Blue-QTI: A Mobile Learning System Using Bluetooth and IMS QTI Specification

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Abstract—**The paper shows the development of a system; called "Blue-QTI"; it uses low cost mobiles phones with Bluetooth and J2ME. The system allows questions and answers under IMS–QTI specification, to do that, the AquRate authoring tools is used. The lecturer installs the software Blue-QTI in his/her laptop and the students, in the classroom, using mobile phones to interact with the lecturer. Only simple interactions are implemented, because limited phones are used. The interactive learning is the pedagogical approach used to develop this tool. Three workshops with lecturers and students were used to test the tool.**

Keywords-Mobile–learning; Interactive learning; Bluetooth; IMS-QTI.

I. INTRODUCTION

According to Alfred Bork, "the psychologists agree that the best feedback is that which comes immediately after the event" [2]. So, to increase interactivity in the classroom, it seems appropriate to include questions and quick answers. However, in a classic verbal scheme, to ask a question to several students takes a few minutes, because for reasons of clarity it should be answered in sequence. If we change the scenario to a system of questions and answers in written form, the teacher takes several minutes to evaluate the answers. This is the reason why the inclusion of mobile devices equipped with wireless communication (m-learning), would help provide the desired level of interactivity. This way, the results to the questions, designed to obtain short answers can be answered quickly and personally by the students (each with a mobile device), can be seen immediately by the teacher. If this is added the fact that most mobile devices have the Bluetooth technology then an opportunity to incorporate interactive learning in the classroom appears, with a common personal device (mobile phone). The solution to do that is to have a mobile learning system based on Bluetooth to be used in a classroom [9][10].

Some others applications are:

- Eduinnova software [11]. It is based on Wi-Fi communication for PocketPC and ClassmatePC, which uses a PDA to gather real time information about the performance of different groups of students. This information is displayed graphically.

- Interwrite [3] - A global company that develops solutions for interactive learning in different educational levels. The company has developed software that supports multiple devices through wireless communication. The device type is selected according to the number of students. This application works on Windows XP SP2, Windows Vista SP1 and Mac OS X 10.4.1 or higher. The software associated is the InterwriteResponse [5].

- Promethean [7] - Company of interactive learning technologies. The software performs wireless communication with devices using a USB device called ActivHub connected to a computer or laptop, and works with Windows, MAC OS and Ubuntu Linux.

The previous applications are based on proprietary specifications. And even more, the use of standards in educational software has not been sufficiently considered in the development of software for mobile devices, which adds value to the development of a solution that includes this options.

The solution presented in this paper considers the IMS-QTI specification; the software is developed using J2ME and Bluetooth technology.

A. The IMS-QTI specification

The IMS-QTI is one of the IMS Global Consortium standards for developing software in the field of learning technologies. IMS-QTI specification [4] describes a structure to represent questions or items (assessment item), manages assessments or complete reviews (assessment test) and reports the results. IMS-QTI presents a model that defines the main components that make up the evaluation process and provides a content format for storing the questions independently of the system architecture or authoring tool used to create them. For the interconnection between systems through IMS-QTI, it is recommended the use of XML. In this case of IMS-QTI, the term "question" is replaced by "interaction". An interaction allows the teacher to specify the tool that the student will have to build a response with. Because there are multiple types of

questions, there are many types of interactions, some of which are explained below.

1) Simple Interactions: These kinds of interactions are based on the selection of an option or multiple options. Some of the interactions in this category are "choiceInteraction", "orderInteraction", "associateInteraction", "matchInteraction".

2) Text Interactions: These kinds of interactions allow answers in text. Some of the interactions in this category are "inlineChoiceInteraction", "textEntryInteraction", "extendedTextInteraction".

3) Graphic Interactions: Graphic interactions have an image as the main element to be used as the background of the statement, and on which all actions performed allow the user to build a response. Some of the interactions in this category are "hotspotInteraction", "selectPointInteraction", "graphicOrderInteraction".

To implement the questions according to the IMS-QTI specification, the AquRate[1] authoring tool is used [1].

B. The J2ME Platform

J2ME is a collection of technologies and specifications that can be combined to build a Java runtime environment to meet specific requirements of a device or particular market [6]. For the proposed solution, the configuration CLDC (Connected Limited Device Configuration) is used. This configuration is for memory-limited devices, low-processing capacity and limited graphics capabilities, such as mobile phones. In addition to this configuration, the profile MIDP is required. The specification MIDP (Mobile Information Device Profile) was created to work with devices with small screens and batteries. With it, you can use programs called "MIDlets" to define the user interface. Also, in the option packages available on J2ME, there is a set of standards application programmer interfaces (API) for various technologies such as Bluetooth.

C. The Bluetooth Technology

The three major wireless communication standards are the infrared (IrDA), Bluetooth and WLAN (Wireless Local Area Network), also known as IEEE 802.11, and its variants. Both 802.11b and Bluetooth connections operate in the frequency band of 2.4 GHz., but they target different markets. The 802.11 technology consumes substantially more power than Bluetooth and is more common to see it implemented in laptop and smartphones with large capacity. On the other hand, there are Java APIs to implement Bluetooth technologies, including the API offered by J2ME to implement it in mobile phones.

The Bluetooth operates normally in the radio frequency spectrum of 2.4 GHz. If Bluetooth enabled devices are in a distance supported by the specification (between 1 and 100

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[1] http://aqurate.kingston.ac.uk/

meters), a PAN network (Personal Area Network) is formed. In order to make connections via Bluetooth, the mobile device must have an API. In this case, the API used is the JSR-82. It is used mainly for high-level programming Bluetooth devices.

II. THE PROTOTYPE

The prototype allows to ask questions, under IMS-QTI Version 2.1 specification, using the authoring tool AquRate over Bluetooth technology, it includes a server computer used by the teacher and mobile phones used by students, The prototype was called Blue-QTI, the name was originated from the combination of Bluetooth and IMS-QTI.

The tools used for development are open source or free distribution. Thus, the development cost is very low. The criteria for selecting the tools were:

- Quality of IDE (Integrated Development Environment): Appropriate code editor with syntax highlighting, possibility of RAD (Rapid Application Development) and the customization option to add new services such as compiling various programming languages.
- Cross-platform: it required that the written code is portable between Windows and Linux directly.
- Appropriate GUI: graphical user interfaces usable and friendly to meet the functions arising from the requirements capture process. For this, libraries are also needed with visual components such as menus, dialog boxes, buttons, text boxes and drop down boxes at least.

To design the prototype, UML was used. Figure 1 shows the use case related to the client application and Figure 2 illustrates a use case of the server application.
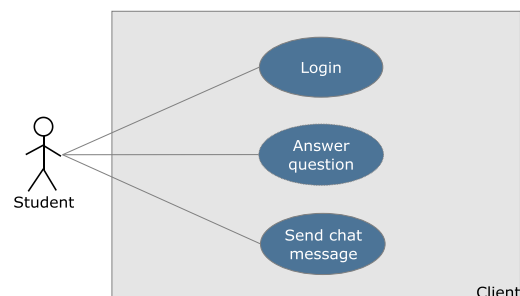

Figure 1. Use Case Diagram Client Application.

Three roles were defined to access the system, identifiable by a user authentication process.

Considering this, the overall architecture of the system is shown in Figure 3 which consists of three basic components:

Client. Resident application on a mobile device that gives students the opportunity to answer questions sent from the server application and send text messages to the server. The device must have Bluetooth and Java support.

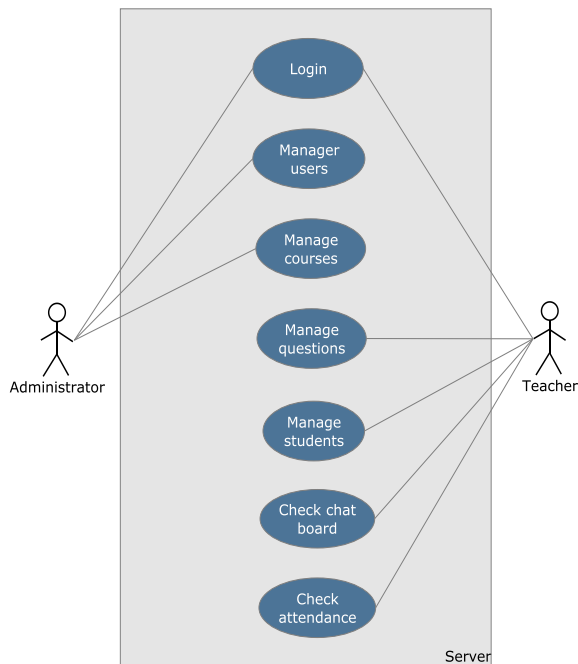The protocol available is piconet that allows eight connections, so only seven mobiles phone can be used.

Figure 2. Use Case Diagram Server Application.

Server. Managed application by a teacher which manages the sending of questions to mobile devices of students, according to the IMS-QTI specification. The computer or laptop where you run the application must have Bluetooth connectivity.

Bluetooth communications channel. It is the wireless technology used to make the connection and data transmission between server and mobile clients. Its implementation is developed in Java.
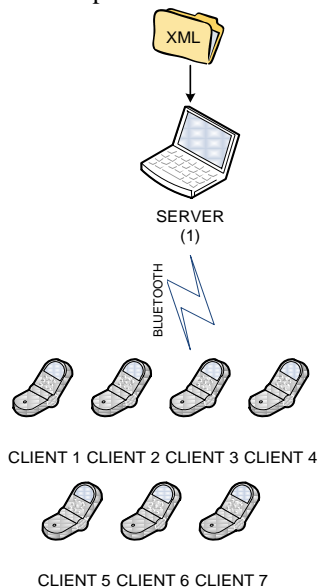
Figure 3. General System Architecture Blue-QTI.

The components and tools used correspond to two separate entities that communicate with each other, corresponding to the client application and server application. The relationship between these components is shown in Figure 4.
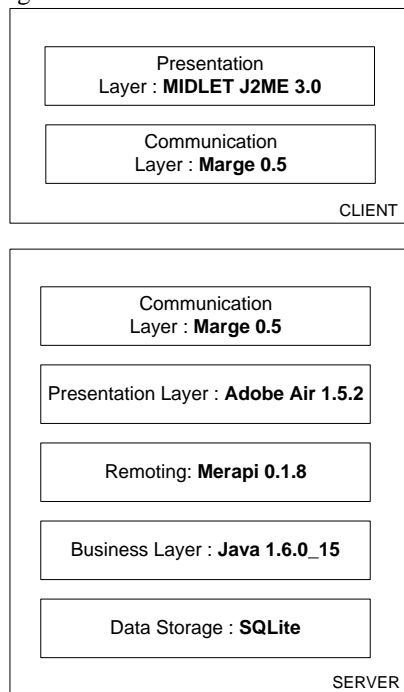

Figure 4. Layers diagram of software components of the system Blue-QTI.

The Server application consists of two executables compiled using the Adobe AIR and Java languages. It interacts to send and receive questions quickly and safely to the student's mobile devices, under IMS-QTI specification. The Client application side is a MIDlet written using the J2ME platform capable of receiving the IMS-QTI questions from the server. The MIDlet sends the answer on the same Bluetooth channel. Text messages are an extra functionality that is deployed in the application server. The database model that implements the Data Storage was built after the consolidation of requirements and use cases, which identified all the concepts involved at the Blue-QTI system. Basically, the database was built to handle the management of students, courses and teachers. This is shown in Figure 5.
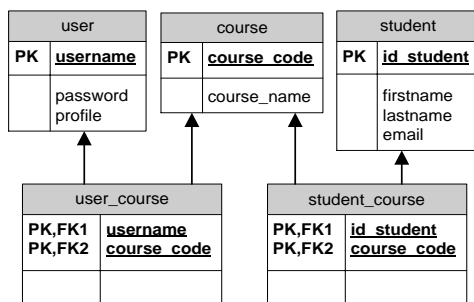

Figure 5. Blue-QTI data model.

The tables "user", "course" and "student", representing the users or educational entities, courses and students, respectively. Table "user_course" is an intermediate table, to assign users to courses and allow them access. Finally, the table "student_course" is a link between students and courses.
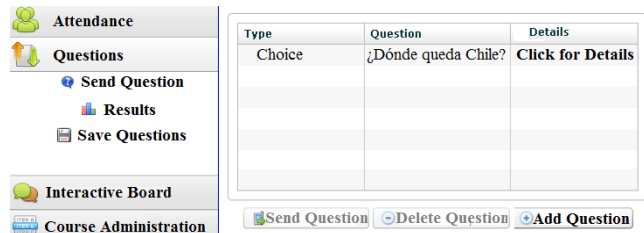

Figure 6. Screenshot associated to the use case "Send Question"

The Blue-QTI system is to ask questions under IMS-QTI specification, so the use case "Send Question" is the most important artifact. The teacher selects a question from an XML file; previously created by AquRate authoring tool; and then sends it to the students whose mobile phones are connected to the computer server. The use case describes the interface and functionality associated with the system. Figure 6 illustrates the use case "Send Question".

III. SYSTEM REALIZATION

The development of the system was conducted in three stages: the first one was related to the server (database and AquRate for interactions under IMS-QTI specification), the second one with the client and the third one aimed at optimizing the client code using the obfuscation technique, so it can be used in mobile phones with low memory capacity [8].
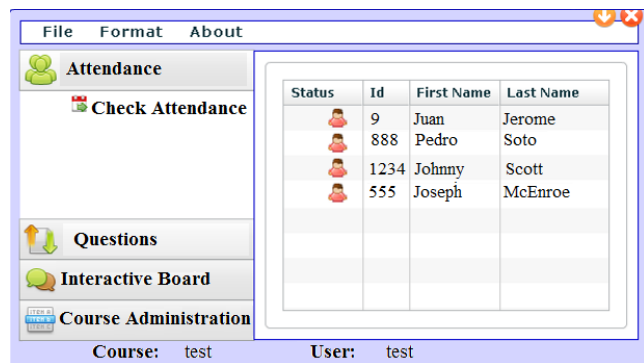

Figure 7. Screenshot showing the students associated to a course.

Figure 7 shows the presence of students connected to the system Blue-QTI. In the "Status" column, the red icon means that the student is disconnected and the green icon indicates that the student is connected. The "Id" column is the identification number of each student given by the teacher. The "Questions" section (see Figure 6) is where the teacher sends questions and also can see the results to the

question in graphical way (see Figure 8). The "Interactive Board" section shows the chatting between students. The "Course Administration" section is where the administrator can administrate the course which means add, modify or delete teachers, students or courses and also assign students to a course.
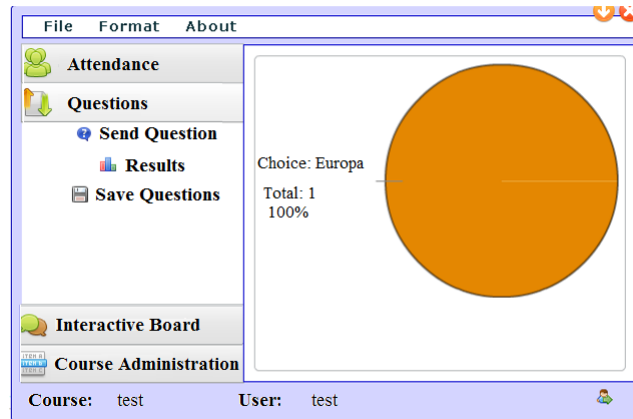

Figure 8. Screenshot showing with the graphical result of a question.

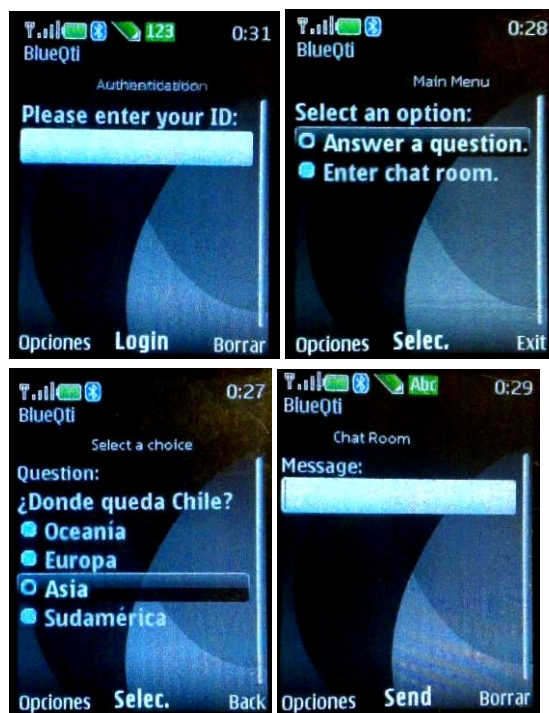Figure 9 shows photos of the client application running in a mobile phone.

Figure 9. Client application photos.

Only seven mobile phones can be used at once, because the piconet only allows eight devices and one of them must be the teacher's laptop. To increment the number of mobiles phones it is necessary a scatternet. However, a scatternet requires special devices.

IV. CONCLUSION AND FUTURE WORKS

A mobile learning system to ask questions under the IMS-QTI Version 2.1 specification was developed using J2ME and Bluetooth. Three workshops were carried on with students and teachers to test the Blue-QTI system, the teachers had the server installed in their laptop and the students had the client installed in their mobile phones. These workshops were intended to test the Blue-QTI prototype from the technical point of view and also its usability. More specifically, these workshops were aimed to answer some questions e.g. how difficult it is for teachers and students to use the prototype?, what happens when a student turns off his/her mobile phone? or what happens when several students try to answer one question several times?, etc. Low cost mobile phones were used in this experiment. Only seven mobiles phones were used in each workshop because the piconet protocol which is the protocol used by Bluetooth can only handle eight connections. All tools used were either open sourced or free.

For future work is necessary to implement the scatternet in order to increase the number of connections. The number of connections will depend on the topology of the scatternet network. It is also necessary to improve the Blue-QTI system to allow other interactions of the IMS-QTI specification.

From the learning point of view is necessary to build pedagogical experiments to implement interactive learning based on the concepts of learning designs in order to test the system in the real world.

V. ACKNOWLEDGMENTS

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