A VIRTUAL LABORATORY TO PERFORM ELECTRONIC EXPERIEMENTS BY INTERNET

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Abstract – This paper presents a work that has been performed since 1999, at Polytechnic School of the University of São Paulo, one of the most important teaching institutions for engineering in Latin America. In its recent version, our Virtual Laboratory allows the control of five typical experiments for introductory courses in electronics, with a satisfactory level of interactivity. The advantages of using Embedded Internet are also discussed, once it would make possible the reduction of costs and the free access to this technology.

Keywords – Virtual Laboratory, Remote Laboratory, Virtual Instrumentation, Embedded Internet, Distance Education, Electronics.

INTRODUCTION

The distance education dates back from the end of XIX century and its evolution comes along with the development of the communication means in general [1], when using the didactic resources systematically organized. With the appearance of Internet, it can be said that distance education enters in its fourth generation, after the introduction of mail, radio, television and multimedia resources, which appeared during the 1980' and 1990', and nowadays they can be found in computers.

Even so, one of the existent deficiencies for distance education courses is the lack of practical classes in laboratory, which are indispensable for the students who enter in contact with experimental processes. One of the solutions for this problem would be the use of virtual laboratories, however, it is not possible to substitute the work that the student performs during a practical class of laboratory.

In this article, we will present the Virtual Laboratory by the Integrated Sensors and Microsystems Group (SIM) of the Laboratory of Microelectronics (LME) of the Polytechnic School of University of São Paulo (EPUSP).

The term Virtual Laboratory (VL) can be used in different ways. While some VLs perform computational simulations; others allow the conduction and the remote control of real experiments by Internet, this is our case.

A VL should allow the accompaniment and the control of experiments remotely and it can be implemented in a computer that possesses access to the Internet, data acquisition cards (DAQs), GPIB interface cards, and other devices. Its operation consists of exchanging data between this computer located in the laboratory (Server), and the computers of remote access (Clients), so they can monitor and control the experiments performed in the laboratory, through Internet, in real time, according to the model shown in figure 1. That allows different people to have access to the same experiment, no matter how far it is from the place where the real experiment is settled [3].
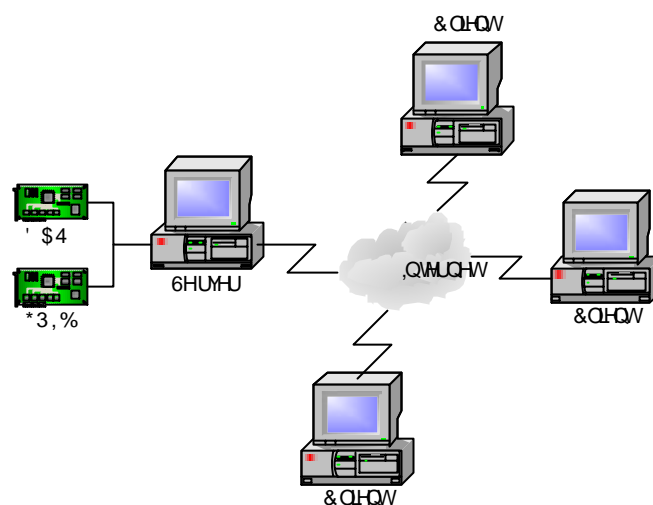

FIGURE 1
OVERVIEW OF A BASIC VIRTUAL LABORATORY.

HISTORICAL

In the first attempt to integrate the available resources of Virtual Instrumentation [4] with the data transmission through Internet, it was used a power supply and a digital multimeter, both controlled by a computer through the interface GPIB. This computer was also connected to the Internet, and it executed a program called Server, which allowed the user to vary the voltage on the output of the power supply and measure it with the multimeter. These voltage values were shared continually with another computer connected to the Internet, and it was executing a program called Client.

Version 1.0

In this version, we decided for the introduction of certain interactivity by the remote user. Thus, an experiment was defined in which the remote user could settle some of the execution parameters.

A simple setup was elaborated, based on a computer

Pentium of 166 MHz and 24 MB of RAM memory, connected to the Internet, and a DAQ with 16 channels of analogical inputs, 2 channels of analogical outputs and 8 bi-directional digital channels.

The chosen experiment was the tracing of curves that are characteristics of a NPN transistor. In this experiment the user could trace up to five different polarization curves for the tested transistor.

The transistor was setup in a small printed circuit board, which contended the polarization resistors. The channels of analogical output of DAQ supplied voltages for the base and the collector in order to stimulate the transistor, while the channels of analogical inputs measured the voltages in several points, so that it was possible to calculate the current values of the base and collector.

The remote user could set the values of maximum voltage that would be applied in the transistor's collector, five different voltage values which would be applied in the transistor's base and the maximum number of points that would be measured by each curve.

These values were sent for the server, which performed the measures and returned the results, visualized by a graph. It was also possible to save the data obtained in a text file so that they could be analyzed in other programs, such as MS-Excel, for example.
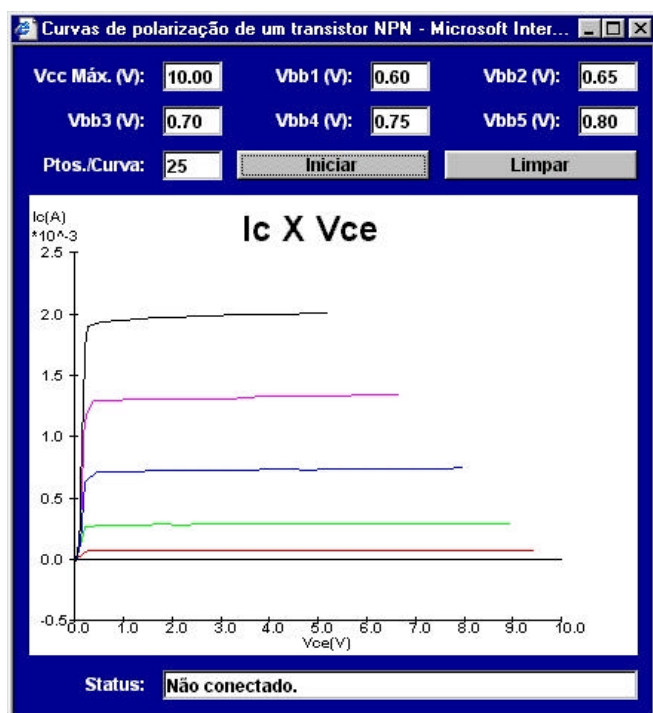

FIGURE 2
JAVA APPLET FOR REMOTE ACCESS IN VERSION1.1.

In this first version, both Client and Server programs were developed in LabVIEW 5.0, a programming language from National Instruments. This language was chosen due to its programming easiness, that allows reaching results quicklyer, and also for its integration with the instruments that use communication protocol GPIB and DAQs used during the implementation of VL.

Version 1.1

Because in version 1.0, developed in LabVIEW, it was necessary to copy and to install a file with more than 3 MB in the remote computer, what could limit the access for users with low speed Internet connections or without permission to install programs, as in libraries for example, the researches for an alternative solution began.

Therefore, a new interface was developed for the Client program using Java language, by which the experiment could be accessed and controlled from any browser which have support to this language, besides it could be accessed for computers with different operating systems.

This new version of the Client program, shown in figure 2, performs the same functions of the Client program from version 1.0, however, without the possibility of saving the received data in a file text, but with just 10 KB of size, being therefore much more portable.

RECENT INNOVATIONS

Our Virtual Laboratory continues to be improved. In the last year, an effort was accomplished in the sense of enlarging the number of available experiments, besides an attempt of increasing the interactivity level between the remote user and the local experiment.

To facilitate the introduction of new experiments, it was defined a data transfer protocol between the experiments server and the remote client, so the first could distinguish which experience should be accomplished.

This protocol determines that data packages should have a header containing a field to identify the client's type of accessing server and a field for the identification of the experiment that will be performed.

Between several suggestions proposed five new experiments were chosen:
- Zener diode;
- Rectifiers;
- Bipolar transistor;
- MOS transistor;
- Astable oscillator.

These experiments were chosen because they are easy to implement and because they demonstrate important concepts presented in most of introductory courses of electronics.

In order to try increasing the interactivity level between the remote user and the local experiment, a very simple solution was adopted and it brought up results that were quite satisfactory. Taking advantage of the fact that most of DAQs in market possess, besides the analogical inputs and outputs, some digital inputs and outputs, it was conceived a method so when using these digital outputs, they could switch relays.

Through the switching of these relays, it would be

possible to introduce or to remove components, such as resistors, capacitors and even diodes in order to change the circuits' configuration of the experiments. This allows the analysis and investigation of some interesting effects.
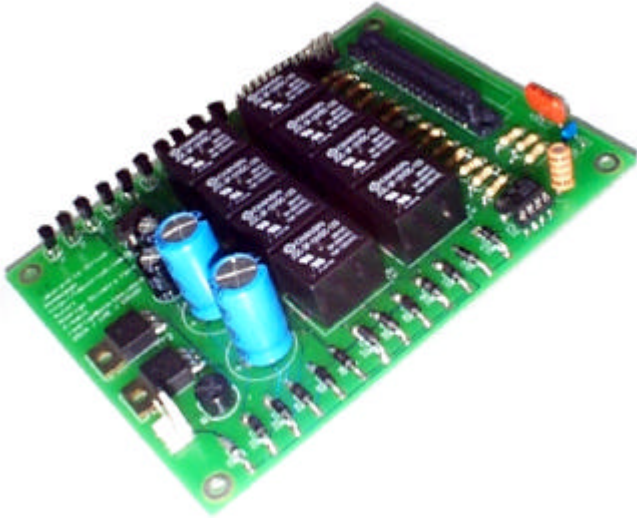

FIGURE 3
PCB WITH THE EXPERIMENTS OF VERSION 2.0.

All the experiments were gathered in one single printed circuit board, which can be connected to a DAQ directly. This plate, shown in figure 3, also possesses some additional circuit for switching the relays and connecting to DAQ.

To allow the access to these new experiments it was necessary to develop a new version of the Server program, shown in figure 4, so that it could identify, through the introduced protocol, the client's type and the experiment to be performed.
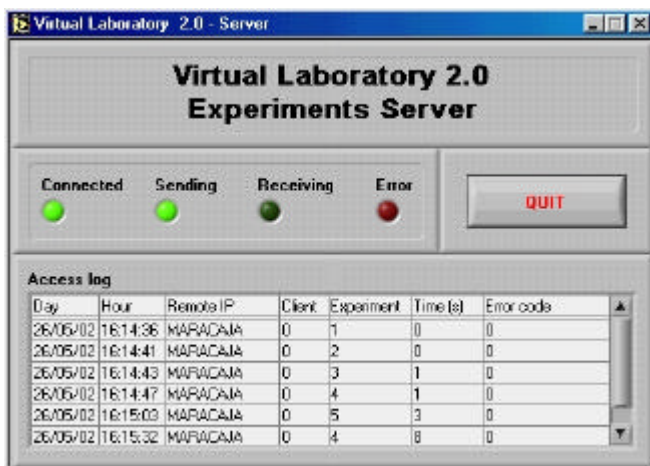

FIGURE 4
SERVER PROGRAM OF VERSION 2.0.

This new version of the Server, developed in LabVIEW 6i, also possesses a new interface, where some information related to its status can be read, such as a connected client

that has been receiving or sending data and some mistakes that occurred during the communication with the Client.

Besides, it is possible to visualize the access log, with the day and the hour of each access, the remote computer IP address, client's type, number of the accessed experiment, duration of the connection (usually smaller than 1s) and error code (in case it had any). These informations are also stored in a database, in order to quantify the amount of accesses to VL and to aid the development of new improvements.

It was also necessary to develop a new Client program, shown in figure 5, which also incorporated the rules introduced by communications protocol.
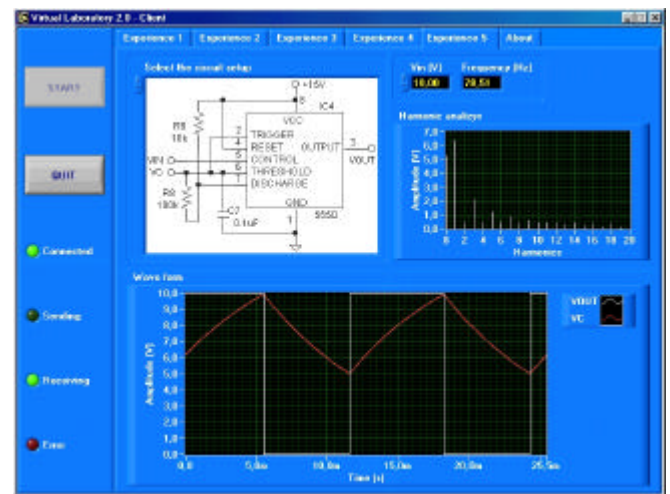

FIGURE 5
CLIENT PROGRAM OF VERSION 2.0.

This new version is capable of providing access to the five new introduced experiments and in case of experiments that possess this functionality, it allows varying the circuit that will be tried.

For while, in this version the Client program was only developed in LabVIEW. To accesses the Virtual Laboratory it is necessary to install the application in the remote computer. The installation file can be found at "**http://labvirtual.lme.usp.br**". Soon, we intend to have a Java version of the Client program, terminating the need of installation programs.

FUTURE PERSPECTIVES

At the present moment, we have several people involved with the theme, besides several graduation students, not only from the course of Electric Engineering, but also from Physics course. They have been trained and they are capable of programming in LabVIEW and Java, besides they understand the architecture of VL. They should be capable of not only providing support or giving maintenance to the system, but they could also implement its own experiments and improvements in the future.

Meanwhile, we continued researching new forms of providing the remote access to the experiments, analyzing the advantages and disadvantages of using several client's types, such as LabVIEW, Java, ActiveX, etc.

By the server's side, we are verifying the possibility to use microcontrollers with Embedded Internet as an alternative to traditional setup based on computers compatible with PC standard and equipped with DAQs and GPIB interface cards.

While the traditional solution cost some thousands of dollars, solutions based on Embedded Internet could cost just some dozens of dollars, once these microcontrollers are extremely cheap.

Companies such as Hyundai Electronics, Lantronix, Microchip Technology, Motorola Semiconductor, Rabbit Semiconductor, Ubicom and Zilog, between others, are selling or developing microcontrollers of 8 or 16 bits with Embedded Internet (actually, implementing support to the TCP/IP protocol and to the Ethernet interface in these microcontrollers).

These microcontrollers are capable of operating Internet servers, by offering support to resources just like HTTP, POP3, SMTP, CGI, Java Applets, ActiveX components, visualization of images and everything that fits in its memories, which can vary between dozens and hundreds of kilobytes.

FIGURE 6
EMBEDDED INTERNET MODULE.

Among the several options offered by the market, we selected the microcontroller model Rabbit 3000, produced by Rabbit Semiconductor (Davis, CA, USA) due to its readiness for modules purchase, as shown in figure 6. It contains the microcontroller, some Flash memory, some RAM memory and the Ethernet interface ready for connection. The adoption of these modules avoids the need of developing a hardware to accommodate all theses components, what decreases cost and time to develop the final application.

To accomplish the development of the application it has been used the programming tool Dynamic C that goes with the development kit of Rabbit 3000. Although this tool is not as elaborated as other existent similar tools in market, it possesses all the necessary libraries to aid and to activate the development of applications of Embedded Internet. Besides, both documentation and technical support offered by Rabbit Semiconductor were satisfactory.

Among the main characteristics of these modules we stand out the great number of digital inputs and outputs (about 50) and the great number of serial communications ports (about 5). We can use these serial ports to control instruments which are compatible with RS-232 interface, besides we may use some of the digital inputs and outputs to emulate a GPIB interface.

Our intention is also to take advantage of these digital inputs and outputs by integrating the DA and AD converters in order to create an economic and efficient solution that takes a similar part as a DAQ.

CONCLUSION

At first, developed as an application that aimed to provide remote data access, acquired online so people wouldn't have to go to the laboratory in order to verify the course of its experiments, the Virtual Laboratory is merging itself in our group as one of our research lines.

The obtained results demonstrate that it is possible to elaborate and to implement a Virtual Laboratory with a wide range of experiments using a low cost infrastructure in comparison to usual laboratories.

ACKNOWLEDGEMENT

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