Plug&Play Remote Lab for Microcontrollers: WebLab-DEUSTO-PIC

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ABSTRACT

The present paper describes how to design and to implement a remote laboratory under a new architecture which principal characteristics are that the main server disappears and that it is based on low cost microservers. The final architecture is thin and cost effective, and allows a simple installation in other universities. The paper presents the implementation of the WebLab-DEUSTO-PIC under this new architecture.

1. INTRODUCTION

Usually, the Remote Laboratory (WebLab) implemented in a laboratory of a university is centralized in a more or less robust server that offers different experiments to the students / clients. Breaking with the previous approach of remote laboratories [1], the Faculty of Engineering of the University of Deusto(Spain) has implemented a new *thin* platform, that based on low cost microservers, allows the student / client to experiment with microcontrollers.

The developed platform makes possible a plug&play installation: Just turn on the prototype, connect it to the network, and the WebLab-DEUSTO-PIC will be available. The innovation of this platform is based on the technological advances experienced by 8 bits microcontrollers not available until the year 2007.

2. TECHNICAL AND FUNCTIONAL CHARACTERISTICS OF WEBLAB-DEUSTO-PIC

Specifically, the WebLab-DEUSTO-PIC is implemented by two PIC18F97J60 microcontrollers that play different roles: Experiment and Server. The first one will run the program uploaded by the student, whereas the second one, the microserver, will allow the client to interact with the experiment: Upload the file to save, passwords control, inputs/outputs, etc. The microcontroller entrusted to execute the program created by the student is programmed with a bootloader, that is able to allocate in the program memory and execute a hex file received by tftp. Although this laboratory is focussed in microcontroller learning, this architecture can be adapted for any digital design discipline[2].

The Table 1 describes briefly the functionality of the platform and the technical aspects of the TCP/IP Stack implemented on the microcontroller PIC18F97J60. The PIC18FXXJ60 family of Microchip is the first implementation in the world of 8 bits microcontrollers with Embedded Ethernet, which allows for the first time a development of these characteristics.

Using the WebLab-DEUSTO-PIC, the student can work at home as if he were in the laboratory. The student only needs any of the existing web browsers in his PC/PDA device with any OS without any plug-in (JVM, Flash Player, etc), that is not restriction at all. Obviously the file to program to the PIC microcontroller by the student must be assembled or compiled using any application that generates a hexadecimal file compatible with Microchip® devices as MPLAB IDE.

Table 1 Characteristics of PIC 18F97J60

Functionality	**PIC18F97J60 Characteristic**
Human string Web address (Server)	DNS Server
File Upload (Server)	Tftp, ftp servers and http2 server through a POST request
Allocation on program memory of the hex file (Experiment)	Bootloader loaded in the microcontroller. After a reset, microcontroller waits for 10 seconds for a tftp connection.
Client Interaction (Server)	http2 server
Secure Conection (Server)	https server
Low Cost (Server)	Less than 4€ each PIC, 200€ WebLab-DEUSTO-PIC
User Authentication (Server)	http2 server
plug&play Install	DHCP server
Email messages	SMTP server
Client-side Requirements: Any OS and Browser.	http server

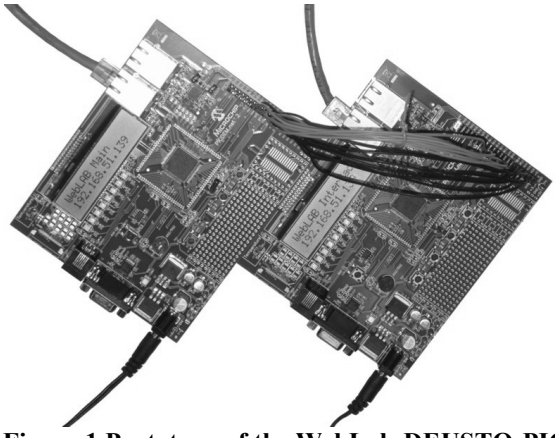

Figure 1 Prototype of the WebLab-DEUSTO-PIC

3. ARCHITECTURE OF THE WEBLAB-DEUSTO-PIC

Until now, usually the remote laboratories were dependents of a computer (Server) that was placed between the experiment and the student. This PC-server realizes tasks of administration and user authentication, as well it allows the student to interact with the experiment. On the one hand the server is connected to Internet allowing access to the students and on the other one it is connected physically

(JTAG, Serial, Parallel, etc) to the experiment.

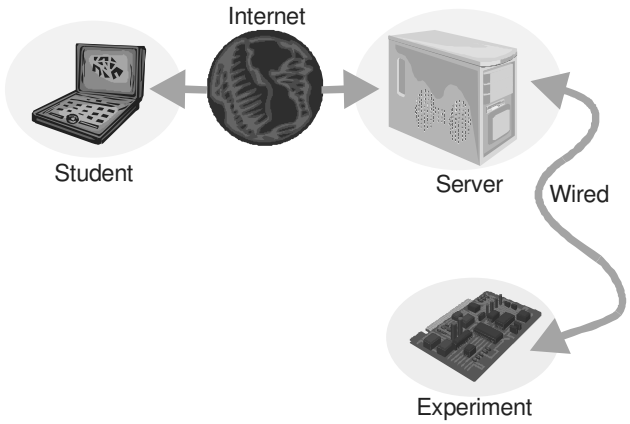

Figure 2 Traditional Architecture of a Remote Laboratory

The WebLab-DEUSTO-PIC [3] is capable, itself, of realizing all these tasks, avoiding the need to place an additional server between the student and the experiment. The student connects directly with the experiment and all the tasks carried out by the PC-server are executed by the microserver included in the WebLab-DEUSTO-PIC.

All the services (user auth., input/output control, etc.) and protocols (http, tftp, dns, etc.) used to carry out these tasks of administration are embedded on the chip. Due to it, this architecture is not as powerful and scalable as other one that there uses a PC-server implementing mass code in PHP, AJAX, etc. But it is much thinner, cost-effective and easily portable to other networks (plug&play). Thanks to the scalability of the implemented architecture, to export any service to an external platform, like Weblab-DEUSTO is simple, but logically as more services are extracted of the microserver, minor will be the portability of the remote laboratory.

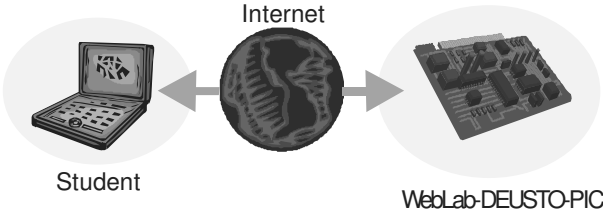

Figure 3 Architecture of WebLab-DEUSTO-PIC

The characteristics of PIC18F97J60 described on Table 1 allows to the microserver installed on WebLab-DEUSTO-PIC to perform all the administration tasks needed for a regular session in a remote laboratory: Using DHCP, the microserver gets dynamically a valid IP of the network and the dns server allows the student the access through an URL http://weblabPIC.deusto.es. The http server implemented on the microserver performs the task of user authentication. Once the student is logged in, the microserver links to the web page that permits the student to upload the hex file, sends it through tftp to the PIC bootloader and loads the web page that validates the experiment. This web page allows the student to change inputs and display outputs. The maximum duration of every session is 5 minutes. Passed the timeout the microserver connects with the following student in the queue.

4. DEPLOYMENT OF THE WEBLAB-DEUSTO-PIC ON A SUBJECT

The WebLab-DEUSTO-PIC is being used in a real subject in the second semester of the second year of the Telecommunications Engineering at the University of Deusto: Digital Electronic Systems. Every student must access to the remote laboratory to perform some projects along the course and also they have to attend sessions in a hands-on laboratory[4]. Students can access from their home or at the university, every session is logged by the WebLab-DEUSTO platform allowing future studies of the impact of this remote laboratory in the development of the subject.

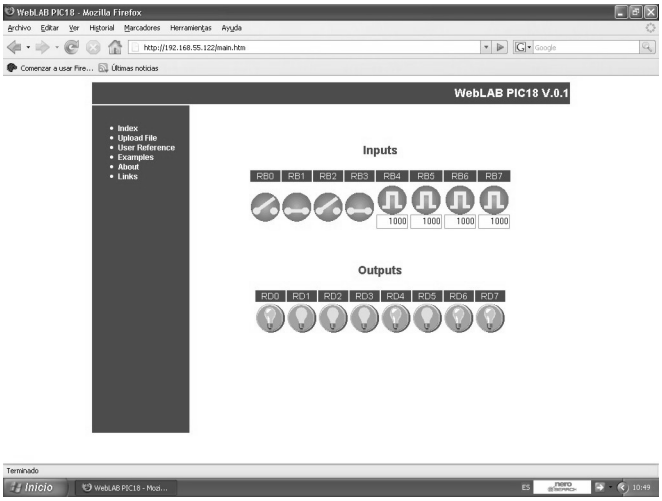

Figure 4 Web page of the WebLab-DEUSTO-PIC

5. CONCLUSIONS AND FUTURE

Main contributions of the presented WebLab-DEUSTO-PIC are focussed on its low total cost (200€), on the use of microservers and on its complete autonomy and plug&play installation. WebLab-DEUSTO-PIC is designed for experiments with microcontrollers, but its architecture can be deployed for any programmable device.

Nowadays the WebLab-DEUSTO-PIC is in testing stage and along the second semester of the course 2007-2008 it is being used in the subject "Electronic Digital Systems". In the near future work will be focussed on implementing for WebLab-DEUSTO-PIC a custom card with more inputs and outputs (USART, engines, I2C, etc.); in integrating the platform in the WebLab-DEUSTO v3.0; in deploying the WebLab-DEUSTO-PIC in more subjects; in integrating the prototype in an educational platform type Moodle; and in integrating new devices (DSP, CPLD, etc.) over the designed platform.

REFERENCES

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