EVOLUTION OF THE WEBLAB AT THE UNIVERSITY OF DEUSTO

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1. INTRODUCTION

The Faculty of Engineering of the University of Deusto has had available a WebLab oriented to Microelectronics since 2001. Currently, the field of WebLab design is very active, and several other universities are adopting them as a service of quality and distinction for Microelectronics teaching, as we have done. This paper discusses two remarkable aspects of our WebLab, namely WebLab-DEUSTO: a) its distinctive software-hardware architecture and b) an evaluation of its use by our students and the academic results they obtained.

2. SOFTWARE-HARDWARE ARCHITECTURE EVOLUTION

We deem that a correct software design is paramount in the final quality of a WebLab. We have been working with WebLabs for five years. In that period we have gone through four different software design approaches for our WebLab. In what follows, we describe and analyse those four approaches with the aim of helping those organisations in the process of designing a WebLab.

The software architecture of our WebLab has undergone through the following four iterations:

1. Socket and Applet-based Proprietary Solution [1].
2. Web-based Solution [2].
3. AJAX-based Web Solution.
4. MicroServer-based AJAX-based Web Solution.

2.1 SOCKET AND APPLET-BASED PROPRIETARY SOLUTION

The first iteration of the software architecture we devised for our WebLab was a proprietary standalone client implemented in C communicating with the WebLab server through a BSD socket. This prototype was used only by lecturers and some guest students.

2.2 WEB-BASED SOLUTION

In the second iteration of our software architecture, the server-side was composed of two elements: a) a Python server which communicated through the serial port with the PIC that controls a PLD and b) a webcam server

broadcasting the images captured. With this iteration, students of the "Programmable Logic" subject had access to the system from an Internet browser outside the University.

The main drawback of this iteration was security. A security alert was raised every time the user downloaded the controlling applet since it required access to his PC's file system in order to upload a file with the new programming logic. Moreover, we had to keep opened two ports in the server's firewall: one for the webcam server and another for the controlling server. This supposed an unnecessary hassle for the firewall maintenance.

2.3 AJAX-BASED WEB SOLUTION

This is our currently deployed iteration. A single client application shown in the user's browser communicates with the server through HTTP. We now have a web-based firewall-safe system programmed with AJAX (Asynchronous JavaScript and XML – http://en.wikipedia.org/wiki/AJAX). The main benefit of AJAX is that it works on any web browser, without any plug-in installation required. The client application is now a pure HTML/JavaScript solution which follows the AJAX web interaction model. This technology is being applied successfully to sophisticated web applications such a Gmail, Google Maps or Flickr. The server side is composed of the elements of the previous version plus a new ASP.NET application, based on Mono, offering a SOAP Web Service interface to client applications.

In this AJAX-based web solution, the WebLab server may be run both in Microsoft Windows and GNU/Linux, and it does not rely on Java anymore. We have also managed to run the client application under Nokia mobile devices running Symbian OS.

2.4 MICROSERVER-BASED AJAX-BASED WEB SOLUTION

We are currently progressing towards the WebLab architecture shown in Fig. 1. This solution will be web-based, firewall-safe and more scalable (will provide several IP-accessible programmable devices). Many groups of users from any client platform will be able to access simultaneously any of the several networked programmable devices.

This fourth generation is again a multi-platform solution, it supports both Windows and GNU/Linux on the server-side. Moreover, there is only one programming language used: Python, maintaining the security features of the previous iterations and removing the Java plug-in dependency on the browser thanks to the adoption of AJAX. However, the most outstanding contribution of this iteration is the incorporation of microservers. A microserver adds to the WebLab hardware an IP address and network-based programmability. All the

communication the server and the WebLab board, previously undertaken by means of RS232 and the PIC, is now undertaken through the Internet.

The adoption of microservers opens many possibilities: use of XML, creation of autonomous WebLabs without the need of a centralised server, makes feasible the creation of intranet hardware networks and so on. Besides, the microservers are versatile, powerful and low cost (around € 100) hardware. Anyhow, the main drawback of adopting microservers lies in being a recent technology where very basic, non-sophisticated services have been deployed so far. Furthermore, it produces a dramatic change to the traditional client/server-based WebLab architecture, which can now move into a more decentralised peer-to-peer architecture. Thus, many of the functional blocks currently allocated to the server can be moved to the microservers.

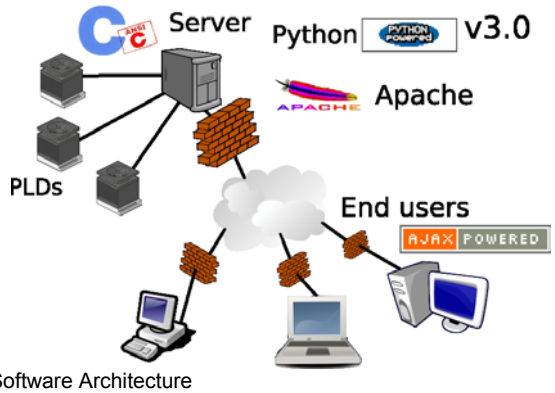

Fig. 1. 4th Iteration Software Architecture

3. ACADEMIC RESULTS

Currently, our AJAX-based WebLab-DEUSTO (http://weblab.deusto.es, http://weblab-pld.deusto.es, http://weblab-fpga.deusto.es) is used for student assignments which require access to a CPLD or a FPGA (Xilinx CPLD and FPGA XC2S144). In particular, the assignments for the subjects "Programmable Logic" and "Electronics Design" of the third and fifth year of Automation and Electronics Engineering, respectively, are carried out with the help of WebLab-DEUSTO.

During the second semester of the 2004/2005 academic year, WebLab-PLD was used by the students registered to the subject "Programmable Logic". This course has 90 students registered, 65 out of those chose to do their assignments using a regular laboratory and 25 using WebLab. Out of the 65 "regular" students, 16 have failed and 49 have passed, that is 75% passed and a 25% failed the practical part of the subject. Out of the 25 students using WebLab, 2 have failed and 23 have passed, that is a 92% pass and an 8% fail. These results clearly show that WebLabs have a beneficial effect on student academic performance. The WebLab only crashed twice in the semester.

Table 2 summarizes the results of a questionnaire given to the students. Grading system goes from 1 to 5. Question 9 has a special interest. The student indicates that even if he is far away from the prototype he does not feel he has lost control of it, in other words, the student feels that the assignment is "his".

Questions	Average (1)	Average (2)
Number of acceses to the WebLab	1.706	495
1. Has WebLab helped you with the subject?	4.6	4.1
2. Did you feel that you were in a better position by having been in the WebLab group?	4.7	3.9
3. Do you think it is a good idea if this WebLab experiment is extended to all the students?	4.7	4.6
4. Is it easy to use?	4.4	4.4
5. What is the quality of the WebCam like?	3.2	2.4
6. Did you feel at ease managing the inputs?	3.7	3.1
7. What do you think about the time assigned to each connection?	3.7	2.7
8. What do you think about the inputs/outputs implemented?	3.8	3.2
9. Being far from the prototype, have you felt you were in control of it?	4.1	3.7
10. Would you like to use WebLab in other subjects?	4.3	4
11. What is your global satisfaction with WebLab?	4.7	3.9

(1) Results in 2004/2005 for the subject "Programmable Logic" in the third course
(2) Results in 2005/2006 for the subject "Electronics Design" in the fifth course
Table 2. Results of a questionnaire proposed to the students

4. CONCLUSIONS AND FUTURE WORK

This work has provided three main contributions. Firstly, it is very important to pay extra attention to the software-side of a WebLab design, even more than to the hardware-side, since many problems of deployed WebLabs come from poor software-side designs (accessibility, security, and so on). Secondly, the use of microservers on the hardware-side will revolutionise and encourage the usage and design of WebLabs. Thirdly, academically it is obvious that the use of a WebLab improves the subject teaching and the opinion that the students have about the labs, the subjects and the lecturers. Anyhow, it is always important to control the quality of new developments in a WebLab, checking the students' opinion. Currently, our research group is working in three aspects: a) extend the use of WebLab-DEUSTO to microcontrollers and DSP, b) redesign WebLab-DEUSTO by adopting microservers and c) document the academic performance of WebLab-DEUSTO.

5. REFERENCES

[1] García Zubía, J. "Programmable Logic and WebLab", *Proceedings of the 5th European Workshop on Microelectronics Education,* Lausanne (Switzerland), April 2004, ISBN: 1-4020-2072-4, PP: 277-282.

[2] García-Zubia, J et al. "A new approach for implementing remote laboratories: a practical case". *2nd International Symposium REV 2005,* Brasov (Romania), July 2005, ISBN: 3-89958-137-7.