

Chapter 2

Teaching Hardware Design with Online Laboratories

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ABSTRACT

This chapter focuses on a cost-effective, hybrid remote laboratory for hardware design. The laboratory is based on a reconfigurable internal debugging interface coupled with an “in the cloud” development and simulation system. Deployment, scalability, administration, and security concerns are discussed, and the possibility of hardware abstraction is introduced. Finally, the remote use of standard test equipment is detailed, examples of typical system usage and workflow are presented, and sample cost tables are provided.

INTRODUCTION

In response to the increasing demands being placed on instructional institutions today, coupled with the scheduling difficulty and expense of standard laboratory sessions, many universities are turning to new methods of instruction in such fields as hardware and software design. One such method is remote laboratory access, whereby a student may access a central laboratory at his or her convenience in order to perform required

laboratory experiments and projects (Zhang, Ball, Clare & Extine, 2005). The access can take place from a student-provided computer, a university computer, or even a public computer with an Internet connection, as no specialized software needs to be installed on the client machine. This concept is advantageous for several reasons. First, the students can be freed from the time and space constraints typically present in a standard laboratory session (Esche & Chassapis, 1998), having, instead, unlimited access to the development tools and hardware for the duration of their course. Second, the maintenance and administration of

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the laboratory can be centralized and offloaded. This can free the instructor to focus on academics.

In addition to remote access being used to complement a student's on-campus instruction or lectures delivered over the Internet, it can be used in off-campus instruction. For example, in a digital hardware design course, where both teaching about hardware and practicing methods of design, construction, and testing go hand-in-hand, the most effective solution is to bring remote laboratory access into the off-campus classroom via a workshop format. This, of course, requires the off-campus site to have computer resources and to have the Internet available.

Another benefit of the remote laboratory is that the laboratory can be physically secured against accidental or intentional damage; this ensures a uniform, fully functional environment for each laboratory assignment. Due to the nature of computer-based remote access, a large library of documentation, tutorials, and other related items can be made available to the students on-demand from the same servers that host the development environment. This library can be used to guide students in the use of the potentially unfamiliar environment, as well as to supplement traditional classroom and laboratory instruction. These features allow institutions that might not normally offer "hands-on" laboratory experience the capability to do so, generally improving instruction and aiding retention in hardware and software design courses.

The usage of a remote laboratory is not limited to education. For example, it may be advantageous for an engineering firm to offer a similar centralized laboratory to its employees. This principle can be extended to almost any field that requires users to have access to a hardware resource, but where said resource may remain idle for a large portion of its lifetime. Maintaining fewer instances of that hardware in a central, shared location may prove to be advantageous in terms of the cost associated with both operation and future upgrades. The remote laboratory system princi-

pally described in this chapter, Remote Laboratory with Reconfigurable Internal Debugging Interface (RL-RIDI), allows centralized sharing of hardware resources, enabling organizations to reduce overall costs while accommodating the needs of many users within an environment of rapidly changing hardware requirements.

BACKGROUND

Remote access laboratory development and growth have accelerated sharply during the last decade. As a result, a greater number of remote laboratory types have been developed and are in use today (Gomes & García-Zubia, 2007). Most of the remote laboratory systems target certain disciplines, mainly engineering and computer science, and are utilized for teaching and training purposes. Several examples follow.

Labshare: This project is jointly developed by the University of Technology, Sydney; Curtin University of Technology; Queensland University of Technology; RMIT University; and the University of South Australia. Labshare's mission is to create a nationally shared network of remote laboratories for student use, thereby improving educational outcomes while reducing overall cost (Lowe et al., 2009).

WebLab-Deusto: This open-source distributed Remote Lab was developed at the University of Deusto, Spain in 2001. It provides remote experimenting with hardware such as FPGAs, CPLDs, and PIC microcontrollers (García-Zubia et al., 2010).

Lab2go - A Repository to Locate Educational Online Laboratories: Lab2go, from the Carinthia University of Applied Sciences, Austria, specializes in identification of publicly available online laboratories developed for interactive experimenting over the Internet (Auer, Garbi-Zutin, Maier, & Niederstätter, 2010, April).

A Smart Layer For Remote Laboratories: This system, developed at LABORIS / Polytechnic

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