A SYNCHRONOUS REMOTE ACCESSING CONTROL LABORATORY ON THE INTERNET

Maarouf Saad[1], Hamadou Saliah-Hassane[2], Hussein Hassan[1], Zouhair El-Guetioui[1] and Mohamed Cheriet[1]

Abstract ¾ *This paper presents the manipulation of real devices used in an instrumentation and control laboratory on the Internet. Control variables could be temperature, level, flow or pressure. A programmable logic controller (PLC) communicates directly with the sensors to receive signals and to activate the actuators. Communication between the PLC and the computer is assured by LabVIEW, a National Instruments graphical software. As well, the user interface is designed using a LabVIEW environment. A client-server application is set up for accessing through the Internet network in order to control process variables. The server contains the application that communicates with the actual physical system. On the client side, another application communicates with the server via a TCP/IP protocol. In this application, the server IP address must first be specified. Then the client sends control signals to the actuators via the server, which are then broadcast on the Internet using a tool such as Internet Toolkit, a National Instruments software package. Throughout the process, both the user interface and animated objects can be viewed by authorized users on the Web. Access to the laboratory can be done either individually or within a team effort.*

This paper will also describe the design process for our control laboratory system, which first controls a physical device (an elevator), then at a more advanced level, an industrial process (a hydraulic bench).

Index Terms ¾ *Automatic Control, Internet, Virtual laboratory, Synchronous, Real instrument, Communication*

INTRODUCTION

The constant technological progress of the Intemet and in the field of telecommunications and information technologies inspired a new method of training aimed at broadening the concept of teaching, training and working. Utilizing the computer and the network as training and teaching supports will constitute a shift towards new scientific applications and techniques. There will be a whole new approach in training technology; measurements that required physical presence will now be carried out through networks and microcomputers equipped with various tools. The difference between reality and virtuality is now the focus in remote learning.

The virtual laboratory is one of the elements of remote learning. The main purpose of the virtual laboratory is to permit experimentation independently of distance, in a way similar to what occurs in conventional laboratories; the student feels involved during the experiment. And with the current technology available, we hope to reach the same objectives as for a conventional laboratory, and even more efficiently in some cases.

Through this new remote learning tool, namely the specifically designed virtual laboratory, one can build knowledge acquisition through access to a wide range of materials and/or software simulation devices and instruments. This new method emphasizes the need to work as a team and to exchange information, namely between teacher-students and students-students, in order to transform training into a constructive joint effort within the framework of simulation and exploration. Remote training has made a lot of progress; the same educational strategies are maintained, but are presented within an efficient, high-performance environment reflecting current technological advances. Thus, learners have access to relevant databases in order to discover principles covered during the tutorials and get hands-on practice of specific specialized procedures being learned.

This methodology also enhances the knowledge acquisition experience and develops learner skills in many ways. Thus, the learner whose experiment is being presented has the opportunity to reflect and analyse results: s/he has a better grasp of the principles involved as a result of self assessment and personal insights. The wide range of applications covered in automatic control provides new challenges for control education to integrate this new technology. Reference [1] is a comprehensive article dealing with control system engineering education. Reference [2] shows the integration of the new technology and MATLAB over the Web. Reference [3] also uses MATLAB for control applications on the Web. The authors present many control applications using MATLAB and SIMULINK. References

[1] Maarouf Saad, École de technologie supérieure, Montreal, Canada, msaad@ele.etsmtl.ca
[2] Hamadou Saliah-Hassane, Téléuniversité, Montreal, Canada, Hamadou_Saliah@teluq.uquebec.ca
[1] Hussein Hassan, École de technologie supérieure, Montreal, Canada, hash1009@lca.etsmtl.ca
[1] Zouhair El-Guetioui, École de technologie supérieure, Montreal, Canada, elguetioui_zouhair@hotmail.com
[1] Mohamed Cheriet, École de technologie supérieure, Montreal, Canada, cheriet@gpa.etsmtl.ca

[4] and [5] show some architectures for remote virtual laboratories. A few trends in building a control laboratory supporting control enginneering courses are given in [6]. The author explains the laboratory equipment, scale model and software environment required for real time experiments. An example of virtual instrument implementation can be found in [7]. This paper presents the manipulation of instruments and real devices for automatic control education over the Web. The design process for the control laboratory system is also explained through two applications: a position control system and an industrial process control.

The current paper is organized as follows. Section 2 explains the laboratory architecture. Section 3 deals with position and process control applications. Finally, Section 4 gives an overview and mentions areas for further research and study.

LABORATORY ARCHITECTURE

The architecture proposed can be illustrated as shown in Figure 1 [5]. The server communicates locally with the process. The control software is located in this server. Communication can be achieved using different protocols. In this paper, RS232, RS485 communication and data acquisition signals are presented. An end user can have access to the process and run an experiment in real time using TCP/IP. To avoid problems caused by the time delay and communication interruptions, the controller is connected locally to the equipment. The user can change different parameters: sampling time, set point, alarm upper and lower limits and controller gain values. On the other hand, s/he can not change the control structure or strategy defined. In a subsequent work session, the user can test different control strategies such as PID control, adaptive control, optimal control.

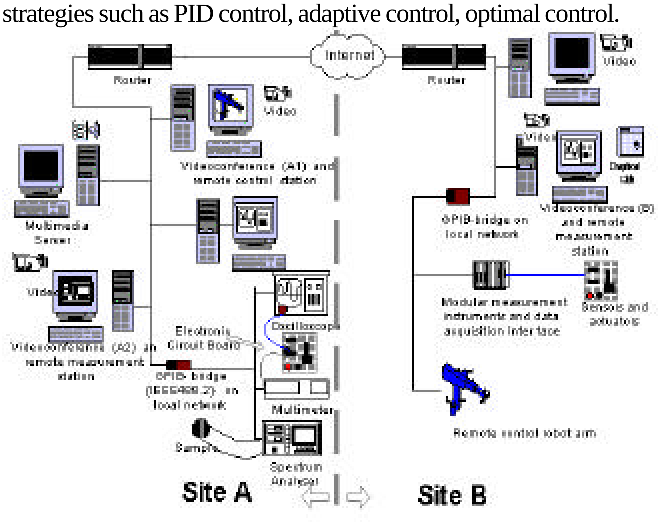

FIGURE 1. VIRTUAL LABORATORY ARCHITECTURE

The virtual laboratory the concept of virtual laboratory shown in Figure 1 permits remote accessing and measurement for activities requiring collaboration on computer networks. More specifically, through these capabilities, one can:

- run experiments while interacting with instruments and remote devices
- run experiment simulations while using numeric models;
- analyze numeric simulation results;
- benefit from resource center capabilities and get pedagogical or technical help over the computer network;
- share data and applications with other participants located in various geographical settings;
- use the synchronous multipoint videoconference and asynchronous conference.

SAMPLE APPLICATION

This section presents two examples to illustrate the manipulation of instruments and real devices for automatic control education on the Web. The first example is a position control system based on a data acquisition device. The second example is an industrial process level control. In this second example, RS233 and RS485 are used.

Position Control System

This section deals with controlling the position control system as shown in Figure 2. It is essentially a DC servo motor and an optical encoder for measuring the angular position. A mechanical coupling gives the linear equivalent of the angular position. The final position is illustrated while positioning a load imitating the displacement of an elevator. The servo motor is in fact the actuator that provides the voltage to the mechanical part in order to follow the set point representing the desired movement.

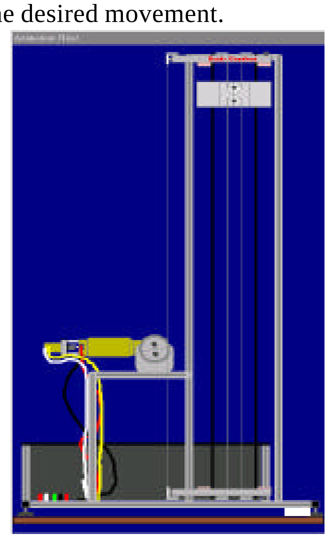

FIGURE 2. POSITIONING MECHANICAL SYSTEM

The block diagram in Figure 3 illutrates the mechanical system and controller.

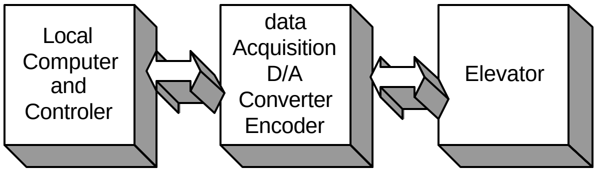

FIGURE 3. BLOCK DIAGRAM

The data acquisition card used is the PCI-MOI-16E-4 of National Instruments. This interface card between the computer and the mechanical system performs the digital to analog voltage conversion in one direction. In the other direction, it converts the angular position to a numerical signal by counting the number of pulses. A Proportional-Integral-Derivative (PID) controller is used to maintain the measured position according to the set point (desired position). The PID controller is programmed using LabVIEW. A proshare digital camera is added to the system to allow an end user to access the position system on the Web. Actually, NetMeeting software is used to share the audio, video and digital signals of the application. Figure 4 illustrates the software interface the user can manipulate on the Web. It shows how the set point, ontroller parameters and upper and lower limits of the physical system can be modified according to performances as required by the user.

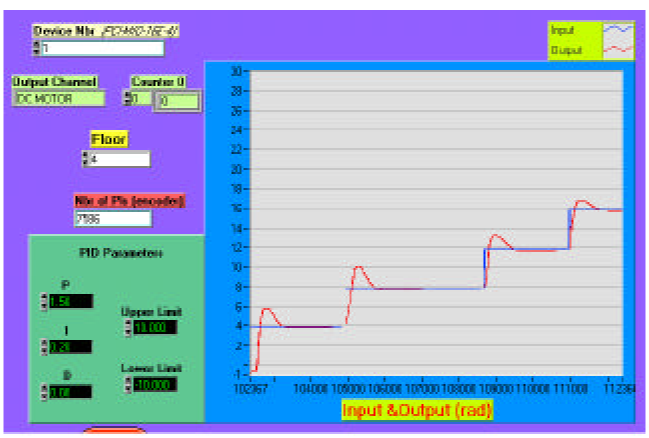

FIGURE 4. POSITION SYSTEM INTERFACE

Industrial Process Level Control

In this application, RS232 and RS485 are used to control the level of the process control. Using LabVIEW, a Code Interface Node (CIN) is built to communicate with the controller. A Fisher-Bailey PLC with serial RS232 and RS485 communication capabilities is used in this application. The CIN program is simply a C langage program acting as a driver to the PLC. All the inputs/outputs are first defined and then integrated to the CIN program to allow an end user to modify control parameters such as sampling time, desired level, values of the PID controller and to read the output level and control the current applied to the servo valve.

The communication via the RS232 serial port is a bipoint link and only permits communication between two points on the same level. On the other hand, the communication RS485 is multipoint. It can connect several controllers on the same communication bus in a master-slave mode as shown in Figure 5.

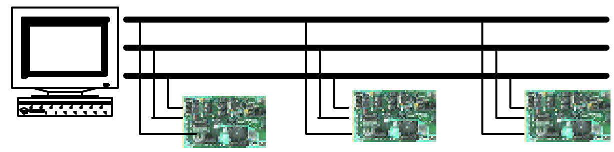
FIGURE 5. RS485 ILLUSTRATION

Once again, with RS232 or RS485, a proshare digital camera is used to transport the video signals on a TCP/IP link. The software interface available on the Web is shown in Figure 6.

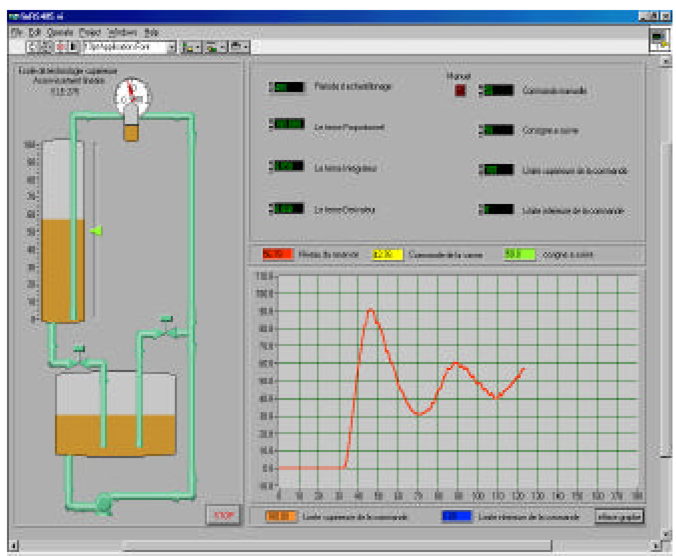
FIGURE 6. LEVEL CONTROL INTERFACE

Figure 5 illustrates a real time simulation of the level and system animation.

In both examples, it is very important to identify system dynamics before selecting the controller structure. The identification process can be easily done in an open loop structure by applying the control signal directly to the system input. The first manipulation on the Web can be simply the application of an open loop signal and measuring the output time response, in this case, the velocity for the first example and the level for the second. User interfaces shown in figure 4 and 6 allow users to perform open loop manipulation to determine the system dynamics. The next step is to perform closed loop control using the identified dynamics to find the controller gain values. Figure 7 illustrates the identification process and the possible results obtained by an end user. It shows the position measured from the encoder and its derivative representing the velocity. This figure is obtained using open loop represention. The reader is referred to [8] for more details about identification, discretization and digital control.

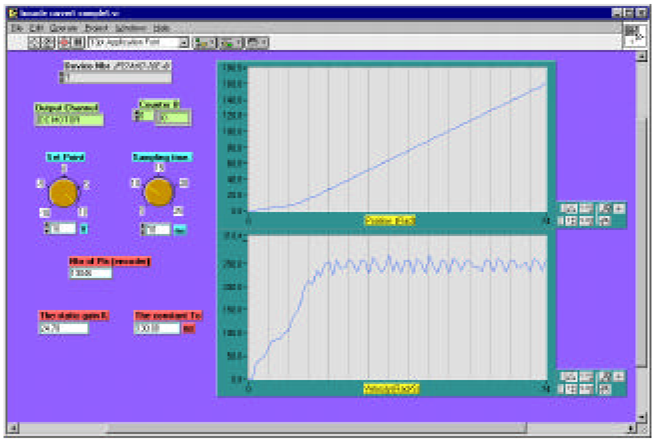

FIGURE 7. OPEN LOOP IDENTIFICATION

CONCLUSION

This paper presented the architecture of a synchronous remote accessing control laboratory. Various communication protocols were tested to access the virtual laboratory on the Web. The applications developped in the paper have shown good results for video, audio and data acquisition signals. Tests performed from point to point were very positive as well. However, the time delay decreased interaction between the process and the user. This issue should be addressed in future work. In addition, tests with multipoints will also be done.

ACKNOWLEDGMENTS

The authors wish to thank École de technologie supérieure and Téléuniversité of l'Université du Québec for providing the facilities to carry out the project.

REFERENCES

[1] Kheir, N.A., Astrom, K.J., Auslander, D., Cheok, K.C., Franklin, G.F. et al., "Control Systems Engineering Education", *Automatica,* Vol. 32, No. 2, 1996, pp. 147-166

[2] Hassan, C., Tuschak, R., Vajk, I., Bars, R., Hetthessy, J. et al., "A New WEB/MATLAB Based System in Control Education", 14th Triennial World Congress of IFAC, Beijing, China, 1999, pp. 241-246.

[3] Tilbury, D., Luntz, J. and Messner, W., "Controls Education on the WWW: Tutorials for MATLAB and SIMULINK", American Control Conference, Philadelphia, 1998, pp. 1304-1308.

[4] Saliah, H., Saad, M., De La Teja, C., "Virtually and remotely accessing and controlling laboratory real devices: A new trend in teaching and learning in engineering', ITHET2000, Istanbul, July3-5, 2000.

[5] Saliah, H., Saad, M., Villardier, L., Assogba, B., Kedowide, C., Wong, T., " Resource Management Strategies for Remote Virtual Laboratory Experimentation ", *2000 Frontier in Education Conference* , Kansas City, October 18-21, 2000.

[6] Horacek, P., "Laboratory Experiments for Control Theory Courses: A Survey", ", 14th Triennial World Congress of IFAC, Beijing, China, 1999, pp. 223-234.

[7] Amoruso, P., Caciotta, M., Carbone, P. and Orsolini Cencelli, V., "An Implementation of a Parallel Virtual Instrument", IEEE Instrumentation and Measurement Technology Conference, Ottawa, Canada, May 19-21, 1997, pp. 682-685.

[8] Ogata, K., "Discrete-Time Control Systems", Prentice Hall, New Jersey, 1987.