Embedding Instruments & Modules into an IEEE1451-FPGA-Based Weblab Infrastructure

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***Abstract*—Adopting standard-based weblab infrastructures can be an added value for spreading their influence and acceptance in education. This paper suggests a solution based on the IEEE1451.0 Std. and FPGA technology for creating reconfigurable weblab infrastructures using Instruments and Modules (I&Ms) described through standard Hardware Description Language (HDL) files. It describes a methodology for creating and binding I&Ms into an IEEE1451-module embedded in a FPGA-based board able to be remotely controlled/accessed using IEEE1451-HTTP commands. At the end, an example of a step-motor controller module bond to that IEEE1451-module is described.**

***Index Terms*—Weblabs, Remote labs, FPGA, IEEE1451.0 Std., Step-motor controller.**

I. INTRODUCTION

Commonly used in educational literature, sciences and engineering terms have different meanings and intrinsic objectives. While sciences are closely related with research activities focused on theory postulation, engineering focus on practices and practical models' formulation [1]. Despite their differences, both require theories and models validations; otherwise these can turn out to be irrelevant, becoming just unused ideas or concepts. In Sciences & Engineering (S&E) courses this is particularly important because the effectiveness of good teaching & learning processes always requires the adoption of practical activities to prove and validate theories and models, incentivizing students to get critical attitudes to construct their own knowledge. These practical activities include the laboratory work commonly provided by the experimental work required in every S&E courses.

Due to the evolution of technology in the last decades, currently this experimental work can be provided by different laboratory types, divided according to the adopted equipment (virtual or real) and their location (local or remote) [2]. Although each type has advocators and detractors [3], real equipment able to be remotely controlled are becoming a widely used option [4], provided by the so-called weblabs that are used to complement or to replace traditional laboratories, where users have a local access to real equipment. Presently, there are several weblabs implemented in different institutions, but developers still have difficulties for providing remote access to their laboratorial equipment and experiments, probably caused by the different architectures and technologies adopted for creating the infrastructures. Therefore, to overcome this aspect, standardization is a direction already proposed in several publications [5][6][7][8], being the main objective of the Global Online Laboratory Consortium (GOLC) [9], that is creating an interoperability standard that suggests using a set of interface definitions and profiles to control, access and interoperate different weblabs.

Despite the importance of standardization, if some efforts are focused on creating a common and cheap hardware platform able to integrate sharable I&Ms, costs will be reduced and collaboration between institutions will increase. It is precisely in this aspect that this paper provides a contribution for creating standard weblabs based on a common platform supported by FPGA-technology, namely by FPGA-based boards, and based on the IEEE1451.0 Std. that describes an architecture to create and network-interface transducers, that can form the I&Ms typically used by weblabs.

Next section provides an overview about the IEEE1451.0 Std. focusing on transducers' operation modes. Section III presents the implemented infrastructure, while section IV details implementation issues to create and bind I&Ms to an IEEE1451-module embedded in a FPGA-based board. According to suggestions made in this section, section V presents an example of a step-motor controller module able to be remotely controlled using standard IEEE1451-HTTP commands. The paper ends with some conclusions and directions for future work.

II. IEEE1451.0 STD.

A. Overview

Defined in 2007, the IEEE1451.0 Std. [10] aims to network-interface transducers through an architecture based on two modules: the Transducer Interface Module (TIM), that controls Transducer Channels (TCs), and the Network Capable Application Processor (NCAP), that provides network access to the TIM and to those TCs. Each module is connected through an interface defined by another standard of the IEEE1451.x family, some already specified according to the IEEE1451.0 Std. (e.g. the IEEEp1451.6 Std. for the CANopen interface) and others intended to be modified in the future (e.g. IEEE1451.2 Std. which defines point-to-point interfaces). The behaviour and features of TIMs are described within optional or mandatory Transducer Electronic Data Sheets (TEDSs) monitored by a status register and controlled by standard low-level commands. These low-level commands, provided by the TIM, may be accessed by IEEE1451-HTTP