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ABSTRACT

This paper focuses on the use of Java Bluetooth wireless technology for evaluation of student performance in classroom. First, an introduction to Bluetooth wireless technology is given. Second, use of Java technology for developing wireless applications is explored. Third, a framework is given for identifying the processes involved in education that can make use of mobile technology. Finally, a case study is presented on wireless classroom application for student evaluation.

Key words: Bluetooth, Java API for Bluetooth Wireless Technology (JABWT), wireless classroom applications, evaluation of student performance

INTRODUCTION

Mobile technology has brought tremendous potential and opportunities for educators to enable and deliver learning in ways that could not have been accomplished before. With its unique features and functions such as mobility, reachability, localization, and personalization, mobile technology shows considerable promise in supporting and delivering education as compared to the traditional means. Mobile technologies that can be or has been used to support education include WAP (Uther, 2002; Trifonova and Ronchetti, 2003), Wi-Fi (Batten et al, 2003; Yerushalmy and Ben-Zaken, 2004), Bluetooth (Alexander, 2004; Chang et al, 2004), and SMS (Carroll, 2002; Thornton and Houser, 2004; MDA, 2004).

In this paper: The next section (section 1) presents an overview of the Bluetooth technology and the essential Application Programming Interfaces (APIs) for of developing Bluetooth applications with Java. Section 2 presents a framework to identify the different study processes. Section 3 presents a case study on mobile classroom application for student evaluation. Section 4 presents the managerial implications.

Developing Mobile Applications With Bluetooth

A very short introduction to Bluetooth technology and the Java Application Programming Interface (API) is given in the following subsections. There are numerous references available on Bluetooth technology (e.g. Bala Kumar, 2004; Halsall, 2005). For introduction to Java Bluetooth API, see Yuan (2005), Bala Kumar et al (2004), Hopkins and Antony (2003).

Bluetooth Wireless Technology

The Bluetooth is an open standard that is governed by the Bluetooth Special Interest Group (SIG) lead by nine major players of the computer industry and more than 2000 additional companies as members. This enormous support from the computer industry ensures that Bluetooth become a widely adopted technology. Some of the important characteristics of Bluetooth is given below:

Bluetooth Radio Technology: Bluetooth communication occurs in the unlicensed Industrial, Scientific, and Medical (ISM) band at 2.4GHz. A typical Bluetooth device has a range of about 10 meters. Bluetooth supports both data channel (packet switched asynchronous connection-less link - ACL) and voice channel (circuit switched synchronous connection-oriented link - SCO) communications with a total bandwidth of 1 Mbps. Bluetooth also supports a combined data-voice SCO packet.

Piconet (also known as 'wireless personal area network'): Within a piconet, one Bluetooth device can acts as a master and there can be up to seven active slave Bluetooth devices. In addition, a piconet can support up to 255 non-active slaves that are waiting to be connected (called parked slaves). All slave devices must be located within a

radius of maximum 100 m (typically 10m) of the master device. Thus, a piconet covers a small area such as a classroom or an office. This means, piconet can be used to set up a spontaneous ad-hoc conferencing involving multiple Bluetooth devices like laptop computers, mobile phones, PDAs, Pocket PCs, smart phones, Tablet PCs, etc. *Bluetooth Protocols*: To perform some basic functions, Bluetooth provides a number of higher-level protocols (e.g. for the basic functions like service discovery and serial communication) and lower-level protocols (e.g. for packet segmentation and reassembly, protocol multiplexing, and quality of service).

Java API for Bluetooth Wireless Technology

There are generally two different platforms available for developing Bluetooth-enabled wireless applications for mobile devices: 1) the .NET platform, and 2) the Java Enterprise Edition (J2EE) platform and its vendor specific implementation. This paper uses J2EE simply because of practical reasons (the university teaches Java language courses only). Whether or not J2EE is better than .NET for developing Bluetooth-enabled applications is not discussed here; it is suffice to say that according to our experiences, we see little difference between these two approaches. For further information on mobile application development on .NET platform, see Fox and Box (2003).

Java API for Bluetooth Wireless Technology (JABWT): JABWT is the basic API that supports development of Bluetooth-enabled software on the Java platform. JABWT consists of two optional packages (Ortiz, 2005):

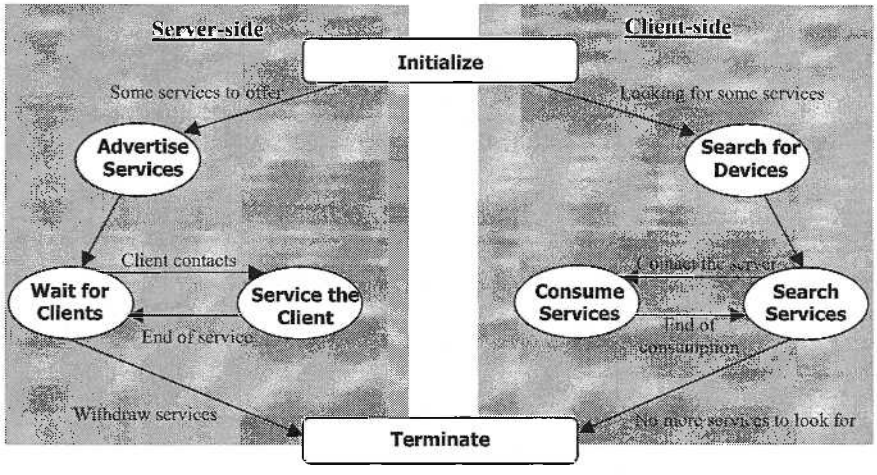

Figure-1: State diagram for server-side and client-side activities

The core Bluetooth APIs expose the Bluetooth protocol stack to developers, especially, the Service Discovery Protocol (SDP), the Serial Port Profile RFCOMM for serial emulation, and the Logical Link Control and Adaptation Profile (L2CAP), which provides connection-oriented data services to upper-layer protocols such as segmentation and reassembly operation, and protocol multiplexing. OBEX is a high-level API for exchanging objects such as electronic business cards and calendar items transmitted in the vCard and vCalendar formats. On Bluetooth, object exchange occurs over RFCOMM.

Bluetooth-enabled Application Types: A Bluetooth-enabled application can be a server, a client, or a peer (a peer is both a client and a server in Peer-to-Peer applications). A server first advertises a service, and then it waits for any clients. Whenever a client contacts the server, the server creates a separate client handler to service the client. When the time comes to cease the service, the server stops advertising and remove the service from its database; see figure-1. A client first searches the nearby devices for services that are of interest. When a service is found, the client establishes a connection with the server and then consumes the service (figure-1). A peer in a peer-to-peer network is both a client seeking for some services, and a server offering some services. Hence, both the server-side functions and the client-side functions will be available on a peer.

Using the JABWT API: There are a lot of classes and interfaces involved in developing a simple Bluetooth-enabled client-server application; rather than showing the programming details, figure-2 shows the state-diagram for the main activities that take place during a simple client-server interaction. In figure-2, a client searches nearby

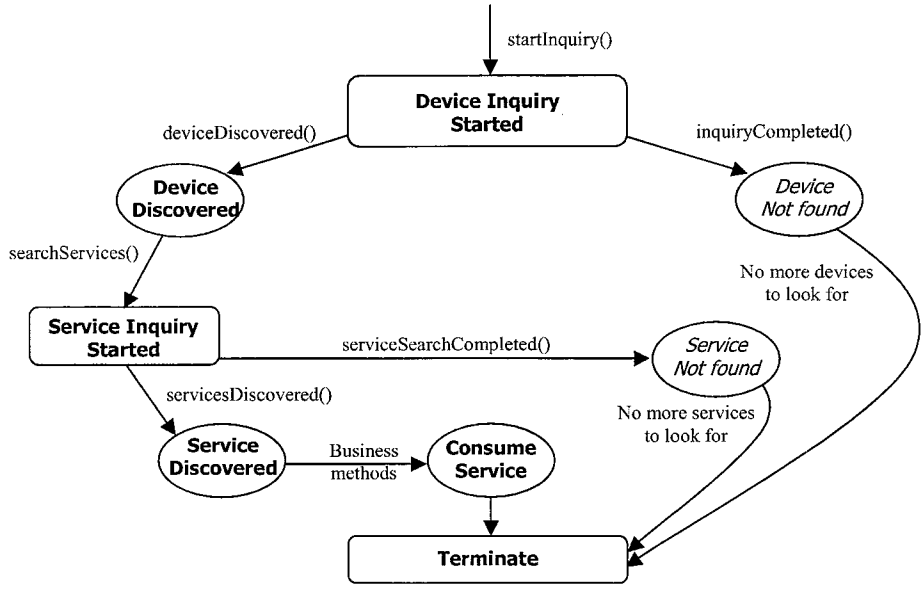

Figure-2: The change of state due to some of the important APIs

Bluetooth devices in a piconet for some services. The main APIs for activities (change of state) are also shown in figure-2.

Framework For Building Mobile Tools For Teaching

The reasons for using mobile tools in education can be many; there are also many technology options available. Thus, a framework is needed for:

1. Identification of the processes that should be supported by mobile technology
2. Choosing the appropriate technology, and
3. Evaluating how the chosen technology can influence the quality of education processes.

The framework is shown in figure-3, depicting the core educational processes, managing (monitoring and control) processes, supporting administration processes, and information infrastructure processes.
Figure-3 shows four layers of processes. The bottom layer deals with collaboration and communication infrastructure processes - processes that deal with basic Internet and Web-based activities (e.g. E-mail, chat, Net

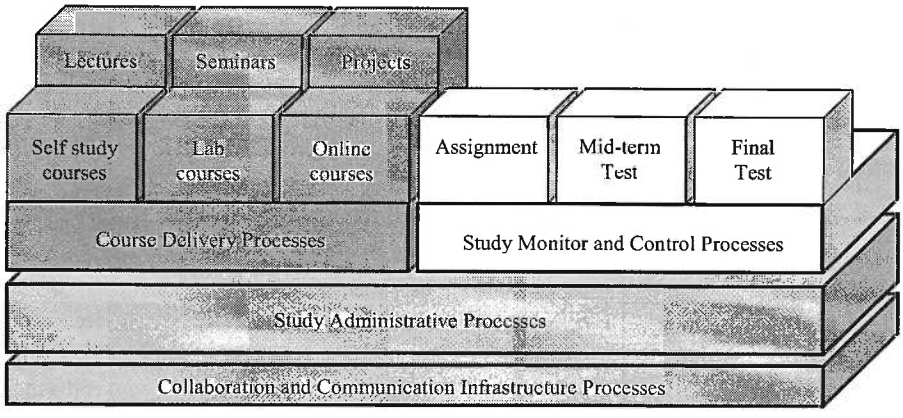

Figure-3: Framework of processes involved in education

meeting, etc.). The middle layer is study administration processes; these are the administrative and course development processes that are handled by the faculty and staff. The upper layer consists of core study processes. This layer is divided into two parts. The first part deals with course delivery processes and the second part deals with student evaluation processes. All the processes are eligible to make use of mobile technology. However, it is the three basic factors (cost, effort, and time) that determine whether or not to employ mobile tools to support the different processes. The next section presents a case study on utilizing mobile technology to assist student evaluation processes.

CASE STUDY: MOBILE APPLICATION FOR STUDENT EVALUATION

This section presents a case study on developing a mobile classroom tool for student evaluation. This case study is based on an ongoing research at the University of Stavanger, Norway, to develop tools and devices that will help gauge students' participation during lectures.

Figure-4 shows the proposed scheme for evaluating students' performance. The scheme consists of a mid-term exam and a final exam in addition to many monthly tests ('Assignments'). Mid-term and final exams are written exams; the monthly assignments are to be carried out during lectures. The assignments are to be conducted fully automatically with the help of Bluetooth-enabled devices.

A Bluetooth-enabled client-server system is under development to conduct assignments during the lectures. The following steps are involved:

Step-1: Questionnaire download (Online mode): All the students following the lecture must be equipped with a Bluetooth-enabled device (mobile phone, notebook, PDA, etc.). When the students enter the classroom one-by-one, they download the questionnaire from the lecturer's Tablet PC.

Step-2: Answering questions (Offline mode): During the lecture (the system is optimally designed for taking questions at the end of the lecture), the lecturer asks multiple choice questions (MCQ) that can be answered easily and quickly with a compact mobile device like mobile phone or PDA. The students first enter their student ID number, and then key the answers for the questions (fill-out the questionnaire).

Step-3: Delivering the answers (online mode): As the students leave the classroom after the lecture one-by-one, they transfer the filled-out questionnaire to the lecturer's laptop computer. The program running on the

laptop will later bundle all the filled-out questionnaires and send it to a Web server that will process these documents.

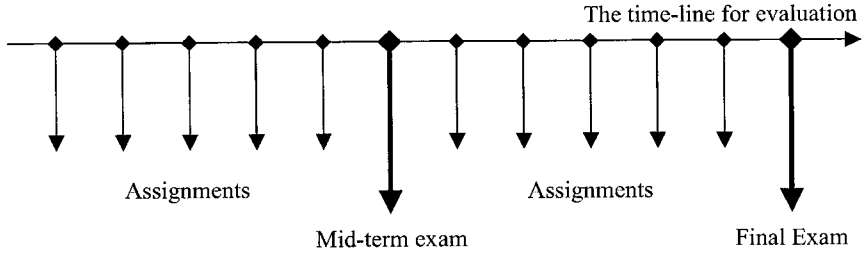

Figure-4: The scheme for student evaluation

MANAGERIAL IMPLICATIONS

Abram and Luther (2004) identify behavioral characteristics of the students and youth today, distinguishing them from other groups in terms of their use of information, personal interactions, and social values. Some of the characteristics of the youth today are:

1. Format agnostic: They accept information in any medium
2. Nomadic: They prefer quality service on anytime – anywhere basis.
3. Multitasking: They prefer using interoperable devices.
4. Experiential: They learn from hands-on interaction, especially as in gaming.
5. Collaborative: They chat, talk and send SMS and email.
6. Integrated: They tend to blur distinctions between private and public domains, learning environments and entertainment.
7. Principled: They possess well-defined value systems.
8. Adaptive: They cope with newer technologies to meet physical and learning challenges
9. Direct: They will ask for help and expect good service.

It is clear from Abram and Luther (2004) that newer and fascinating tools must be taken into use to motivate students these days; the case study given in the previous section explores the use of Bluetooth-enabled mobile devices for evaluation of student performance in classrooms.

Case study describes a system that complements traditional classroom evaluation. Students use their mobile phones to submit answers for assignments at the end of lectures. The lecturer's computer automatically collects the answers (messages) sent by the students. Thus the proposed system is paperless, faster, and effortless. By automating assignments, faculty is relieved from the tedious task of correcting and registering the assignments. The system is also cheaper because all the students' need is their mobile phones.

Developing such a system is basically a programming problem demanding knowledge of Application Programming Interfaces (APIs) like JABWT. Though it will take considerable amount of time for academics to learn these APIs, researchers involved with online education can reap enormous benefits with the programming knowledge.

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