A TRAINING PROGRAM FOR MOBILE TECHNOLOGY: THE FIRST YEAR OF THE EMBEDDED ACADEMY PROJECT

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ABSTRACT

Mobile computing is becoming a powerful technology for higher education students and faculty, making possible to access learning materials, advanced learners and teachers anytime, anywhere. However, before developing applications to support educational activities, it is im¬portant to define content and courses for efficiently teaching the mobile technology discipline. This paper describes technical and pedagogical experiences gained from the first year of the Embedded Academy Project, which aims the diffusion of knowledge related to mobile devel¬opment technologies, such as J2ME, Symbian, and OMA. The curriculum content and sequence of the training course are presented. Moreover, assessment data, results, and lessons learned are discussed.

Keywords: Mobile Technology for Education, Mobile Teaching, Mobile Learning

I.   INTRODUCTION

In recent years the advance in technology is making feasible to incorporate more computing power in many devices that people use. Mobile phones and other mobile devices are becoming key devices to help people and corporation to perform daily tasks. The actual scenario points to the need to develop many new applications and businesses based on mobile phone technologies in different ways. On the other hand the Internet and the Web have promoted the development of applications to allow individuals to change their behavior. Daily tasks can now be performed without the need to move from home or work, such as planning trips, payment of bills, the integration and interaction in virtual communities, among many other activities.

Nowadays, continuous advances in technology have allowed a rapid proliferation of advanced mobile devices, such as personal digital assistants and smart phones. Within this context, while envisioning the future, such advances are rapidly allowing users to have wide access to information using mobile devices, such as smartphones and handhelds, in ubiquitous wireless networks [1, 2]. It is important to point out that in the IEEE Spectrum's 40th anniversary issue, 40 leading thinkers from the science and engineering answered the following question, among others: "What technology will have the biggest impact in the coming decade?" [3]. Mobile-related technologies are the most voted (7), followed by bioinformatics (6) and nanotechnology (5).

The impact of the mobile technology on the education is imminent. Several applications that make use of mobile computing are becoming a powerful technology for higher education students and faculty, making possible to access learning materials, advanced learners and teachers anytime, anywhere. However, before using the mobile technology power to support educational activities, it is needed to answer a simple question: how to teach mobile technology? Since this discipline gathers hardware and software disciplines, what are the content, courses, and methodology for efficiently teaching it?

The Embedded Academy Project (http://www.embeddedacademy.org) is a technological research cooperation program between Nokia Brazil and the Electrical Engineering Department with the collaboration of the Computer Science Department, Federal University of Campina Grande, aiming at the development and diffusion of knowledge related to J2ME (Java 2 Micro Edition) [4], Symbian operating system [5] and OMA (Open Mobile Alliance) [6].

The J2ME platform implements the Java language for devices with low memory and processing resources, such as cell phones. Symbian is a company that licenses the Symbian operating system for the largest mobile phone companies in the world, such as, Nokia, Ericsson, Panasonic, Samsung, Siemens and Sony Erics-

son. Symbian is an open multitasking operating system that is a standard for cellular phone software development. It has been developed for wireless devices as well as devices with low resources. The OMA is composed of two hundred companies including the world's leading mobile operators, device and network suppliers, information technology companies and content and service providers. OMA makes available different standards to the development of mobile services.

In this paper, technical and pedagogical experiences gained from the first year (2004) of the Embedded Academy Project are described. The curriculum content and the chronogram of the training course are presented in Section 2. In Section 3, pedagogical issues and the project-based learning approach are discussed. In order to provide information related to strengths and weaknesses of the curriculum content, assessment data and pedagogical results are shown in Section 3. Also, lessons learned and the next steps of the project, including the second year aims and objectives, are discussed in Section 5.

2.   CURRICULUM CONTENT AND COURSE CHRONOGRAM

In what follows, the training program for teaching mobile technologies related to the first year of activities and courses of the Embedded Academy Project is described. It is important to notice that all the courses are included in the undergraduate curriculum, being part of the regular Electrical Engineering undergraduate course. Computer Science students can take the courses as optional. The program schedule is shown in Figure 1.

Course	Lectures	April	May	June	July	August
OOP	45		▓	▓	▓	
CPL	30				▓	▓
ESA	30		▓	▓		
EOS	30					▓
GSM	30	▓				
GPRS	30	▓				

Course	Lectures	August	September	October	November	December
ESSE	30	▓	▓			
PSOAE	30		▓	▓		
SFM	30			▓		
Project	240	▓	▓	▓	▓	▓

Figure 1: Technical Program Schedule

Object Oriented Programming (OOP):

The objective of this course is to develop skills related to programming and problem-based learning and introduce the basic concepts of objects, classes and instantiation, as well as attributes, methods, parameters, variables, expressions, primitive operators, attributions and return values. Also, the aim is to teach the use of control structures and conditional commands and additional object oriented concepts: types, abstract types and interfaces, abstract classes, polymorphism, dynamic bidding, inheritance, casts, and how to deal with errors and exceptions. Next, recursion concepts, loop invariants and guards and data structures concepts such as vectors and collections are introduced. Concepts related to basic concepts of design and concurrency and distribution in Java as well as the comparison between Java and C++ are discussed.

C++ Programming Language (CPL):

the objective of this course is to introduce C++ language basic elements, constructors, de¬structors, control structures, functions, arrays, pointers and references. Also, parameter passing, exception handling, multiple inheritance and overload of operators are presented.

Embedded Systems Architecture (ESA):

in this course, basic concepts of embedded systems, such as microprocessors, microcontrollers, microconverters and digital signal processors are introduced. Also embedded systems architecture and programming as well as digital systems interfaces and communication protocols are discussed.

Embedded Operating Systems (EOS):

in this course, advanced applications development based on Symbian OS are discussed. System services, device drivers, fun¬damental OS aspects, software tools and organization, and device drivers models are also presented. Moreover, user library E32, resource management, descriptors, arrays, file server, stream storage, active objects, and client/server architecture are discussed.

Global System for Mobile Communications (GSM) and General Packet Radio Service (GPRS):

in this course the basic concepts basic concepts of GSM and GPRS, as well as TCP/IP and other related protocols are introduced.

Embedded Systems Software Engineering (ESSE):

the objective of this course is to introduce the basic concepts of software engineering including modelling and design based on UML. Emphasis in o developing advanced applications based on the Symbian OS including user interface design and development.

Mobile Embedded Applications Development (MEAD):

in this course, aspects related to the Symbian OS engine development and APIs and Dynamic Linked Libraries (DLLs) are introduced. Active objects, client/server applications and sockets are detailed. Also, concepts related to the database management system and binary compatibility as well as applications support is introduced

Software Frameworks for Mobile Embedded Systems and J2ME (SFM):

In this course an introduction to mobile devices, embedded applications and J2ME are introduced. User interface, persistent data storage and network and Web services are detailed. Also, J2ME packages, and optimization of applications, as well as a case study are detailed.

3.   PEDAGOGICAL ISSUES: APPLYING A PROJECT-BASED LEARNING METHODOLOGY

The main objective of the set of courses thought to the students was to provide the basic knowledge and skills on the development of mobile applications based on J2ME and Symbian. Also, some basic concepts related to software modelling based on UML were introduced in order to provide the necessary knowledge on abstract design techniques, such class diagrams, use case diagrams, and message sequence charts, to start the design and development of the projects before starting coding.

In the context of Embedded Academy Project, a project-based learning approach for teaching mobile software development has been applied. Eleven projects has been defined, some of them proposed by the students, other proposed by the teachers. The target platform for all projects is the Mobile Phone Series 60, Symbian OS v7.0s, Nokia 6600. In a first step students coded the applications using simulators for both J2ME and the Symbian OS. After, the students deployed the applications on the target device and performed running tests. In what follows, the goals of such projects are described.

Mobile Menu:

develop a J2ME application that makes possible to access the menu provided by restaurants, snake bars, and bars. A client application can access a WEB server using a GPRS or bluetooth connection and select item and place orders.

Mobile Virtual Pet:
> develop a J2ME mobile version of the well known *Tamagotchi's* game.

Traffic Infraction System:
> develop a J2ME application that provides information about traffic infractions, sup¬porting the traffic officer. The officer can access a database using a GPRS connection in order to verify the status of the driver and/or vehicle and issue tickets.

Workflow:
> develop a J2ME application that allows to monitor and validate workflow procedures performed by human operators in field operations. A server workflow application, based on a GPRS connection, issues tasks to be executed by the operator in the field. The operator then identifies the device to be operated, a pressure valve for instance, validates it based on photograph sent by the server, executes and confirms the operation.

Lego Mindstorm Controller:
> develop a J2ME application to program and control a Lego mindstorm robot by means of a bluetooth interface.

Interactive Multimedia System:
> the objective is to develop a Symbian application to allow users to download video and audio files us-ing the bluetooth interface. The system also must support video and audio streaming.

Mobile Industrial Drive Interface:
> develop a client Symbian application that allows to substitute devices for human-machine interface in the context of industrial drive systems. The application allows a human operator interacts with the drive systems remotely based on either a bluetooth or a GPRS connection.

Universal Remote Control:
> develop a Symbian application that makes possible to use the mobile phone as a universal remote control. The remote control is compatible with the most known electronic manufacturers in the market. Basic functions are implemented, such as: for TV, on/off, channel +/-, volume +/-; for VCR/DVD/SOUND, on/off, play, stop, pause, forward, reverse, volume+/-.

Middleware:
> develop a middleware for remote procedure calls based on the Symbian OS. The mid¬dleware hides the complexity of the distributed application, providing mechanisms for the developer to make remote proce-dures calls.

Time Limited Call:
> develop a Symbian application that limits the time of a mobile phone call. The application must inter-rupt a running call when the predefined time defined by the user is elapsed.

Let's Talk:
> develop a Symbian application that can act as a chat. A bluetooth network is used to identify people whose profiles matches the user's profile, and invite them to chat.

> The main objective of the projects was to verify programming skills of the students. Also, user in-terface design as well as how to establish and manage both bluetooth and GPRS connections for data transfer were developed. All Symbian applications were developed using C++ language.

4. ASSESSMENT DATA AND DISCUSSION

The students involved in the program were selected from both, the undergraduate courses on electri¬cal engineering and computer science. The process to be accepted on the program included the grade index, a curriculum vitae analysis, and an interview. From a total of 129 students applied for the program, 40 were selected, 30 from the undergraduate course on electrical engineering and 10 from the undergraduate course on computer science. The major requirements for a student to be accepted were: (i) students should have a score of at least 7.0; attending classes for at least the 4th term (a scholar year is divided in 2 terms); and, should not be finishing the course in the next 1 1/2 terms. Most of the electrical engineering students had only basic programming skills, while computer science students were more advanced.

The evaluation of the students was based on two parameters: grades obtained and the results of the projets. All the students were able to get sufficient grades in both aspects. Two of the projets could not be completed: Middleware and Universal Remote Control. The major problem with the first one was difficulties to integrate the stubs for remote procedure call with the underlying communication protocol, in this case bluetooth. In the second project that could not be completed the main problems were related to the granularity of time used by the Symbian OS to schedule active objects and the level abstraction provided by the infrared application programming interface. It was not possible to send raw binary data using the infrared interface, only ASCII characters using a asynchronous serial protocol could be used. These two problems did not allow to send raw bit stream of data as require for most commercial appliances such as televisions, CD players and many others. From the evaluation of the results of the projects it was possible to identify that more emphasis must be done on communication protocols such as bluetooth. All the applications developed based on GPRS could be completed without major problems. It has been observed, based on these results, that the application programming interface (API) for J2ME is much simpler to use than the Symbian API, in order to use the same protocol, in this case bluetooth.

5. LESSONS LEARNED AND NEXT STEPS

In order to satisfy the current needs to develop mobile software applications a program for training undergraduate students from both electrical engineering and computer science have been detailed. The program is defined to be executed in a time frame of two years and a project based approach has been chosen as the key pedagogical method. The objective is to develop basic programming skills on J2ME and the Symbian operating system for the first year and software engineering focused on mobile software development for the second one.

For the first cycle, a series of changes in the course contents and execution sequence have been already defined. First, based on the observations that we have made, the J2ME course will be offered immediately following the Object Oriented Programming and Java course. By the end of the J2ME course all the students will execute a J2ME project. The C++ programming language will be based on an approach that takes into account that all the students had already developed solid knowledge on Java programming. Therefore, the C++ will be tough considering this. As was pointed out before, half of the projets were developed in J2ME and half in C++ for the Symbian Operating System. The embedded systems course will be based on the architecture of Texas Instruments OMAP 1510 and 1610 processors, that are the actual processors of the smartphones used in the project. Also, some basic knowledge on Embedded Linux will be introduced in the Embedded Operating Systems Course.

It must be pointed out that in the scope of the Embedded Academy Project it was initially planned a first year or basic courses and project oriented activities, that have been reported on this paper. For the whole project a second year have been already defined. The focus on the second year is on software engineering. It is planned that the students will be able to acquire knowledge and skills on the following topics: design patterns [7], software development processes with emphasis on agile methods [8], software architectures [9], and Embedded Linux. The main approach for this second year is based on the concept of software factories. By the end of the first year the students participate in a Workshop of Mobile Applications Development. The students had the opportunity to present the results of the developed projets.

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REFERENCES

[1]   Mark Weiser. The Computer for the 21st Century. *Scientific American*, 265(3):94–100, Septem¬ber 1991.

[2]   M. Satyanarayanan. Pervasive Computing: Vision and Challenges. IEEE *Personal Communi¬cations,* 8(4):10–17, August 2001.

[3]   Ashton Applewhite. The View from the Top. *IEEE Spectrum*, 41(11):36–51, November 2004.

[4]   Sun Microsystems. Java 2 Platform, Micro Edition (J2ME). http://java.sun.com/j2me/. Ac¬cessed in 01/10/06, 2004.

[5]   Symbian. Symbian OS -The Mobile Operating System. http://www.symbian.com/. Accessed in 01/10/06, 2004.

[6]   OMA. Open Mobile Alliance. http://www.openmobilealliance.org/. Accessed in 01/10/06, 2004.

[7]   Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides. *Design Patterns.* Addison-Wesley Professional, 1 edition, January 1995.

[8]   Alistair Cockburn. Agile Software Development. Addison-Wesley, 2001.

[9]   Clemens Szypersky. Component Software, Beyond Object-Oriented Programming. Addison-Wesley, 2002.