Mobile Devices and Remote Labs in Engineering Education

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Abstract

The remote labs or WebLabs promote the experimentation in the studies of engineering allowing the access and control of real laboratory equipment through Internet. In general a WebLab is a client-server application where the client application can only be used from a PC, and it is not considered the use of mobile devices as potential clients. This is due to the fact that the WebLabs are designed from the hardware point of view, and not from the software engineering point of view. Any WebLab can be designed and implemented to be accessed using a mobile device, but only the AJAX technology can provide a unique solution for a wide range of platforms, including mobile devices. This work compares the different strategies to include mobile devices in remote labs and describes the benefits of using the AJAX approach.

1. Introduction

The acquisition of experimental skills is of paramount importance in students of science and engineering fields [1]. How effectively they acquire those skills implies perceiving the teaching-learning process, which entails the learning goals; the methods and means used to achieve those goals and finally, how assessment is done. Regarding experimental skills, there are presently three means: hands-on, virtual labs (based on computer simulations), and remote labs. The previous list follows a timeline, i.e. remote labs are more recent and thus less characterized.

The EU needs to strengthen its competiveness due to the Lisbon Agenda. In this way the EU needs more engineers who are experimenters in order to produce goods and services which comply with nature and are in great demand on the global market.

ICT can be used to restore and increase the amount of laboratory work without increased expenses. Furthermore, learners want an extended accessibility to learning resources and increased freedom to organize their learning activities which is also one of the main objectives of the Bologna Process. From a technological perspective, such flexible education corresponds to an adequate exploitation of ICT, especially the Internet.

The use of WebLabs or Remote Labs is widely extended nowadays. A WebLab is generically a hardware and software application which allows a student to complete his practices remotely, for example from his home, just as if she was in the laboratory. The student takes control of the devices in the laboratory through a web page, and she can monitor the results in the same web page, through a WebCam, a data file, or virtual instruments.

WebLabs are being used more and more ever since the nineties, and we now have WebLabs for process control, automatic control, in centres like M.I.T. in the U.S.A. [2]; University Polytechnic of Valencia [3] in Spain; University of Siena in Italy [4], the New University of Lisbon [5] and others. None of these WebLabs can be accessed using a mobile device, i.e. a mobile phone, but the Weblab designed at the University of Deusto [6] can be accessed and controlled using a mobile phone.

The work is divided in five sections. The sections 2 and 3 describe the advantages of remote labs and the remote lab used at the University of Deusto: WebLab-DEUSTO. In section 4 different approaches to integrate mobile devices in remote labs are presented and analyzed without discussing when this device is useful for the teaching/learning process. The work finishes with the conclusions and future work.

2. Advantages of remote labs

The design and use of a remote WebLab in a Faculty of Engineering has the following clear advantages:

- *Better performance for the lab* equipment since they are available to students during 24 hours a day and 365 days a year.
- *Organization of laboratories*. It is not necessary to keep the labs open at all times, only have operative the WebLabs.
- *Organization of work for the student*. With WebLabs both students and professors can better organize their own time, including class time schedules.
- *Autonomous learning*. WebLabs promote autonomous work; fundamental in the new European Higher Education Space.
- *Open to Society*. WebLabs open the laboratories to Society.
- *Distance courses*. WebLabs allow the organization of engineering courses without the need to have the students present, avoiding many of the current problems.

3. WebLab-DEUSTO

The WebLab developed by the University of Deusto, WebLab-Deusto (http://weblab.deusto.es) is a didactical tool that is integrated into the teaching of the university. In this section architecture, technology and results of WebLab-DEUSTO are presented.

WebLab-DEUSTO is a system that has being improved since 2003 and it consists of four different WebLabs: WebLab-CPLD, WebLab-FPGA, WebLab-PIC and WebLab-GPIB. In these WebLabs the student can develop, simulate and implement programs in real hardware.
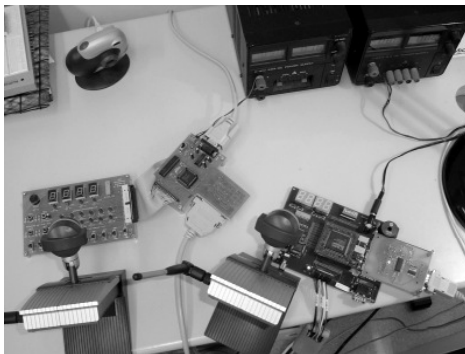

Figure 1. WebLab-DEUSTO hardware

The Table 1 shows the students' opinion about the WebLab in the subject "Electronics Design" in the second semester of the fifth year of Electronics Engineering at the University of Deusto. The maximum grade is five, and the least is one.

Table 1. Results of WebLab-Deusto

Questions	2005/06	2006/07	2007/08
Number of acceses to the WebLab	495	1.985	754
1. Has WebLab helped you with the subject?	4,1	3,8	3,3
2. Did you feel that you were in a better possition by having been in the WebLab group?	3,9	3,7	3,7
3. Do you think it is a good idea if this WebLab experiment is extended to all the students?	4,6	4,1	4,2
4. Is it easy to use?	4,4	3,7	4,0
5. How is the quality of the WebCam?	2,4	3,0	3,1
6. Did you feel at ease managing the inputs?	3,1	3,5	3,5
7. What do you think about the time assigned to each connection?	2,7	3,2	3,5
8. What do you think about the inputs/outputs implemented?	3,2	3,4	3,6
9. Being far from the prototype, Have you felt yourself to be in control?	3,7	3,6	3,7
10. Would you like to use WebLab in other subjects?	4,0	3,8	3,8
11. What is your gobal satisfaction with WebLab?	3,9	3,8	3,7

The main conclusion of Table 1 is that the WebLab-DEUSTO is seen by the students as an effective tool to improve the teaching/learning process with experimentation.

The design and implementation of the current WebLab-DEUSTO was preceded by an analysis of the client technologies [7]. The conclusion of the analysis is that the best technology to integrate mobile devices in remote labs is AJAX.

AJAX. A client application implemented with AJAX only requires a web browser, independently of the device which runs the web browser. The only requirement is that the web browser must support the AJAX technology. In mobile devices, we can find the Opera Mobile web browser, Nokia Web Browser, etc.

4. Integration of mobile devices in remote labs

The client side of the WebLab-Deusto is a web application which uses AJAX in order to provide rich interaction with the user. Due to this, it can be run on any AJAX-enabled web browser, this is, any web browser which implements the commonly used web

standards (XHTML, CSS, JavaScript, DOM) and also provides the XMLHttpRequest object, without requiring the installation of any third party plug-in such as Java or Adobe Flash. Therefore, it is feasible to find potential web browsers in very different platforms, including Microsoft Windows, Mac OS, GNU/Linux, or, as focused in this paper, in mobile devices including cellular phones, PDAs or even video game consoles.

In this sense, Opera Software has a proprietary web browser called "Opera Mobile" available under mobile platforms, like different Nokia series, Windows Mobile, and so on. Since WebLab-Deusto uses only AJAX, it can be run on any AJAX-enabled web browser, like the Opera Mobile (Fig. 2), without any change in the architecture of the project.

Figure 2: WebLab-FPGA on a Nokia 6630

The other approach to access a WebLab from a cellular phone is programming a specific client for the mobile device. In order to avoid losing portability between different mobile devices, there are cross-platform development platforms available, mainly J2ME (provided by Sun Microsystems as an Open Source project) and Compact.NET (with Microsoft as only provider). If the WebLab uses a standard protocol as SOAP, the development of the client with these technologies would cost even less than the AJAX client. Today, with this approach, the WebLab developers can aim at a wider range of devices.

The main drawback of this approach is that it obviously requires the development and maintenance of a new client, so every new feature in the WebLab should be ported to both the Web client and the J2ME or Compact.NET client. With the AJAX approach used in WebLab-Deusto, the user would automatically download the last version of the WebLab client every time she enters the WebLab's web site.

5. Conclusions and future work

Accessing remote labs from mobile devices is still far from common. However, the increasing number of ever more capable mobile devices with better communication, computation and, above all, interaction capabilities will soon lead us to do more things from our mobile devices anywhere at anytime. Thus, it is important to adequate our WebLab infrastructure to this scenario as it has been described in this work. In this regard, the adoption of the cross-platform and cross-device AJAX technology supposes the way to go as it has been argued in this work.

Future work will be related with how to access WebLabs using devices that are being used by the students in their life: Wii, PSP, second life, etc. Furthermore the researchers have to analyze when these devices are suitable for a better teaching/learning process.

6. References

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