Reconfigurable IEEE1451-FPGA based weblab infrastructure

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***Abstract* - Weblabs are spreading their influence in Science and Engineering (S&E) courses providing a way to remotely conduct real experiments. Typically, they are implemented by different architectures and infrastructures supported by Instruments and Modules (I&Ms) able to be remotely controlled and observed. Besides the inexistence of a standard solution for implementing weblabs, their reconfiguration is limited to a setup procedure that enables interconnecting a set of preselected I&Ms into an Experiment Under Test (EUT). Moreover, those I&Ms are not able to be replicated or shared by different weblab infrastructures, since they are usually based on hardware platforms. Thus, to overcome these limitations, this paper proposes a standard solution that uses I&Ms embedded into Field-Programmable Gate Array (FPGAs) devices. It is presented an architecture based on the IEEE1451.0 Std. supported by a FPGA-based weblab infrastructure able to be remotely reconfigured with I&Ms, described through standard Hardware Description Language (HDL) files, using a Reconfiguration Tool (RecTool).**

***Index Terms* - Weblabs, Remote Labs, Reconfiguration, FPGA, IEEE1451.0 Std..**

I. INTRODUCTION

The permanent discoveries in S&E domains require ways of spreading them through the society. In this process, education takes an important role, becoming fundamental to create good teaching and learning methods so future scientists and engineers can encompass the evolution promoted by those discoveries. This is a key issue that can be fulfilled by enabling new ways of providing the required laboratorial work, which is fundamental so students can understand, validate and eventually questioning learned theories. Only with critical attitudes students may construct their knowledge in a specific domain, and the laboratorial work, focused on the interaction with real equipment with the inherent unpredictably of the obtained results, is a key component that must be provided in S&E courses [1][2][3][4]. However, the evolution of knowledge on S&E domains, the limited resources and time constrains of the courses' curricula, impair that all laboratorial work may be provided using traditional laboratories. To handle these issues, the advantages brought by new technological solutions, especially by the possibility of networking the I&Ms usually adopted in every laboratory, promoted the appearance of weblabs, which allow remote conducting real experiments through the Internet. Current trends show their widespread in education [5] as important resources used to complement and, in same cases, replace traditional laboratories [6][7], supported by several international consortiums and projects, some of them currently active, as illustrated in table I.

TABLE I. WEBLABS' RELATED CONSORTIUMS AND PROJECTS.

Lab2go: Created by the Carinthia University of Applied Sciences Villach, Austria. It is an online web portal repository where developers can describe their own weblabs using a predefined Online Laboratory Metadata - Reference Model Specification. Further information available on http://www.lab2go.net/.
iLab Project. Created by the Massachusetts Institute of Technology, United States of America. It provides a scalable and decentralized web service infrastructure named iLab Shared Architecture (ISA) that enables inter-connecting different weblabs. Further information available on https://wikis.mit.edu/confluence/display/ILAB2/about+iLabs.
Labshare: Consortium, since 2011 an Institute, composed by several Australian universities. It aims to provide a set of services for the integration and development of remote experiments in Australia. Further information available on http://www.labshare.edu.au/.
VISIR (Virtual Instrument Systems In Reality): Open weblab platform created by the Blekinge Institute of Technology, Sweden, for running and managing remote experiments. Further information available on http://openlabs.bth.se/.
GOLC (Global Online Laboratory Consortium): Consortium that aims to define standard solutions for creation of sharable, online experimental environments. Further information available on http://online-lab.org/.
LiLa (Library of Labs): Consortium headed by the Stuttgart University that provides an organizational framework for the exchange of experiments between institutions. Further information available on http://www.lila-project.org/.

Despite the advantages of using weblabs [3], the Accreditation Board for Engineering and Technology (ABET) [8][9][10], indicates as fundamental for a successful learning in S&E courses the design skills acquired by students, which focus on the design, build, or assemble instruments and systems using specific methodologies, equipments, or materials. Although some weblabs already allow reconfiguring the infrastructure using a setup procedure that enables connecting preselected I&Ms into different locations of an EUT (e.g. [11]) (this partially fulfilling the design skills requirements) they are not able to be reconfigured with different I&Ms, as in traditional laboratories where users may select all type of available I&Ms. Furthermore, the I&Ms may be expensive and/or inaccessible, not persuading the adoption of weblabs in some courses, especially in countries with economical restrictions. In these countries, it becomes even more important an institutional collaboration, not only by providing remote access to experiments, eventually created by highly reputed institutions in a specific domain, but also by facilitating I&Ms' sharing according to the requirements of each experiment. This last aspect is not handled by current weblab infrastructures, because they adopt traditional I&Ms based on hardware platforms, impossible to be shared and integrated in other remotely located weblabs. Additionally, weblabs traditionally follow non-standard architectures requiring specialized developers and technicians to create and setup remote experiments,