TCP/IP Communication between Server and Client in Multi User Remote Lab Applications

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***Abstract*—Remote labs in difference to virtual labs allow as usual only a single user access. To manage the user access for such remote experiments a reservation system is used. The aim of this work is to develop a simultaneous multi user access to the lab server and the remote experiment. This approach was tested for the READ remote lab and a Microcontroller remote lab, installed at the CUAS. The system controlled by LabView has been implemented using a Data Acquisition Card from National instruments. The performance of the simultaneous access was tested under load with a variable number of users. For the MRL a queue gives access to the peripherals to the main user, while the others wait for their time slot to use the system. This was implemented in such a way due to the synchronous characteristics of this lab.**

***Index Terms*—Citrix Application, Data Acquisition, LabView Run-Time Engine, Remote Access, Remote Laboratories, TCP/IP Comunication, Tele-learning, Virtual Instruments.**

I. INTRODUCTION

In all electronic engineering disciplines the basic subject about microcontrollers is taught. The best way to introduce the content of this topic to undergraduate students is by means of practical exercises, avoiding great theoretical explanations on the blackboard.

The students need to work with teaching kits in order to assimilate the basics of programming microprocessor systems. The usual method implies that the student has to be present at the laboratory, where the microcontroller mock-up is physically located.

The trend in higher education is to facilitate work to the students avoiding displacements as much as possible, transforming the traditional teaching in a semi-present or totally non-physical teaching environment. Today this is well-solved for the subjects that don't need any lab work, using Internet applications, but additional labour is necessary in areas such as microcontrollers.

On the other hand, the tendency in higher educational programs is to move from traditional teaching methodologies to new ones, as Problem Based Learning (PBL). This methodology proposes a practical problem to students and sets up a learning environment to help them to find the proper problem solution on their own initiative including the necessary theory. It has been proved that this kind of methodology increases the interest of students in the learning process.

To achieve a complete e-learning teaching experience and for satisfactory implementation of PBL methodologies, a remote lab becomes mandatory. Students need to practice, test and do exercises.

Knowing that nowadays nearly everybody has at least one computer with Internet connection at home, it makes sense to take profit of the network for doing academic work. Remote laboratories permit to experiment via the Internet, without doing simulations of any kind. Moreover, thanks to these systems, the students can practise when and where they want, the equipment is not in danger and it is not necessary to invert money for supervision staff.

II. SYSTEMS DESCRIPTION

The web server hosts the HTML files that contain the ASIC and microcontroller remote laboratories home pages, information pages about the implemented exercises, as well as the links to log on the system and it is located, in our case, apart from both LabView servers.

The LabView servers are connected to the ASIC and the microcontroller board via the DAQ (Data Acquisition) card and therefore control all the data acquisition and generation for the experiments, as well as all the measurements performed. The Citrix Server is the application server that hosts and delivers the PAC-Design and Keil µVision2 applications in order that remote users can create schematics for the ispPAC10 and programs for the microcontroller.

With the purpose of creating an environment as close as possible to a real lab, the utilization of a camera to observe the behaviour of the microcontroller board is important to provide a real feedback to the user.

A. Mock-up Boards and software development

The microprocessor remote lab has been developed using as starting point an existing work bench for presence learning and teaching. This is divided in two main parts; hardware which is composed by the microcontroller board µdee537, and the Keil µVision2 as a software development, running on a Personal Computer.

The development software, a microcontroller development environment of Keil, is the µVision 2. It is very popular among microcontroller programmers and gives the user the possibility to edit, assemble and debug an application for several families of microcontrollers.

The hardware of the microcontroller system is composed for two boards, as we can see in Figure 2.

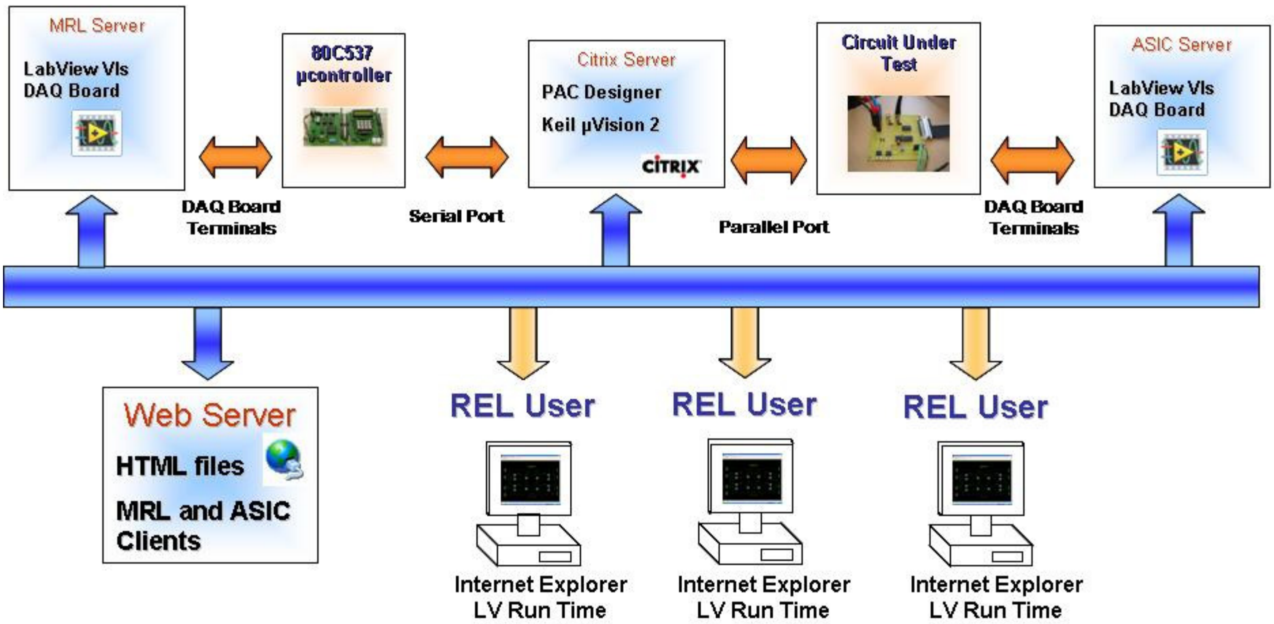

Figure 1. System Diagram

The first one contains the microcontroller (80C537), the memories and the basic peripherals (switches and leds). This board also contains all necessary circuitry, like voltage regulators. The second one is an expansion board that contains the rest of the peripherals (keyboard, display and analogue Input/Output).

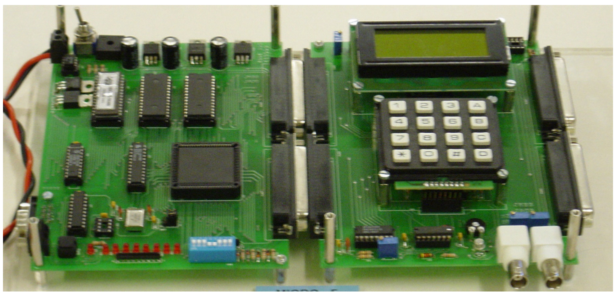

Figure 2. Mock-up board MRL

This board is prepared to load and execute programs developed in a PC. The transference of the program is done by the serial port RS-232, which places the program in one of the RAM memories of the board. Once loaded the program we can execute it and verify its correct operation.

The ASIC used for the analog circuit design experiments is the ispPAC10. The ispPAC10 is member of a family of analog circuits capable of realizing a variety of popular analog functions including precision filtering, summing/differencing, gain/attenuation and integration.

The interaction elements between mock-up board and each user are the following: power supply switch, reset utton, leds, generic switches, keybard, input/output analog signal connector, potenctiometer and temperature sensor.

B. TCP/IP communication

Our application follows a client/server model and information is exchanged via TCP/IP protocol.

The Internet protocol suite (commonly TCP/IP) is the set of communications protocols that implement the protocol stack on which the Internet and most commercial networks run. It is named for two of the most important protocols in it: the Transmission Control Protocol (TCP) and the Internet Protocol (IP).

The server links up the client program and the mock-up board. The communication between the server and the mock-up board is done by a Data Acquisition Board (DAQ).

The DAQ card is used to generate and acquire analog and digital signals for the microcontroller mock-up in order to control the peripherals of the board. The DAQ employed is the NI PCI-6229. The DAQ board is connected to the PCI bus of the server computer, where the device driver software has been installed to provide communication between the LabVIEW virtual instruments and the DAQ card.

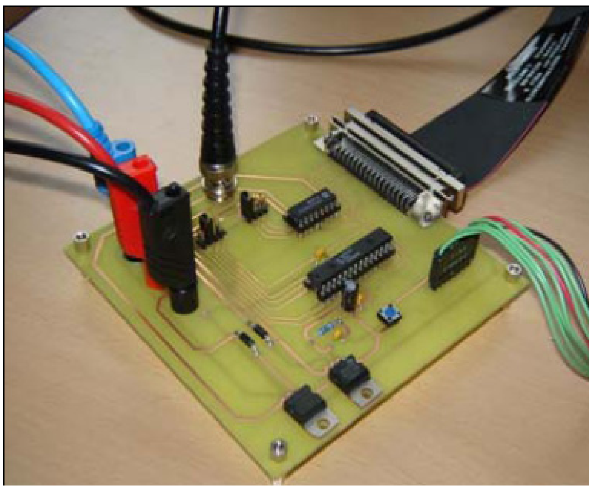

Figure 3. Mock-up board ASIC

When the server obtains the information of reading elements, the data are packed and sent to the client by TCP/IP. Then the server receives the state of the writing variables and write them to the DAQ. These actions are executed constantly while the connection is active.

On the client there is a main program responsible for users authentication. After authentication, the client allows users to access others Vis (peripherals), where it's possible to modify and visualize all the variables and perform experiments.

The client receives the value of some parameters, packs them and sends the packet to the server and receives the packets from the server with the responses of previous requested operations.

C. Control Access

The scheduling process and the secure access are important aspects to take into account. Regarding the scheduling, at the moment, there is only one physical system available for several potential users. Consequently, it is necessary to have a user access control to give the admission to the physical system only to one student, and to limit the time per session. On the other hand, this remote lab can not be an open system. Therefore, it's necessary a user access control that assures that the access is only permitted to registered users.

Before accessing to the MRL a username and a password are requested. If nobody is connected when someone else is requesting the access, and both username and password are correct, the access is granted. At that time, the client is allowed to interact with the microcontroller system during predefined time slot controlled by the administrator of the system. However, if a user is already connected, the client has to wait until the disconnection of the previous user for obtaining the control. In order to do it, a user's queue has been created. It allows to establish an access order and gives a feedback to users, regarding their waiting time.

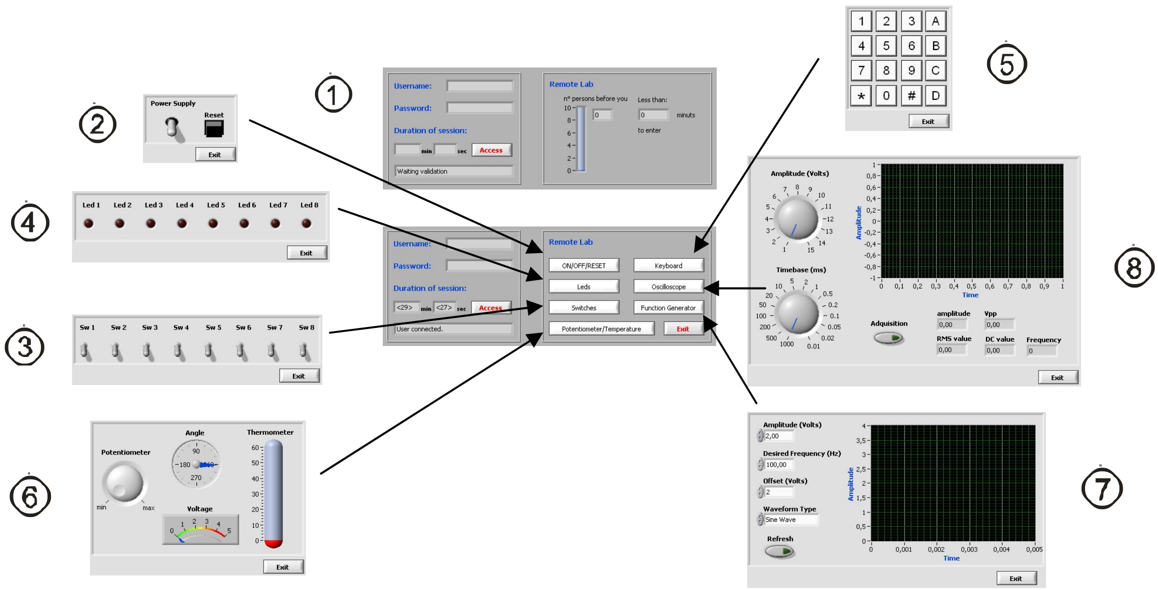

Figure 4. User interface of the system

D. User interface

The user interfaces of the system are the LabView front panels of the virtual instruments. It's necessary to download the MRL client via a standard web browser and install it in the user personal computer. The user simply needs to execute this software every time he/she wants to work with the remote lab.

The client side also should have some extra software – LabVIEW Run-time Engine and Citrix client installed in his/her computer in order to make a properly use of all the functions of the MRL. The client is available at the Remote Lab website and the LV Runtime engine is available for download from the NI website.

After inserting a valid login and password the session is started and the access to all other VIs is enabled. Whether a session is finished by the user or by time out, the system becomes ready for another user's access.

Fig. 4 displays the user interface and the different elements to interact.

The following table summarizes the created Virtual Instruments:

TABLE I.
DESCRIPTION OF THE CREATED VIS

	Peripheral VI	Function
①	User access	User access control to permit the access to the physical system
②	Power Supply / Reset	Switch on the board and reset the microcontroller
③	Switches	Switch control to change the state of the switches
④	Leds	To monitor the state of the Leds
⑤	Keyboard	Virtual keyboard to replicate the pressed key
⑥	Potentiometer	Value change of position and temperature sensor.
⑦	Function generator	To generate a signal for feed the analogue input.
⑧	Oscilloscope	To visualise and measure the signals of the A/D converter.

E. The Citrix Server to Deliver the Application Software

Citrix Presentation Server is used in order to provide to each user access to the Keil and PAC-Design software, running in the server, to program the microcontroller and the ASIC.

The Citrix Presentation Server is a remote access/application publishing product, built on the Independent Computing Architecture (ICA). The Citrix software provides secure access to applications and programs installed on the server to a wide number of clients.

The LabView Client has the link to the Citrix server where the Keil uVision runs. The user has to authenticate again against the Citrix server in order to access the Application software.

III. CONCLUSIONS

The new self-made remote microprocessor work bench for the 8051 family, based on the Citrix server software and remote LabVIEW applications has been presented, including successful practical results.

The Microprocessor Remote Lab gives the students and lecturers new chances in the learning process. It is a useful tool in order to overcome the drawbacks related with availability of laboratory resources.

Students have at their disposal the microprocessor work bench in a remote way. This helps lecturers to implement new teaching methodologies, as PBL. With 24 hours of remote laboratory access, students can organize lab jobs in a satisfactory way, by minimizing displacement and maximizing learning performance.

The system cannot be considered as a replacement of related practical lessons, but a tool to bring practice in situations where laboratories cannot de fully assembled.

In spite of that, the circuit behaviors could be well visualized for the performed exercises.

Different approaches can be used to deliver the access to remote users. A previous version of the system was implemented using LabVIEW web Server. TCP/IP communication has been developed in order to make a more flexible access control and a toughness system. The development of client and server applications with low level (TCP/IP) protocols has shown to be a good solution for LabVIEW based remote labs.

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