outdoor activities in such places where there is no access to networks such as Internet and computers.

The rest of the paper is organized as follows. Section II focuses on related works about location-aware and m-learning systems. Section III describes the requirements, application
architecture and technologies used to create this application. In section IV the system is evaluated and validated. Finally, section V presents the conclusions and point directions for future works.

II. RELATED WORK

This section reviews related works on mobile computing, location aware services, and relevant approaches. The system proposed in this paper gathers contributions from the available proposals described below.

A. Mobile Computing

The mobile computing paradigm is one of the emerging technologies in the modern era. However, there are a lot of challenges to meet. This makes mobile computing a hot research and development area [6].

In [7] authors present the secure and open mobile agent (SOMA) distributed framework that implements three mobile computing services - user virtual environment (UVE) (providing users with a uniform view of their working environments independent of current locations and specific terminals), mobile virtual terminal (MVT) (extending traditional terminal mobility by preserving the terminal execution state for restoration at new locations), and virtual resource management (VRM) (allowing mobile users and terminals to maintain access to resources and services by re-qualifying the bindings and moving specific resources or services to permit load balancing and replication).

B. Location Aware

There are several kinds of technologies that can determine the user's location, such as, GPS, differential GPS, mobile phones, etc. With the development of PDAs with GPS sensors integrated, this opens the door to location-aware applications, especially to applications that trigger events connected with the current user's location [8-10]. With location-aware computing, it is possible to create applications for mobile devices that use information about the location to provide access to services.

In the paper [11], the authors have shown that advances in location-sensing technologies and factors promoting wide-scale deployment will make coarse-grained location information widely available.

This paper deals not only on location management and location update strategies but also user mobility [6].

C. Related Applications

In the related literature, several m-learning applications are available and important contributions are described below. In [12], the authors present the development of mobile learning environment that follows a user-centered design approach.

This m-learning design framework is used to identify appropriate design requirements in practice.

In the paper [13] discusses the design and development of a series of prototypes of a multimedia learning object for mobile phones. It also presents the development of four iterations of a prototype with refinements made at each stage in the light of peer testing and student feedback.

A mobile learning system taking into account learning context, so called contextual mobile learning is presented in [14]. In this system, one can learn just-in-time in his daily lives whenever he needs to learn, using mobile computing devices.

III. M-LEARNING SYSTEM

This section addresses the system requirements, architecture and technology used to develop this m-learning system.

A. System Requirements

M-learning application has to have a user-friendly user’s interface and capable to operate in remote environments where there is no Internet connection. The system must have the ability to display learning contents that use rich multimedia (audio, images, and video) which are saved locally and will work in a standalone mode.

In order to be location-aware it needs to communicate with a local GPS receiver. Nowadays, too many PDAs already include this feature then it easy to obtain a GPS signal. In terms of quality of GPS reception, we assume it with good conditions since this system is designed for outdoor activities.

B. System Architecture

The system architecture of the proposal is illustrated in Figure 1. It includes a learning management system (LMS), a set of PDAs that will be handled by different students, and a repository. The LMS will hold the results of the assessments and include it in the corresponding student record. Each PDA has the m-learning application installed.

![Fig. 1. System architecture.](image-url)
It is important to mention that a LMS may be defined like a software application that have functionalities prepared to deliver, report and administrate learning content and evaluate learner progress [5].

At the end of each training course, the m-learning application communicates wirelessly and save a file with evaluation results in the File Repository. Finally, the information that is in the File Repository will be imported by the LMS. M-learning application runs in standalone mode. The interaction with the LMS will occur only at the end of the training process.

Figure 2 shows the architecture of the application. The m-Learning application may be described considering the following main five blocks: the positioning block, the contents block, and the graphic user interface (GUI) block, the communication module block, and Application Management block. Briefly, the positioning block received the GPS signal and sends the corresponding information to the application management block. The contents module stores the multimedia contents. The GUI was designed to offer an easy interaction between the user (student) and the application.

Following, a detailed description of each module of the application architecture is presented. The positioning module is composed of a GPS sensor and an API to control and communicate with the GPS. The contents module may be defined as a repository where all multimedia contents (audio, image, and video) and their corresponding configuration files are stored. The GUI defines the methods that are available to interact between users (students) and the application. The communication module drives the communication between the m-learning application and the files repository. It also stores several files including the files with scores of evaluated students and the corresponding methods needed to create and read these files. The files repository module interacts with the LMS. Finally, the application management module manages the communication between all modules. This module is the core of the application as it receives coordinates sent by the positioning module (deciding whether the application should launch a event), and deals with the actions sent by the GUI (such as changing content, answering questions, exiting from the application, changing course, and all the options that the user may choose). With these actions received from GUI and positioning module, the application management module determines the inter-module communications.

The flowchart of this module is presented in Figure 3.

![Fig. 2. Application architecture.](image)

![Fig. 3. Application flowchart.](image)
(multimedia and configuration files) of the contents module is valid. Then application module sends the status of content validation to GUI configuration, and wait for further communication.

After this step, the student may use the GUI to start the GPS unit. To perform this operation, GUI sends a request to application management that starts the GPS (application management automatically receives information about location). Following, when the application management receives a GPS signal, it checks if any associated event exists to this coordinates (if there is some events associated, it sends the event information to the GUI). If there is any evaluation associated with this event, application management communicates with the GUI and also sends the information to the communication unit (this is the module that has algorithms to save the files and will be used to integrate the results of students assessment with the LMS).

C. Technologies

M-learning application is designed for PDAs with Windows Mobile 6 or higher versions. Two major solutions can be used for developing applications to these devices, which are the following: Java 2 Micro Edition (J2ME) Connected Device Configurations (CDC) and .NET Compact Framework (CF). The .NET CF is used in the proposed system, mainly because there is no need to install virtual machines (that change from vendor to vendor). The .NET CF runs on common language runtime and has native APIs to use Windows Mobile and eXtensible Markup Language (XML) files.

Microsoft Visual Studio 2008 Professional Edition IDE (Integrated Development Environment) has included the SDK V6.0, which offers an emulator of windows mobile 6. To test the GPS functionality, a GPS emulator (FakeGPS) was installed, which allows testing basic features needed to develop this application. This application is built on C# [15].

IV. System Evaluation and Validation

This section presents the system evaluation and validation of the proposed system. It was also customized and validated to interact with a Portuguese LMS, called Aulanet [17]. Before being focused on the application, we will explain some basic concepts needed to understand how the application works. The first concept is the event concept. In this sense, it consists of a location (latitude, longitude) where the event will be triggered and contents like text, audio, image, video, and evaluation (questions). The second concept is the route that consists in a set of events and information of the training aids.

The training contents of m-learning application are defined in an XML configuration file where the event coordinates and the paths to all multimedia contents related to those coordinates are stored (in the future one application will be developed to generate these kinds of files).

M-learning application has a user-friendly interface that may be seen in Figures 4 and 5. In the initial window (Figure 4a), a student can select the file with the information of the route training, after the file validation the user can have access to enter the training.

![Fig. 4. M-learning application (a) route description and (b) localization map window.](image)

When a student enters in a route (Figure 4b), he will see a window that gives a brief description of what will happen in this training course. This text description contains information about the route, places to visit and the training duration. In this window, besides these details about the route, the student can use “Start Route” button that offers the possibility to start the GPS and initialize the route (Figure 4b). This new window shows the map with an area where the events will happen (in three different zoom levels), the locations where the training events will happen (marked with a blue spot), and the trails that will give faster access to these events (painted in green color).

In order to identify the local’s identification, the application marks a red dot on the map for each received coordinate from GPS. With this solution the student can know which places he already visited and the ones that he still needs to visit.

When the application receives a coordinate from the GPS, which is within the area of one event, it triggers by displaying the event’s contents (audio, text, image, video, and evaluation). Audio contents are displayed in a new window, where the user can control volume, turn-on and turn-off the audio with information of the place where he is at that time. The video content consists of invoking the mobile windows media player with a video about the surroundings (Figure 5a) shows an example of the invocation of a video content. The image content type is shown in a new window with a small photo gallery with a set of images related to the event. The text content is built on a window with detailed information about the event location.

Finally, the evaluation content can be displayed in a window where is possible to assess the knowledge that students learned in that location. This may be carried out using the following three types of questions: multiple choice questions (Figure 5b is an example of such question), true or false questions, and subjective questions (where the user can enter text with the correct answer). In order to complete the questionnaire session, the student needs to press the submit
button. This button is used to store the answers in the file that later will be transferred and incorporated into the LMS. The LMS used to test and validate the system is the AulaNET [16], from EduWeb [17].

![Fig. 5. M-learning application (a) video event and (b) evaluation event.](image)

V. CONCLUSIONS AND FUTURE WORK

This paper proposed and described a new location-aware m-learning system in detail. The system was evaluated and validated through a real use and following a real case. Exhaustive studies were performed by EduWeb team, research team, and several students. The proposed m-learning application is ready to assess students in pre-defined locations. The evaluation results are transferred wirelessly and easily imported by the LMS AulaNET, from EduWeb.

For future works, this application can be extended by incorporating some changes, such as the ability to recognize contents created in Adobe® Flash® and offer the possibility to insert and save student’s answers directly in the LMS through a network connection. The development of the later functionality will make the system architecture more robust and efficient in the sense that the answers may be sent to the LMS via the file repository or directly from the PDA.

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