Work in Progress – Using Internet Applications to Control Remote Devices for an Instrumentation Laboratory

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Abstract **- Undergraduate Engineering students have undertaken a research project on the creation and the development of an internet based real-time access to laboratory devices. SelfLab@Home is a novel tele-education project of the Department of Electrical and Computer Engineering of the University of Calgary. Its original objective was to become a self-paced remotely accessed training for the use of four basic laboratory devices: oscilloscope, waveform generator, DMM (digital multimeter) and a power supply. The high-level design components include a Client Interface, a Client/Server Interface, a main Server, a Server/Hardware Interface, the Agilent Oscilloscope, and a Video Streaming Scheme. The implementation of this project required the following components: Client Web Browser Interface, Web Server, Application Server, Hardware Dynamic Link Library (DLL), Video Streaming Scheme. A joint team of high school students enrolled in the Research Enrichment program and fourth year students have built this remotely accessed instrumentation laboratory to give all undergraduate students a chance to learn how to operate the equipment from outside the lab while working at their own pace.**

Index Terms - remote control, project-based course, distance education, instrumentation laboratory

PROJECT CONTEXT AND COMPONENTS

For their team design project course, fourth year engineering students have undertaken a research project on the creation and the development of an internet based real-time access to laboratory devices. SelfLab@Home is a novel tele-education project as well as the first contribution of the Department of Electrical and Computer Engineering of the University of Calgary to two international projects on remote control and tele-robotics. Its original objective was to become a self-paced remotely accessed training for the use of four basic laboratory devices: oscilloscope, waveform generator, DMM (digital multimeter) and a power supply. The high-level design components include a Client Interface, a Client/Server Interface, a main Server, a Server/Hardware Interface, the Agilent Oscilloscope, and a Video Streaming Scheme. The implementation of this project required the following components: Client Web Browser Interface, Web Server, Application Server, Hardware Dynamic Link Library (DLL), Video Streaming Scheme. Figure 1 illustrates the module interaction in SelfLab@Home. A Web Server has been built and is running a Java-based server program (J2EE).

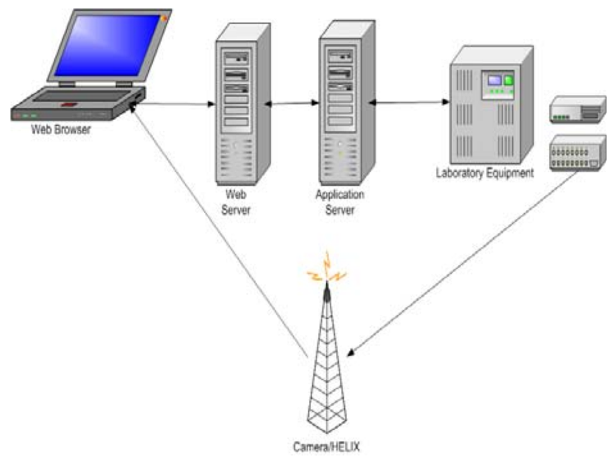

FIGURE 1
MODULE INTERACTION

For the present status of the project, there are only three components in the laboratory equipment module: the switch, the oscilloscope and the waveform generator [1]. A matrix switch handles all requests sent to the laboratory instrumentation module from the application server module. The switch determines the device responsive to the request, and signals the device to complete the task. The inclusion of both a web server and an application server results in a more efficient division of tasks. This modularization of tasks (figure 2) allows for parallel processing of information by the different servers, thus increasing the overall system capacity, rendering the process more 'real-time'. Another advantage of implementing the application server is that it makes the web server independent of changes in hardware [2].

INTEGRATED SELF-EDUCATION FOR THE TEAM PROJECT

This project illustrates the learning benefits and the collective efficacy of student project teams in engineering education.

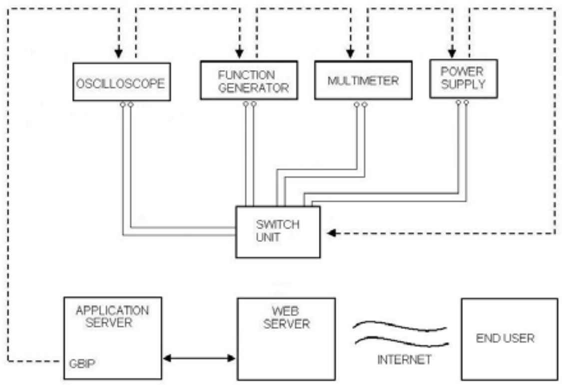

FIGURE 2
HIGH LEVEL IMPLEMENTATION DIAGRAM

We describe the impact of learning for a fourth year design project on student lifetime knowledge at both ends: project builders (twelve fourth year students enrolled in the three programs of Electrical, Computer and Software engineering of the Department of Electrical and Computer Engineering of the University of Calgary) and product users- all students taking electric circuits laboratories (for our programs or from the Faculty of Engineering-common core).

The project SelfLab@Home and its final product: a remotely controlled laboratory instruments system, is a first attempt to motivate students to do the pre-lab exercises for an instrumentation laboratory and reuse them to refresh their training in using the appropriate functions of the buttons and devices needed for any electronic data generation and acquisition. The components of this educational environment have been created based on the criteria of professionalism stated by the guidelines of the Association of Professional Engineers, Geophysicists and Geologists of Alberta (APEGGA) and the University of Calgary learning plan. The project has the following objectives: 1) Using Internet applications to control remote devices: This is the software part of the tele-operation project for the novel real-time instrumentation laboratory (SelfLab@Home) [3]. The students create a package designed in a client/server architecture with asynchronous multi-user support capability. The server (may run on Linux or Windows) tasks involve: transfer the video stream to an user, communicate and process connection requests from clients, control the instruments and acquire output signals and may be programmed using multithreading (for on-line display). The control of the instruments is easily carried out by a remote client (see also the hardware part of this tele-operation project) via an user friendly control panel. 2) Real-time instrumentation for tele-operation (the hardware/devices part of the project):this is the genric adaptive training environmentwhich uses daptation in combination with the example-based feature of instruction. It is an adaptive computer assisted instructional system which provides individualized instruction using different methods, and taking into account that students learn at different rates.

The set-up of the hardware consists of the optimization of data streaming from the instruments' screen or display and data acquistion/instruments control by and to the server (computer), matching the bandwidth of data streaming from the camera to the computer-server (firewire interface) and client and program the matrix switch for the cross-control of the instruments and cameras, over the GPIBs.

The existent lab manuals for electrical/electronics based courses of the first two years of undergraduate studies in engineering are organized in the "cook-book" structure, with recall of theoretical concepts taught in lectures. The laboratory component trains students in a bottom-up, sequential discovery of rather ideal applications and the interpretation of real/measured results is often an arduous task for the beginners (students with no work experience in related fields) [1]. For the sake of saving time and effort, the pre-reading laboratory part is minimized or discarded. In an attempt of a top-down approach for the theoretical introduction of an experiment, the instructor is lecturing over the laboratory set-ups. Many web-based laboratory manuals are supplemented with a PowerPoint presentation with the complete description of the experimental procedure and set-up components, but explanations on measurement errors or difficulties which may occur are not presented. The students focus on the right sequence of "press-the buttons and turn-knobs" without enquiring on the role of these measurements hints. The animated or visual components of our training web site is a part of the efforts made by the Electrical and Computer Engineering (ECE) Department to offer comprehensive study skills in common core courses which involve design projects and electrical/electronic measurements with similar instruments. The virtual laboratory permits students to work independently on their own projects, allow for greater transparency between theory and practice ("learning by doing"), promote faster comprehension of theoretical principles and instrument operation. The multi-media environment provides an excellent tool for continuing education or distance-learning in modern instrumentation.

The student project teams found themselves in two important roles: conception and realization of the web based instrumentation laboratory and instructional designers for future student users. The highest complexity of this project consisted in its preparation and organization or management. The students had to carefully analyze various techniques of implementation, find errors and debug bits of programs and adopt engineering methods in its design and implementation. All these operations have been incorporated into a distributed and sequential process of self-education which promises to lead all project members involved to a rewarding and successful completion.

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