Multiuser Intelligent M-learning Environment

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Abstract. In this article we present the architecture of an m-learning (mobile-learning) environment using Bluetooth as communications technology. We also describe its practical implementation into a technical laboratory where students can access, work and leave at any time. The system incorporates artificial intelligence techniques in order to adapt itself to the characteristics of each user. This strategy allows us to recognize each student, organize his/her work and evaluate his/her results, without educator intervention. Nevertheless, the teacher will be reported about the student activities and will be advised when the situation requires it. The Bluetooth facilities assure good isolation between different classrooms and multiuser wireless connections.

Keywords: M-learning, AI Planning and Scheduling, Expert systems, Bluetooth.

1 Introduction

Traditional education, where a teacher transmits to their students some knowledge in the classroom, is a very well known communicative process. In the same way that others human situations of communication, teaching and learning are being highly affected by the development of the new technologies of information and communication (TIC). This influence has given rise to the creation of the e-learning concept. Two of the most relevant advantages of this new educational framework are the flexibility and the context adaptation capacity.

It is evident that these features are greatly improved if the potential offered by the wireless communication systems is added (and then the term m-learning is used). Moreover, it is possible to go one step further, integrating also artificial intelligence techniques in order to automate and personalize the learning experience offered to the students, which opens a world of educational possibilities [8].

Among them, this article focuses on the problem of management within a group of students arriving into a laboratory, making practices, getting real time results, asking questions, interacting with the educator -if needed- and leaving at any time. The m-learning environment presented here offers a real solution to this challenge. It uses a Bluetooth scheme and takes advantage of this huge potential. The obtained wireless system is agile, trustworthy and dynamic.

Another fundamental question supporting the versatility and effectiveness of this m-learning answer is the characterization and monitoring of its users. A recognition strategy -based on Artificial Intelligence- allows the system to determine the capacities, preferences and availabilities of the students and to adapt its interaction with them in order to optimize its results.

The paper is structured as follows. First, we provide an overview of the current e-learning and m-learning technologies, in order to settle the context of the work presented. Then, we provide some basic information about planning and scheduling and Bluetooth that are, respectively, the artificial intelligence and communication methodologies supporting the m-learning architecture proposed. In order to present that architecture, first we describe the educational environment where we are going to implement it: a technical laboratory. Then the main modules of the architecture itself are described. Lastly, we summarize the main concepts and propose some challenges for future work.

2 E-learning and M-learning

Current e-Learning and Virtual Educations technologies have experienced an increasing research interest thanks to the use of information technologies and the Internet [5]. These technologies have generated a new kind of tools and frameworks that can be used by educators to design, deploy and control courses. Several well known e-Learning standards, such as IMS [4], SCORM [10] or LOM [6], are currently being used to define and develop new adaptive virtual based education tools. These tools support the creation of personalized learning designs (LD). These new designs make possible to reuse and exchange useful information among different platforms. These new tools can be used by educators (and/or course designers) not only to define the contents of a course (i.e. by using the IMS LD specification), but also to create adaptive and personalized learning flows, so that the educational system can monitor and control the whole learning process.

When these systems incorporate wireless elements, as movable telephones, PDAs or laptops, the term m-learning can be used. In this context, many of the fixed systems advantages can be taken. Among them it is possible to be emphasized: the possibility of giving service to many users simultaneously, the capacity to put the contents to disposition of the students at the opportune time and place and the flexibility in the access to any electronic document. According with some authors [11], the wireless communication with movable devices presents some more details that give it a special character. Some of them are: The possibility to use very small time intervals and the need to simplify the contents presentation due to the limited display and input capabilities of the mobile devices. Nevertheless, it is interesting to mention that in mobile learning several problems exist that are not present in e-learning. One of the most important is the hardness to obtain or send printed material.

The earliest application of mobile computers for teachers and learners started at the beginning of the 1970's at the Xerox Palo Alto Research Center. Nevertheless, the authentic m-learning concept and its technical developing began at the end of the 1990's. From that moment on the number of mobile devices and its applications are growing faster and faster and today they are more than three times the number of personal computers. Some experts even think that mobile phones are going to be an alternative to PC's. In this context, m-learning appears like a very valuable investigation and application field.

3 Artificial Intelligence Techniques

The goal of Artificial Intelligence (AI) [7] is to study how to build machines that perform tasks normally performed by human beings. Within the AI field, our work focuses on *AI planning and scheduling (AI P&S)*. These techniques have been applied to solve complex problems in domains such as robotics, logistics or satellites. In this last domain, it has been an special interest in the development of autonomous architectures that can carry out a large number of functions such as planning activities, tracking the spacecraft's internal hardware, and ensuring correct functioning and repair when possible, without (or little) human intervention. In these new models of operations, the scientists and engineers communicate high-level goals to the spacecraft, these goals are translated into planning and/or scheduling sequences; then a continuous check of the spacecraft status is verified in order to detect any damage and act accordingly.

Then, a *planner* solves a problem by finding a sequence of actions that transform an initial state into a final state. In order for a planner to solve a problem, it is needed (1) to specify the domain that is composed of a set of operators that allow the planner to go from a defined initial state to a state in which a set of goals is fulfilled, and (2) to describe the initial and goal states. The standard language to specify the domain and the problem is PDDL, now in its 3.0 version [3].

A *scheduler* organises activities along the time line by taking into account the resources available. One of the main drawbacks in scheduler systems is the lack of a language that allows us to define the deadlines and resource constraints.

Traditionally, both areas have evolved separately of each other. But nowadays applications require more communication between them. It becomes necessary to take into account inside the planning/scheduling reasoning the time at which the plan/schedule will be provided and executed. This is the case of the architecture described in this paper where activities (i.e. units of learning that the students need to follow) should be planned in a period of time (i.e. the student finishes his/her work in 3 weeks) and depending on the results, some tasks should be generated dynamically (i.e. if the work sent is correct, then he/she starts a new unit of learning).

4 Bluetooth

Bluetooth wireless technology is a short-range communications system intended to replace the cables connecting portable or fixed electronic devices. Bluetooth is now the largest radio-based technology after GSM. Currently, consumers specifically recognize the significant technological advancements of Bluetooth in three markets [1]:

- **Mobile phones / Handsets.** Bluetooth-equipped cell phones are rising quickly, with an estimate of 303.7 million units sold worldwide by 2007.
- **Headsets.** The headset trend is becoming the new wearable technology. Industry experts say Bluetooth headsets will also be able to use with iPods switching from music and calls.
- **Automotive Industry.** The Bluetooth applications for cars are being included in newer car models coming out and also being sold as after market kits. The hands free solution as a safety benefit is one of the most demanded options.

Due to the wide adoption of Bluetooth and its quite interesting properties, a lot of effort has been made trying to evolve it beyond the initially envisioned wire replacement function to a large-scale networking technology. Now it is possible to use Bluetooth communications in a multi-user environment like the one found in a classroom or a library while maintaining short connection times and good performance behavior. Also, using artificial intelligence planning techniques, it is possible to handle the communication needs of an m-learning environment in a very efficient manner.

One of the most interesting features of Bluetooth technology in an m-learning environment is its short range of operation: most portable devices have a coverage area of 10 m, rapidly decreasing when obstacles are present (i.e. walls). It means, for instance, that devices inside a classroom are discoverable and can join the network whereas those outside the classroom are not. It makes this technology suitable for context-dependent applications, where two adjacent rooms can be considered two different m-learning cells, perfectly isolated from each other, and users are clearly identified as forming part of one cell or the other.

5 A Simple Scenario

The chosen scenario is a technical laboratory, which constitutes an m-learning cell, where students can enter or leave at any time during a given schedule. They are supposed to carry their own laptop computer with Bluetooth capabilities. The system detects such students and manages profiles and access rights. Once a student is authenticated, the system sends to the laptop the application needed to interact in the m-learning environment, if it is not already installed. The system also sends to the student the appropriate tasks, according to the schedule and the personal situation. The student can send the solved practices back to the system for evaluation which, in turn, gives him/her feedback about the punctuation obtained, on-line advice on how to proceed if the work done is incomplete or below the minimum required level, or the next task to accomplish if he/she has passed the exam. The student can ask the system for any kind of information about the course, like the practices' program, their content, groups to join, exam dates, and so on. He/she can also ask for on-line advice or for an appointment with the educator at a later date.

The system also interact with the educator, who can enter his agenda, the programmed practices, support material and so on. The system sends the educator various logs, not only about the performance of the whole system, but also about the work done by every student in the laboratory: number of tries for every practice, punctuation obtained, and time needed to accomplish the work, progress made, and so on.

Apart from presenting statistical data in several fashions, the system is also able to learn about the behaviour of the students, valuate the difficulties encountered for every task assigned and detect such things like two students presenting similar solutions to the same task. When the system is not able to evaluate the practice presented by the student, it will ask the educator for advice on how to proceed. If the solution proposed by the educator allows the system to go ahead with the evaluation, it will be incorporated to the knowledge database for future use.

6 M-learning Architecture

Figure 1 shows the basic architecture of the m-learning environment. It comprises a Bluetooth communications module, a Server, an integrated Planner and Scheduler (P&S) and an expert system called Evaluator.

The students interact with the m-learning platform by means of a **Bluetooth communication system**. This system is responsible for: detection of users entering or leaving the m-learning cell, establishment and release of work sessions with these users, and exchange of data between users and the learning environment. It will also manage and optimize in an intelligent manner the communications performance of the m-learning cell. With this intelligent management it is possible to extend the number of simultaneous users of a Bluetooth piconet from 7 to the amount normally found in a laboratory (from 20 to 30 users). At the same time, it also significantly improves the discovery and establishment times of Bluetooth in order to fulfil the real-time needs of the interaction with the users.

The **Server** will interact with the client application in the user's laptop using the Bluetooth module. It is responsible for the dialog and transactions with the students, performing all the tasks not requiring intelligence. A user entering the m-learning cell will be authenticated and registered. The basic m-learning application, if not present, will be sent to the student's laptop, as well as the tasks assigned by the P&S module to the student. It will manage all the requests asked for by the students, sending them to the P&S module or the Evaluator when appropriate. In turn, it is responsible for delivering to the students all the

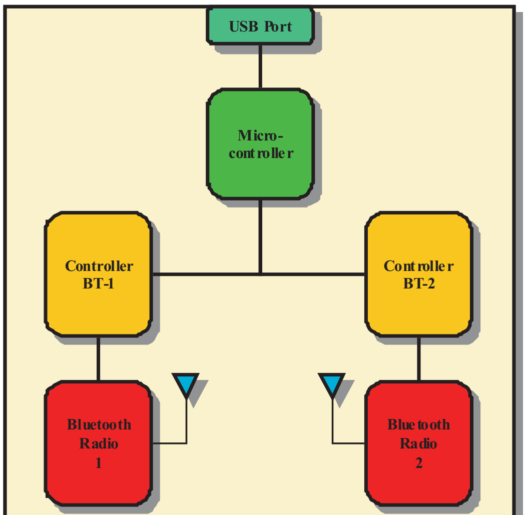

Fig. 1. M-learning environment architecture.

information coming back from the Evaluator or the P&S module. Eventually, the Server will take care of detecting users leaving the m-learning cell and will update the active users' database accordingly.

The Server is also the bridge between the educator and the system. All the information about the courses or the practices, as well as the educator's agenda, the students list or the laboratory groups list is accessed through the Server. Only the information pertaining to the P&S or the Evaluator (domain, constraints, evaluation rules, and so on) will be introduced using the management console module of the Evaluator.

The **Evaluator** is a dedicated PC platform for automatic evaluation of the practices sent by the students [2]. It comprises three main functional blocks:

– **Practice manager.** It implements an automatic service for delivering and collection of practices, without physical intervention. Periodically checks the registered student database, maintained by the server, seeking for new users in the m-learning cell. For any new user, it looks at the student's personalized program and sends him the scheduled practices, together with a practice management agent. The agent allows the student, not only to send the solved practice for evaluation, but also to ask for on-line or physical advice about the work to be done, among several other capabilities. It comprises two main modules, the student module and the tutorial module. The former stores the progress made by the student in his or her interaction with the expert system. This information is useful for chosing the next task to be asigned to a student. The tutorial module is devoted to the course program development and the way the contents are delivered. It controls the progress and sequence of contents, answers the questions raised by the students and detects the kind and level of help they need.

- **Expert system.** Once the student has finished the practice, it is sent for evaluation. In order to do that, the practice management agent delivers the information coming from the student to the expert system which, according to a given set of rules (implementing the evaluation criteria), analyzes the information and reports the qualification obtained. Moreover, it notifies to the student the list of errors found, as well as a series of guidelines in order to improve the student's experience. All the events all collected by a trouble-tracking system and saved in a database, together with the answers recorded by the teacher through the management console. This database is the learning repository for the expert system, which can afterwards propose more elaborate answers and guidelines, based on the answers of the students and the difficulties found. The expert system has also the potential to detect when the answers sent by two different students are significantly similar, reporting the degree of similarity found and notifying the teacher, who can then send a message to the involved students in order to clarify the situation. The expert system does so thanks to the use of NLP (natural language processing) techniques.
- **Management console.** The teacher has at his or her disposal a complete set of tools for performing on-line administrative tasks and track the activities accomplished by all and every student in real time. Among them, it is worth mentioning: a database compiler, in order to incorporate the expert system database to the report manager; an interactive graphical interface for real-time event monitoring and dialog with the students; a query tool, for definition and incorporation of tasks and evaluation rules; an event-reporting module for interaction with the Planner; and a report generator.

Finally, the **P&S module**, by means of the IPSS system [9], detects the characteristics of the different students (observing how they use the system). Then, in every case, the way to interact with each one is determined. In this process of mutual interaction two things may be considered: the objective of learning or formation that is wanted to be reached for the students and the resources susceptible to support them. This way of work allows for a complete adaptation to each student (maximizing the effectiveness of the whole process), also offering the possibility of managing user groups. The result is a personalized program for every student. The general course program is the environment and guideline, giving the boundaries (lower and upper) where the individual programs can be dinamically established. The final result obtained student by student gives feedback in order to improve the overall program for the next season.

In addition to the domain defined and the constraints introduced in the P&S module, the information provided by the Evaluator is very important. The personalized program of a given student may be dynamically altered as a result of the evaluation information. Two students of the same laboratory group may follow similar or very different paths, depending on their own achievements.

7 Conclusions and Future Work

In this paper we have presented a basic m-learning architecture. Bluetooth permits the creation of cells with a classroom scope, allowing for a context-aware approach. The addition of intelligence greatly improves the learning possibilities and the user experience: the Evaluator contributes with an automatic evaluation and feedback methodology and the P&S module improves the system with a student by student approach. This work is just the basic architecture, but offers plenty of opportunities for further research. The management of many adjacent cells, with users roaming between them is one of the issues. Another one is the automatic generation of activities depending on the student's performance. Finally, the modularity of the system and integration with existing or new e-learning components is another field that offers plenty of potential.

Acknowledgements

This work has been funded by the research Junta de Castilla-La Mancha project PAI07-0054-4397 and by the CICYT project CYCIT (TST 2006-12085).

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