

# An Approach for WebLabs Analysis

Javier García-Zubia, Diego López-de-Ipiña, Unai Hernández, Pablo Orduña, Iván Trueba  
Faculty of Engineering, University of Deusto, Avd Universidades 24, 48007 Bilbao (Spain)

**Abstract**—The Faculty of Engineering of University of Deusto has a WebLab oriented to Microelectronics available since 2001. The first part of this paper shows several requirements that a WebLab should meet and the following sections present the WebLab-Deusto.

**Index Terms**—WebLab, Remote Laboratories.

## I. INTRODUCTION

The following paper is divided into five different sections. The first one gives a classification of WebLabs, which can be found on the Internet structured by the type of action to be applied to the experiment under control. Next, some characteristics that should be considered when working with WebLabs are explained. The groups of features are presented according to their common area, which should be one out of these four possible: didactic of the WebLab, technologies involved in the WebLab, universality of the WebLab and management of the WebLab. After revising the general concepts, the third section introduces the WebLab developed by University of Deusto, classifying its different experiments and characteristics according to the criteria described in the previous sections. Finally, the conclusions are presented.

The aim of this paper is to define a framework for developers of WebLabs, in such a way that all remote laboratories could be classified and analysed according to a common set of key variables.

## II. KINDS OF WEBLABS

At first sight, someone may say that there are as many kinds of WebLabs as different subjects in which a WebLab can be created. Actually, it is possible to create a remote laboratory about any experience related to any of the modules conforming a degree at University. However, selecting only common parameters among remote laboratories related to different fields, could lead to a non-realistic classification of the key features in WebLabs. This is the main reason why this paper involves the study of those WebLabs focused on the area of Electronics and Automation. In this specific area the following classification can be done:

- Remote instrumentation
- Remote parameters control
- Remote control logic

### A. Remote instrumentation

WebLabs based on the remote control of instrumentation devices are those WebLabs that have one or more experiments in which the user is only able to excite inputs (using virtual switches, signal generators and so on) and show virtual or real outputs (LEDs, signals on

an oscilloscope and so on), thanks to the use of a webcam [1].

In such WebLabs the user acts as a mere observer, provided that the only role he plays is to read the outputs of the system. Usually, either the user can modify some parameters of the instruments affecting the experiment and verify its results, or he can only display measures of some physical variables captured by the sensors of the experiment. Both tasks are normally carried out by using a webcam or an output virtual instrument, such as a virtual spectrum analyzer.

### B. Remote parameters control

The main difference between this type of WebLab and the previous one is that in this remote laboratory user is able to change some control parameters in order to modify the logic of the system. PID control is the most significant example of such a WebLab, in which the user cannot reconfigure the regulator's structure. In those WebLabs, the user's interaction is restricted to the modification of several parameters of the checking of these changes' effects, by means of a display. That is, in this case, the user is able to write data on the experience and to read the expected answers.

### C. Remote control logic

In this third group of WebLabs, a user can modify both the logic and the system control parameters. It would be a good example to think of a classic didactic model (LEDs, 7-segments...) controlled by a CPLD or FPGA that has been loaded with the student's program. The same premises could be applied to a microcontroller, a DSP, or a PC-controlled system by a LabView program. Here, the risk is the destruction of the system due to a programming error because the student has unrestricted control over all the variables of the experiment.

One example of this kind of WebLab is the asix4web Remote FPGA [4], developed by the Institute of Computer Technology of Viena University. Along the first courses of the subject "ASIC design", the students must develop short projects using a FPGA supported by Altera. They can test the loaded program using buttons and switches as inputs and 7-segment as outputs.

Students can develop their own designs at home. They need to download the MaxPlusII, free powered by Altera. Afterwards, whenever a student wanted to test some new project, they had the labs of the university available to test their practices. In order to solve this inconvenient, the asix4web project (acronym of Application Specific Integrated Circuits for Web) allows students to connect to the Altera's board through the Internet.

In short, the WebLabs of the electronic and automation area can be classified according to Table 1, as follows. In this classification, it is considered the reasoning of

professor Dieter Mueller [5], who classifies the WebLabs according to the type of remote activities: a) remote sensing (read), those laboratories in which user acquires information about the system (remote observation, monitoring, measurement, etc); b) remote action (write), those laboratories in which the user can change the system behavior (remote programming, remote parameter assignment, remote manipulation of physical objects); c) those laboratories in which is possible the both activities: remote sensing and remote action.

### III. CHARACTERISTICS OF A WEBLAB

In this section, four questions, which represent the main characteristics of a WebLab, are developed. When a WebLab is designed and developed, the research group should be able to answer the following questions:

- Is the WebLab a didactic tool?
- Is the WebLab universal?
- Is the WebLab technologically advanced?
- Is the WebLab involved in the organizational structure?

Such questions must be answered in the affirmative way in order to achieve a really useful tool for students, but the developers must prove the actual compliance of these requirements, to give adequate support for the previous answers.

In the following sections, those questions are analyzed by developing and suggesting some implicit parameters underlying each point on behalf of constructing a coherent and homogenous study of a WebLab.

TABLE I.  
TYPE OF WEBLABS

Kind of remote control	Control level over the experiment	Example
Instrumentation Control	It's possible to change the inputs and look at the outputs. Remote sensing /action(read/write) [5]	 [2]
Parameters Control	It's possible to change the inputs and the parameters of the system. Remote action (write) [5]	 [3]
Logic Control	The client is able to change the inputs, the logic and the parameters of the system. Remote action (write) [5]	 [4]

#### A. Teaching

WebLabs may be a complementary working tool for students, used in their daily labor, as the Internet is. But to reach this point, it must be demonstrated their didactical usefulness. In spite of an inherited vision of the teaching field as a free market, resulting from the benefits given by the Internet, the biggest discussions about how to adapt

the education to the new cyberspace are taking place inside the institutions of the educational systems. In the case of engineering education, this improve of the educational system has a special and peculiar aspect, because of the need to add practical sessions to theoretical sessions [6].

From the previous paragraph is taken out that in the engineering area, the theoretical teaching of a subject must have a practical application of the theoretical knowledge. In this way, the WebLab designed for this reason, must carry out the proposed objectives of the subjects, and it should make easy the work of the student. So that, the WebLab should present an easy and intuitive interface in order to minimize the effort of interact with the laboratory in a remote way. The control of the inputs and the showing of the outputs should be fast and easy [7].

The student must have the feeling of being inside a laboratory and he should be able to interact with the devices located there, as if the access to the equipments was real, not to be only an eyewitness of the experiment as it happens in some virtual laboratories in which the user only shows a simulation of some actions [8][9].

Professor Soysal [10] compared the different experimental methods used at the engineering teaching. According to Prof. Soysal, the main objective of an educational experiment is to demonstrate physical phenomenon to the students, in order to help them to understand the concepts and the underlying principles. During the experiments, the students improve their practical experience and they acquire professional abilities. From this study can be taken out that WebLabs are not a rival of the traditional laboratories, but they are very useful as complement of them.

To make a practical analyze about a WebLab from a didactical point of view, the following indicators may be considered:

- **A priori didactical study:** feedback should exist between student and teacher in order to evaluate the evolution of the student. It may be done using opinion polls, achieved objectives or continuous evaluation of the student's work.
- **Competences:** as the WebLab is a learning tool used in a subject, it should promote some of the subject's competence, for example the collaborative work.
- **Educational platform:** it may be advisable that the WebLab will be involved in a educational platform, as Moodle. In this way, the WebLab would be a complement of the tools developed for the student's learning

#### B. Universality

This section describes different questions about the accessibility, availability and resources of the WebLab.

WebLabs should be a complement to the conventional laboratories, so they must be more time available than traditional laboratories: a WebLab must be online 24 hours 365 days, allowing the students to interact with the experiments without an schedule. To achieve that, the WebLab should be always on.

Moreover, a WebLab should be an open system for everybody, so that anyone could connect to the experiment and interact with it. It is true that is necessary a log of the access but it shouldn't be limited for the student enrolled in the course or the staff of the research group.

Furthermore, the WebLab should be available in several languages to make the access possible to people from everywhere.

And if is talking about universality as reference to available experiments, the user should be able to access to different devices and kind of WebLabs, for example a robot, a DSP or a PID control.

The indicators to this characteristic might be:

- **Accessibility:** as the WebLabs are based on Web, they should fulfill the W3C standard.
- **Multilanguage:** if the WebLab may be available on several languages, it will be access for user from everywhere, creating multicultural work group and promoting the collaborative work.
- **Open system:** is the experiment open to anybody? Or must be the user enrolled on the subject? Is it only a research work? Is it open 365 days and 24 hours per day?

### C. Technology

This question about characteristics of a WebLab is related with the technologies that have been applied to develop it: the technologies that make possible to interact with the WebLab.

One of the main characteristics is to be a multiplatform system [11]. If one system is multiplatform, it means that it can be accessed using an anything operative system (Windows, Linux or so on). Using this kind of system, the universality of WebLab is ensured.

Other characteristic of the WebLabs is the facility of access for the users. If users have to install software or a plug-in to use the WebLab, it will be an inconvenient. So, if is possible to develop a smart-client [11]. With this client, the student doesn't need to download anything (for example, ActiveX or Macromedia Flash), so the use of the WebLab will be easier. To achieve this kind of remote laboratory is necessary to develop the WebLab using actual technologies. Nowadays, the powerful tools are Web 2.0 technologies, for example AJAX.

Some of the indicators to study the quality of the technologies applied in the WebLab are:

- **Security:** the security of the WebLab should be developed by IT services of the university. The number of open ports to interact with the experiment may be considered and the access to the user's device too.
- **Platform:** if the maximum of users is wanted, the WebLab must be a multiplatform system and it should be developed using Web 2.0 technologies to reduce the necessity of download plug-ins. In that way, the WebLab will be accessed by a mobile phone or a PDA.

- **Reusable code:** for developers, this characteristic is very useful, because it allow them to adapt the code to new experiments quickly and in a simply way. The system architecture should be adaptable to new WebLabs too.
- **Control of the WebLab:** according with Table I, the WebLab may be classified according to the control over the inputs and outputs and the logic and parameters of the experiment.

### D. Management

To be considered the WebLab as an academic tool, it should be included into the curriculum of the subject and University should be informed of this. In this way, the WebLab will receive resources from the university in order to improve its quality and service.

In the same way, as the WebLab is a Web application in which different users interact, is necessary an administration service on the server to manage the users, their roles and permissions over the system.

A way to achieve it, is using a learning management system as Moodle [12][13]. In this LMS, the student can find all the resources and tools that he needs: tutorials, simulations, lessons, references, forums, handbooks and the WebLab access, for example.

Therefore, the indicators to analyze the management of the WebLab may be:

- **Institution support:** this indicator means if the WebLab is only a research resource or if it is a didactical tool supported by the university.
- **Integration into the subject:** the WebLab is a tool that is used during the course by the students and it takes part in the subject program.
- **Users' management:** there is a management system to administrate and control the users and their actions in the WebLab. It is necessary a log to control the connections too.

## IV. WEBLAB-DEUSTO

The WebLab developed by University of Deusto, WebLab-Deusto (<http://weblab.deusto.es>), is a didactical tool that is integrated into the teaching of the university [14]. Is a system that has being improved since 2004. Nowadays is a system that is used by 150 students roughly and it consists on three different WebLabs:

- **WebLab-CPLD and WebLab-FPGA:** in those WebLabs the student develops a VHDL program and he loads it into a CPLD or FPGA in a remote way. Through a GUI students can activate the inputs (virtual buttons and switches) and show the outputs thanks to a webcam. Those WebLabs are used by the teacher of the subject during the explanation of the lessons and the students use it to develop the final project of the subject. In those WebLabs, the logic control of the experiment is modified.

- **WebLab-GPIB:** thanks to this WebLab, the students can control the devices on the laboratory in a remote way. The student develops a C program with the necessary GPIB instructions to control the devices and to generate signals and to show them on the spectrum analyzer. The outputs of the experiments are accessed through the webcam and the files created by the.

Those laboratories are used on different subjects at Faculty of Engineering at University of Deusto and they are accessed by their own URLs. If a user wants to access

TABLE II.  
WEBLAB-DEUSTO

Subject	Application	WebLab
Electronic Design	5th year of Automation and Electronic Engineering	<a href="http://weblab-pld.deusto.es">http://weblab-pld.deusto.es</a>
	The student has to develop a VHDL program and demonstrate that it works on a CPLD	
	The WebLab is used as a complement during the software laboratory and it is fundamental to the develop of the final project	
Programmable Logic	3th year of Automation and Electronic Engineering	<a href="http://weblab-fpga.deusto.es">http://weblab-fpga.deusto.es</a>
	The student has to develop a VHDL program and demonstrate that it works on a FPGA	
	The WebLab is used as a complement during the software laboratory and it is fundamental to the develop of the final project	
Electronic Instrumentation	5th year of Telecommunication Engineering	<a href="http://weblab-gpib.deusto.es">http://weblab-gpib.deusto.es</a>
	The student has to develop a VHDL program to control, the devices on the laboratory using GPIB commands: spectrum analyzer and RF generator.	
	The student has to do one of the practice of the subject using the WebLab-GPIB, in order to optimize the time and the resources of the laboratory	

to them, he needs to mail to webmaster. To interact with the WebLab-Deusto is not necessary to be enrolled into a course. The following table shows the WebLab-Deusto experiments and their application environment.

If the WebLab-Deusto is analyzed using the characteristics that have been studied on the previous sections, the following results are obtained:

a) Teaching

- **A priori didactical study:** in some subjects, the practice or the project must be done with WebLab-Deusto. As result of this, the student obtains results that are evaluated by the professor. Finally, the student must fill a survey about his experience with the WebLab-Deusto.

- **Competences:** WebLab-Deusto is involved in the competences of the subjects: self learning and collaborative work.

- **Educational platform:** the main web of the WebLab-Deusto is a LMS, based on Moodle, but the experiments are not integrated on it. There is a demo but there are not tutorials, lessons or another tool for learning.

b) Universality

- **Accessibility:** at the moment, WebLab-Deusto doesn't fulfill with the W3C standard.

- **Multilanguage:** WebLab-Deusto is accessible in Spanish and English.

- **Open system:** the user doesn't need to be enrolled on the course. The experiments are available 365 days and 24 hours per day.

c) Technology

- **Security:** the security of the WebLab-Deusto is supported by university IT services. The application runs over the port 80 (HTTP) and the client is a smart-client: the user doesn't need to download any software.

- **Platform:** the WebLab-Deusto is a multiplatform system developed using Web 2.0 technologies (AJAX) and it is accessible from any mobile device as cellular or a PDA.

- **Reusable code:** the architecture of WebLab-Deusto is so versatile that the change of WebLab-CPLD to create the WebLab-GPIB has been automatic.

- **Control of the WebLab:** there are two types of WebLabs: logic control (WebLab-CPLD and WebLab-FPGA) and instrumentation control (WebLab-GPIB). On the first ones, the user can change the inputs and the logic control and on the last one, the user can control the inputs and he can show the outputs.

d) Management

- **Institution support:** WebLab-Deusto is one of the main project of the innovation chancellor, so the WebLab has financing and support from the university.

- **Integration into the subject:** WebLab-Deusto is involved in the subjects' curriculum. WebLab-CPLD and WebLab-FPGA are needed to complete the final project on the subject and they are used during the software lessons. WebLab-GPIB is not involved in the subject plan yet.

- **Users' management:** at the moment there aren't roles. All the users have the same permissions and there is a connections log.

## V. CONCLUSIONS AND FUTURE WORK

This work presents three main contributions: a) establish a common framework is necessary in order to make an uniform analysis of the actual online WebLabs; b) create different levels in each characteristics is useful to study a WebLab; c) the results of this study give the developers a point of view about the quality and usability of the WebLab under study.

As it is seen on the previous sections, a useful WebLab should be involved in the curriculum of a subject. The university should support the development, the use and the improvement of the WebLab as a quality tool and an advance. The WebLab should be developed using actual software and hardware: Web 2.0 technologies and microservers. The WebLab should be accessed by anyone who wants to interact with the experiment, and the user should have all the resources that he needs to complete the exercises and lessons as well as the information that he needs to know the evolution on the subject: tutorials, manuals, forums, evaluations, etc.

Currently, our research group is working in the following aspects: a) developing *thin* WebLabs using microservers and low cost devices in order to achieve high connectivity and plug and play experiments, b) a new approach for WebLabs based on Web 2.0 technologies and Service Oriented Laboratory Architecture (SOLA).

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## AUTHORS

**J. García Zubía** is with the Faculty of Engineering of the University of Deusto, Spain (e-mail: [zubia@eside.deusto.es](mailto:zubia@eside.deusto.es))

**D. Lopez de Ipiña Zubía** is with the Faculty of Engineering of the University of Deusto, Spain (e-mail: [dipina@eside.deusto.es](mailto:dipina@eside.deusto.es))

**U. Hernández Jayo** is with the Faculty of Engineering of the University of Deusto, Spain (e-mail: [uhermand@eside.deusto.es](mailto:uhermand@eside.deusto.es))

**P. Orduña** is with the Faculty of Engineering of the University of Deusto, Spain (e-mail: [pablo@ordunya.com](mailto:pablo@ordunya.com))

**I. Trueba** is with the Faculty of Engineering of the University of Deusto, Spain (e-mail: [itrueba@eside.deusto.es](mailto:itrueba@eside.deusto.es))

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