Design of Remote Laboratory dedicated to E2LP board for e-learning courses.

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Abstract—Recently, with advent and exploitation of computer and communication technologies, remote laboratories have been widely popular among many universities. They are built in order to enhance learning and minimize the gap between theory and practice. Remote laboratories provide on-line pervasive workbenches, which allow an interactive learning environment that maintains student attention. This paper reports on development of remote laboratory, which is currently performing under E2LP FP7 project. The paper addresses many solutions in the development stages along with powerful technologies involved. E-learning portal will create and provide new teaching methods in embedded systems design through the real and simulated experiments.

I. INTRODUCTION

Laboratories, which are found in all engineering and science programs, are an essential part of the education experience. Not only do laboratories demonstrate course concepts and ideas, but they also bring the course theory into life. In a traditional laboratory, the user interacts directly with the equipment by performing physical actions (e.g. manipulating with the hands, pressing buttons, turning knobs) and receiving sensory feedback (visual and audio). However, equipping a laboratory is a major expense and its maintenance can be difficult. [1]

Since the experiments are performed in a laboratory that contains expensive equipment, the students must be supervised which limits the time they have. This also requires a class with many groups performing the experiment at the same time, and thus many instruments are required to support each group. Laboratory experiments are also a serious problem for distance learning students who may not have an access to the laboratory at all. [2]

As an alternative, virtual online laboratories can expose students to hands-on learning without incurring the high costs of instructional facilities. [3]

Remote laboratories are those laboratories that can be controlled and administrated online. They differ from the virtual simulated laboratories as they are interacting with physical instruments. [4]

II. REMOTE LABORATORY

In E2LP (Embedded Computer Engineering Learning Platform) project [5] a Remote Laboratory (RL) is an experiment, demonstration and a process running locally to design and control an experiment board based on a FPGA device, but with the ability to be monitored and controlled over the Internet (future E-learning portal).

In the base case, the RL can be an experiment board connected to a computer through a standard interface and with the host computer connected to the Internet, which provide remote access. The client can be any computer connected to the Internet with an ability to see the same interface as the local host and also have the same programs, interfaces, modules etc.

The concept of E2LP RL should allow the user to do several actions over an Internet connection, which are the list of E2LP Remote Laboratory functionalities:

1. Dedicated software and hardware solutions will provide an access to laboratory equipment and enable students to set them up and operate them at the required level to carry out exercises.

2. Users could access the essential data sheets, tutorials and software tools, which are available on the E-learning portal as an introduction to the course, which is a RL’s content management system (CMS). Each laboratory exercise is presented to the user through tabs and such division will be implemented into Moodle based platform for e-learning course (Basic information, Theoretical explanations Instructions, Feedback questionnaire for lab evaluation).

3. After booking in a given time space Users could remotely program given set of exercises over the Internet and simultaneously, in real time could monitor the evolution of the experiment on implemented dedicated Graphical User Interface (GUI) of the Front Panel of the board. Fig. 1

4. Automatic verification of course assignments, supported by Moodle plug-in, will allow an advanced management of assignments and submissions together with feedback information mechanisms for both teachers and stu-
controlled environment is an experiment base board, which is controlled by programming device (Xilinx Platform HW-USB-II-G). This programming device provides integrated firmware to deliver high-performance, reliable and user-friendly configuration of the base board and enables user to program other Xilinx CPLD devices. This programming device is fully integrated and optimized for use with specialized Xilinx iMPACT software, which enable users to perform remote operations such as programming and configuring FPGA via JTAG interface.

The NI PCI-6509 digital card with 96 bidirectional I/O lines enable user by dedicated GUI interface (Error: Reference source not found) to control each pin in the boards front panel interface and consequently enable him to control each led, switch and button. Furthermore specific module communicates with LCD pins on boards front panel interface and translate them into RS232 ASCII char.

In remote operations user firstly power the board from the website (this is done by power controller module and digital card) and run iMPACT on one computer but the operations are performed on a device attached to another computer through a Xilinx Cable Server. Xilinx ISE includes such program as well as provide a set of programming tools, which allow user to perform operations remotely. To use this functionality user only needs to specify a remote server address in proper configuration in iMPACT software. This is the most important feature of programming device, from the RL point of view.

It should be pointed that all exercise could be done remotely, but feedback from some interfaces is not available. Error: Reference source not found below represents implemented necessary interfaces according to requirements.

Connection with the Remote Laboratory is provided via e-learning portal and is based on Apache server, PHP and SQL server. It provides an access to knowledge (exercises, data sheets) through a web user interface and has an ability...
TABLE I
IMPLEMENTED INTERFACES IN RL

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Direction (In/Out)</th>
<th>Implementation in RL</th>
<th>Access to the interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCD 16x2 Character Display</td>
<td></td>
<td>(Not-tested) Full¹</td>
<td>GUI</td>
</tr>
<tr>
<td>Dip Switches</td>
<td></td>
<td>Full</td>
<td>GUI</td>
</tr>
<tr>
<td>Push Buttons</td>
<td></td>
<td>Full</td>
<td>GUI</td>
</tr>
<tr>
<td>LED</td>
<td></td>
<td>Full</td>
<td>GUI</td>
</tr>
<tr>
<td>RS-232</td>
<td></td>
<td>Full</td>
<td>Standard tool²</td>
</tr>
<tr>
<td>Power Supply ON/OFF</td>
<td></td>
<td>Full</td>
<td>GUI</td>
</tr>
</tbody>
</table>

¹ – now under development
² – e.g. HyperTerminal, Putty, etc.
GUI – web interface

System entity represents the system as seen from outside. Imagine observing the system on Fig. 4 from outside, without the possibility to see what is inside the system. The only things you will see are its input and output ports. Input ports are like input variables to a function, while output ports are like results of the functions. Each output port in a combinational digital system represents the result of one Boolean function of input ports. If the system has N output ports and M input ports, it computes N Boolean functions of M variables, i.e. functions of the same input ports.

In order for the tool to know to which components on the board we want to connect inputs and outputs of our system, we need to specify which pin from FPGA we want to associate with which port of our system. Let us connect inputs iA and iB to two switches and output oY to a LED. You can always refer to the complete list of FPGA pins on E2LP platform and to which components they are connected. Pin assignment is done in a special tool for that, the Xilinx PlanAhead. It can be run from Xilinx ISE.
If configuration completes without errors, the FPGA_DONE diode on the board should be turned on, meaning that the FPGA is configured and working. If you change the state of the switches connected to inputs iA and iB, you should observe the corresponding change to the LED connected to output oY based on a Boolean function which the circuit implements (NAND). Fig. 5

IV. CONCLUSIONS

Proposed solutions based on integrated together Remote Laboratory components and e-learning Moodle Platform enable student to acquire desired knowledge about digital systems and significantly support learning process.

Remote laboratory and e-learning portal enable user to access E2LP base board over the Internet, configure it compiling VHDL code and having feedback immediately on his own computer. In the same time he can monitor E2LP base board and operate on remote laboratories equipment.

**Listing: VHDL description of the NAND function implementation digital system from Figure 4**

```vhdl
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;

entity MyFirstDigitalSystem is
  Port ( iA : in STD_LOGIC;
         iB : in STD_LOGIC;
         oY : out STD_LOGIC);
end MyFirstDigitalSystem;

architecture Behavioral of MyFirstDigitalSystem is
  signal sS : std_logic
  begin
    sS <= iA and iB;
    oY <= not(sS);
  end Behavioral;
```

**Listing: UCF constrain file definition of the digital system from Figure 4**

```ucf
NET "iB" LOC = Y24;
NET "oY" LOC = N24;
NET "iA" LOC = W19;
```

Fig. 5 Evolution of the exercise on GUI web interface
Future development of RL based on integration of external equipment and services and development of Moodle platform will be done in accordance with the exercises necessities and end-users needs.

V. REFERENCES


