Distributed Remote Electronic Lab with Standard Modules

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Abstract: The use of laboratories is essential for the education in engineering and science related fields at a high qualitative level. Active working with experiments and problem solving does help learners to acquire applicable knowledge that can be used in practical situations. At the Carinthia Tech Institute we developed easy to use and reuse online lab standard modules.

1 Introduction

The use of laboratories is essential for education in engineering and science related fields at a high qualitative level. Laboratories allow the application and testing of theoretical knowledge in practical learning situations. Active working with experiments and problem solving does help learners to acquire applicable knowledge that can be used in practical situations. That is why courses in the sciences and engineering incorporate laboratory experimentation as an essential part of educating students. Experimentation and experience-based learning is also performed in many other subject areas, for example in economics where students lead virtual companies and compete on a simulated market.

Labs were always playing an important role in education. Nevertheless the nowadays, experiments have become more and more complicated. Due to this fact the demand on specialised and expensive equipment increased. Only some large research centres and perhaps some universities can afford such equipment, and even these can only have a limited number of what is desired. Online laboratories are therefore THE solution.

During the last years a lot of remote and virtual laboratories have been developed within pilot projects. As they are not integrated into a common framework it is difficult for a learner to access and to use them. They differ widely in their user interface, user management and time reservation scheme. This large diversity makes it very difficult for educational institutions to integrate online laboratories from different sources into their course offering.

At this point we can say that there is an increasing demand on standard lab environments, avoiding the requirement for deep knowledge about surrounding technologies and which are easy to access.

The Carinthia Tech Institute developed the following easy to use and reuse online lab standard modules:

- Virtual Electronic Lab (VELO) [7]
  - for tools with Web interface (e.g. MATLAB) [10], [13]
  - for tools without Web interface based on Citrix MetaFrame [11], [13]
- Remote Electronic Lab (REL), based on LabVIEW [8]
  - with real instruments connected by GPIB interface
  - with virtual instrumentation by data acquisition cards
- XML templates for interactive lecture scripts

Detailed descriptions of these tools have been already published. Together with partners we have also developed some helpful applications for an easy use of online lab solutions in educational contexts:

- a switch matrix board
- a time reservation system

Furthermore remote-control of hardware by use of Embedded Web Servers is one of the development trends. Servers within our distributed remote lab are located in Villach (Austria), Brasov (Romania), Barcelona (Spain), Limerick (Ireland) and Kanpur (India). Each of these servers is running one online experiment.

2 Switch Board

One of the problems coming up with remote labs using real instruments is that they have to be hard-wired to the circuit. To make an access to more than one node in the circuit with a single measurement instrument possible, we designed a simple and cheap Switch Board.

This Switch Board allows connecting each of its 4 inputs to 4 different nodes in the circuit. The Switch Board is connected to the PC via the parallel interface and is controlled like the other measurement instruments in our lab by a LabVIEW program.

It consists of a standard 25-pin D-SUB connector for the PC connection, 4 BNC-Connectors for connecting the measurement instruments, 12 relays switching both, signal and ground, connections of the BNC connector to a pin array, which carries the circuit under test. An external 12V power supply is needed to provide the energy for the relays. As power supplies for most experiments don't have to be switched, these are hard wired to a second pin array (Figure 2).

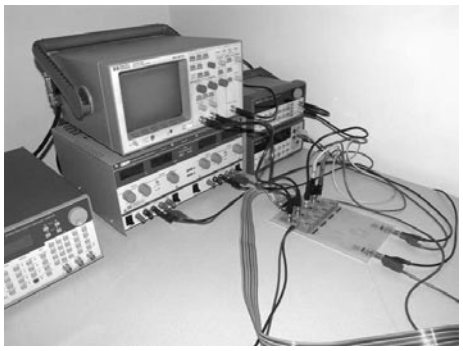

Figure 1: Remote Electronic Lab

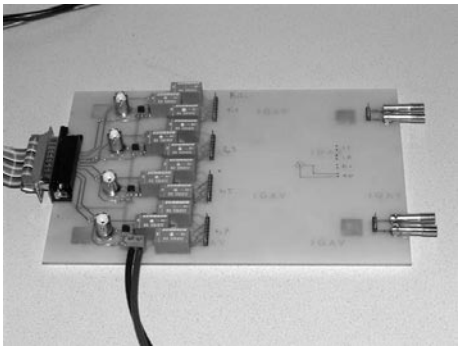

Figure 2: Switch Board

3 Reservation System

Usually Remote Labs are single user systems. To control the access to online laboratories, some time-slot and resource-management system is needed. Our approach is based on the idea to unify access control, time management and resource management for a cluster of labs at different locations.

At the moment there is one central server which does all the database maintenance, and which handles all the reservation requests.

We are working on concepts to eliminate this single point of failure. On the computer which runs the lab experiment, a small program is communicating with the database server and checks incoming requests for validity.

Before someone can access a lab experiment he has to allocate a time-slot. Each remote laboratory site is linked to the reservation system. Usually a user authentication is also required to access a lab experiment.

Figure 3 shows the Login window for the distributed lab. In Figure 4 a list of available labs to allocate time for is shown.

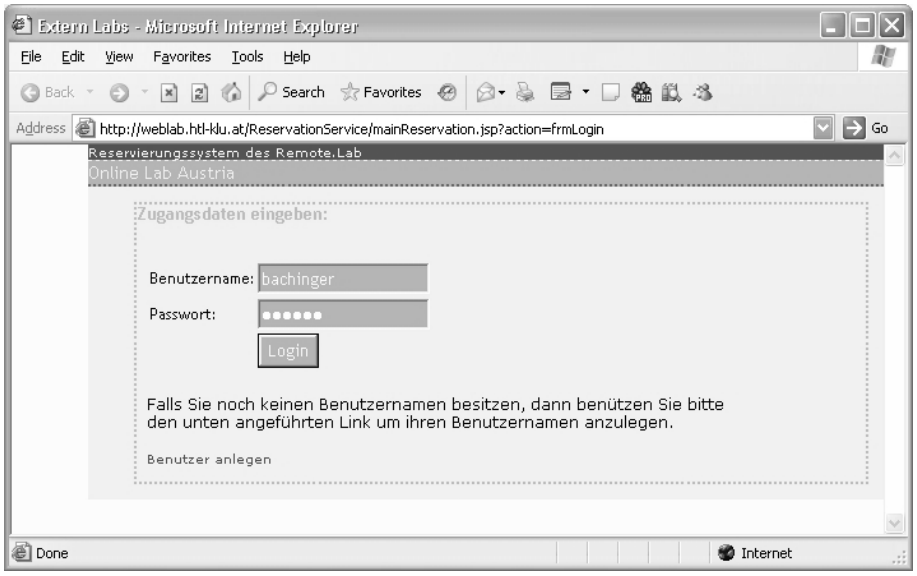

Figure 3: Login window for the distributed lab

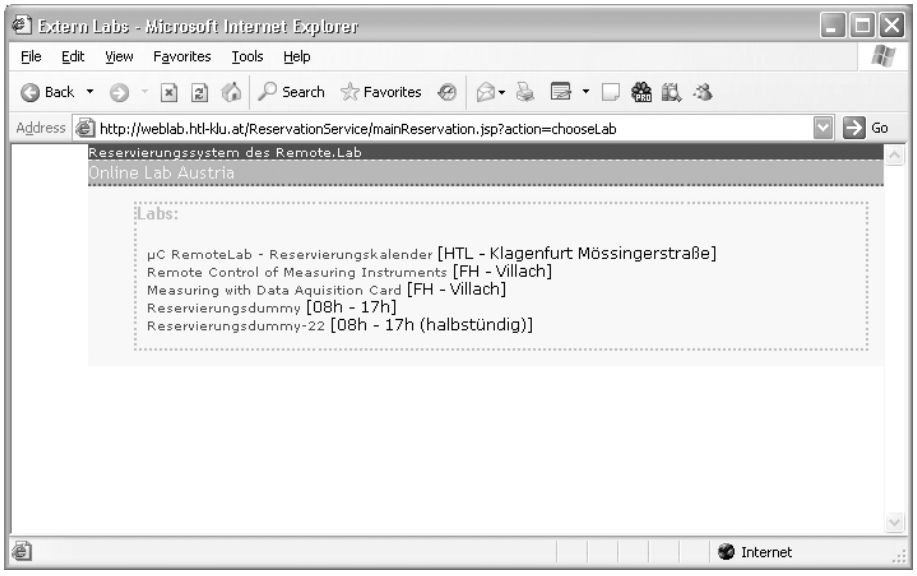

Figure 4: List of available labs

After choosing an online-laboratory (Figure 4), someone is linked to a list showing all available the time-slots.

By simply clicking on one of these fields, its content changes to a cross. So the time is reserved for the current user.

A maximum of four reservations at a time is allowed. Reservations which have already been done can also be cancelled.

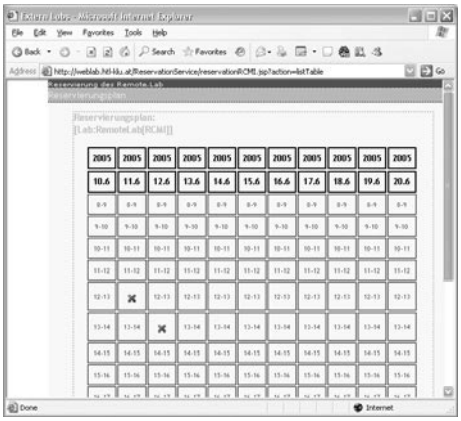

Figure 5: Reservation scheme

4 Online ASIC Design System

As a very complex solution and a combination of a virtual lab and a remote lab we are about to realize systems for online development of digital (Xilinx) and analog (Lattice) ASIC's.

The following steps will be implemented:

1. ASIC (digital/analog) design system running on a lab server. The user only needs a web browser.
2. Simulation of the design on the lab server.
3. Download of the design to the connected hardware (evaluation boards).
4. Test and measure with real or virtual instruments via the Internet.

So a complete design cycle can be realized for example from a home working place. Also simulators and real hardware (evaluation board) can be on different locations (distributed online lab).

5 Remote Hardware Control with Embedded Web Servers

Today very compact Embedded Web Servers are available on the market. These Web-servers can be used in a wide range of applications. The Embedded Web Servers can replace personal computers required for e.g. remote labs with special Hard- and Software. They can be used in educational and also in industrial environments. Micro-Webservers are cheap, and nearly each measuring instrument has a serial port (which is used for the connection to the Micro-Webserver). As we have shown above, up to seven instruments can be connected to one Embedded Web Server at the same time. For further numerical and graphical analysis, measurement results can also be transferred to computers, running software like Matlab, Simulink etc.

Another advantage by use of this technology is the flexibility. It doesn't depend on the instruments or on the software solutions which is in use. So it is possible for educational institutions to set up several standard lab experiments for the use over the Internet. In general any hardware which can be programmed, configured, maintained and used over the internet, can be connected to Embedded Web Servers. This is also interesting for industrial solutions: on the one hand resource-sharing in the field of SME's becomes possible in a cheap and time-efficient way and on the other hand for the development of remote engineering solutions. Figure 6 shows a typical configuration of hardware control by use of the Micro Web Server Technology.

Micro Web Servers allow the executions of different user interfaces (UI) - especially html pages or flash animations are appropriate. Table 1 gives a short overview about the pros & cons of different user interfaces.

User Interface	+	-
Command line	Simple to implement, universal	Less user friendly
Image with clickable areas (PC, PDA)	Simple to implement, user friendly	Restricted functionality
Flash Animation	Most user friendly	Programming is difficult

Table 1: Different user interfaces

By use of a touch-screen someone gets the feeling of controlling a real instrument panel (see figure 7).

Micro Web Server based solutions among others have the following advantages:

- No serviceable parts, like fan or rotating hard disk

- Quick start up of the system
- No license of operation system or additional software needed
- Guest operation system independent, Windows, WinCE, MacOS, UNIX, LINUX, BEOS, etc.
- No use of unusually ports, only http protocol on port 80
- No special firewall configuration needed
- Needs very less time to create a web based front panel
- Control of remote instruments is very close to reality by us of a touch screen
- Watchdog for automatic reset after failure
- Easy cloning of the whole system
- Backup of the whole system remotely in a few seconds
- No permanent administration like updates, hot fixes or service packs necessary
- Battery powered mode possible, because of low power consumption

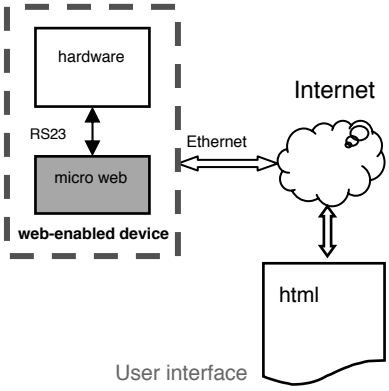

Figure 6: Micro Web Server Schematic

Figure 7: Hardware control via touch screen

Conclusions

This paper has shown different types of Standard Modules for distributed Remote Electronic Laboratories and their practical implementation. The combination of different types of standard modules like a switch board, a system for Online ASIC design or the use of Embedded Micro-Web-Servers leads to an increasing amount of online-experiments that can be easily installed, controlled, combined and be accessed.

This paper has also introduced a time reservation system, which facilitate the integration of online laboratories from different sources into any e-learning course.

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