REMOTE LABS: ELECTRICAL ELEMENT CHARACTERIZATION EXPERIMENT

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Abstract *¾ American higher education have been in pursuant of establishing virtual classrooms where learners can obtain their education at the comfort of their homes and via the Internet. However, one must ask," how can students perform real lab experiments over the Internet?" To examine this distance education (DE) challenge, two researchers from Florida Atlantic University (FAU), Drs. Alhalabi and Hamza, along with a team of graduate students in the fields of Computer Science and Engineering and Educational Technology and Research, have built a proof of concept experiments that combine real instrumentation, data acquisition equipment, and interfaces to different computer ports in an unprecedented fashion! This innovative set up allows, for example, the instructor to set up a simple experiment the way it would be set up in a real laboratory-- thus realistically providing experiments over the Internet.*

Index Terms ¾ Distance education, Internet education technologies, remote laboratories, and virtual laboratories.

Introduction

Remote laboratories deal with performing real lab experiments remotely via the Internet. The Center for Innovation Distance Education Technologies (CIDET) at FAU was recently established with an aim to develop and implement new DE technologies to help FAU lead the race in such a high tech world! At CIDET, researchers develop educational lab systems enabling students \to access via the Internet, real lab setups situated either in a central location or distributed over several remote areas. For example, in the case of an electronic lab, a student can remotely wire and rewire various electronic components already mounted on a re-configurable breadboard. Then he/she submits a test input sequence to the circuit and observes the true output. If real-time view is necessary, video camera can continuously display the experiment activities on the remote user's screen. CIDET has already designed such a system with all needed technologies available in hand. A proof of concept experiment was developed in the CIDET research lab at FAU. The experiment can be accessed at http://jupiter.cse.fau.edu/directory.html

Electrical Element Characterization experiment

This remote lab experiment is connected to the server through special data acquisition hardware. As a proof of concept of remote labs, the investigators have already designed and built a working demo of Electrical Element Characterization experiment. This prototype, shown below, is a simple electrical circuit that has been set up in one of the departmental labs. The actual hardware is composed of basic data acquisition and control board with an 8-bit digital I/O port, an analog input module, and an analog output module. The digital I/O lines are used to turn on the lights in the lab, turn on the testing equipment, and/or to select one of the resistors under test (say 100 ± ohm). See the interface applet snap shot in the figure below. The students logged on remotely via Netscape, can enter a sequence of current values (say min 05.050 and max 14.333 with a step of 1.500 ma) to be injected through the selected resister. Current injection is carried out by the analog output module (programmable current source). For every current value injected through the resister, the corresponding voltage drop is read from across the resister by the analog input module (voltmeter) and transmitted back to the remote student as shown in the window snap shot image.

The student can now plot the IV (current/voltage) characteristic graph which is the voltage curve corresponding to different current values. If the curve is a straight line, then the student concludes that the resistor has a linear coefficient. If at high current values, the curve starts to bend, then the student concludes that the resistor loses its linearity due to thermal effect. If a temperature sensor is added to sense the resistor temperature, then more specific information can be concluded about the IV curve that then includes the thermal behavior. The actual values are always different from the theoretically computed ones using the assumed known values for the elements. The difference is due to the fact that the true values of the electric elements are never guaranteed—see the figure (a compliment of CIDET documented information, 2001).

The URL address to this working demo is http://jupiter.cse.fau.edu/directory.html. Any person can use

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guest/guest for user ID/password or register your own name (name/name). At the last page you can see actual snap shots for the experiment setup, the measuring equipment, and the demo light already on, taken by a camera with real time video streaming. Figure1.

A typical scenario of a remote lab experiment involves the following steps [14]-[15] – it should be noted that the server is assumed to be running and that the client is on the experiment's web page through the Internet.

- **Registration**: A student accesses the URL to perform the experiment. If he/she is not a registered student the system should ask the student to first register for the lab before trying to perform the experiment. Once the student registers he/she should be given a user login and password for their future use. It should be noted that self-registration is not allowed for any user. A student's unique key-login name is checked against a database of students' list.

- **Logging-in**: Once the student has a valid login and password he/she can login to the remote real laboratory server. He/she then can choose an experiment from the list of experiments to perform.

- **Performing the experiment**: When a student starts performing the experiment, he/she is able to enter input values and submit them to the hardware. The hardware, then, acts upon the input parameter and generates results. The results are finally collected by the local host computer and sent back to the student's computer. The student can rerun (submit different values to) the experiment as many times as he desires. Once satisfied, he can submit the results for grading.

- **Instructor login**: The instructor/TA login is recognized and thus taken to a different panel (page) where they can perform different tasks like viewing lists and results, grading students, adding experiments, etc…

Development Issues

Few decisions had to be carefully made for the development of the research model and a language had to be chosen for the implementation of remote labs. One of most important decisions in this research is our choice of Java language [1]. The following are some reasons behind our choice [2].

- Java is a very innovative language, which enables one to write programs that can be embedded in Internet web pages. As our entire system of building remote laboratories relies on the Internet, Java is a good candidate due to its Internet readiness [3].
- The clients (students) in this environment could logon from any system. As Java is a machine independent language, which creates programs that run on a wide variety of computers using a range of operating systems [4].
- The Java program does not execute directly on the computer and hence it will not interfere with the operating system or users data. Instead, as it runs on a standard hypothetical computer called 'Java virtual machine'. This solves the problems of security and unauthorized access [5].
- Java is a language well suited for interactive web applications.
- Java language offers the feature of multithreading. This allows many students to work on the same laboratory setup simultaneously [6].
- Java is an Object Oriented programming language unlike others like CGI and HTML. Therefore, Java programs can be easily maintained, as reusability of code is possible [7].

Distributed Interface and Protocols

Since the remote laboratory is a distributed environment the implementation can be in Common Gateway Interface (CGI), Sockets, Interface Definition Language (IDL), or Remote Method Invocation (RMI) methodologies. Java RMI was chosen to build the distributed computing environment, written purely in Java. There are several other distributed computing environments available and RMI was compared and contrasted with each one of them. The following are the reasons why RMI has been adopted:

- **CGI** : The Common Gateway Interface is a standard interface that allows Web developers to execute programs on an HTTP server. This is a very crude form of client-server computing where a HTTP client invokes a program running on the server (usually passing it some data), and the program sends some results back to the client for display on a browser. CGI programs operate on a stateless mode, which means that there is no persistent connection maintained between the client and the server programs [8]. In contrast to CGI, RMI operates in a persistent mode. The network session between the client and the remote objects remains active until the client or the server closes the connection. To be specific, the Java RMI's garbage collection process automatically closes the TCP stream when the remote object is no longer referenced. Because of its persistence, RMI is far more effective than CGI in cases where the client is running within the Java virtual machine. The extra overhead is eliminated and the performance is improved.

- **Sockets**: Architecturally, the RMI process operates in a very similar way to those written with Socket objects. Both support persistent network connections between the client and the server [11]. In RMI information between the client and server objects is performed through object serialization i.e. the objects are broken down so that they can pass through the TCP/IP layer.

However in Sockets one must create the program logic to marshal (pack the data) and un-marshal (unpack the data) the objects that are serialized. The RMI is a higher-level architecture than sockets. Although the two perform similar functions, the RMI allows you to concentrate on value added program logic and not have to deal with network or object transports.

- **IDL** : The IDL short for Interface Definition Language [12] is a standard defined by the Object Management Group for defining object interfaces. This is intended to establish the object's interface definition regardless of the programming language and environment within which it is implemented. The IDL operates in a model that is similar to the RMI. RMI is useful in brokering object requests when the objects are written purely Java. Although there are many alternatives for building distributed applications, the Java RMI shows its strength in several areas.

- **JDBC**: The Java Database package was used as an interface for executing SQL statements The reason is that it helps large-scale applications like remote labs, to be written to the JDBC interface without worrying much about which database will be deployed with the application. It also keeps the main application insulated from vendor specific issues. The JDBC is built on drivers based on other databases API's. They are and deliberately mapped to the ODBC counterparts [11].

Conclusion

There is no doubt that the effectiveness of distance education, mainly on-line learning, still worries people. Many still believe that the best education occurs when learners, educators and learning resources are in close physical contact. However, it is a fact that the educational life of, even the most traditional educational institutions, include more academic resources than can be found within their campus walls. Students have been encouraged to tap into knowledge located at sites around the globes [13]. This has been made possible through the recent advances in several fields of technology, mainly, communications, electronics and the explosive growth of the Internet and its World-Wide Web. And perhaps enough evidence is now available to assure doubters that, given careful planning and adequate investment and supervision you can indeed consider distance education an effective method of teaching [14]. A new and an innovative idea of a facility that will realistically provide lab experiments over the Internet was born within the CIDET research labs at FAU to address the need for laboratory sessions in online education. The idea: Remote Labs for Distance Education.

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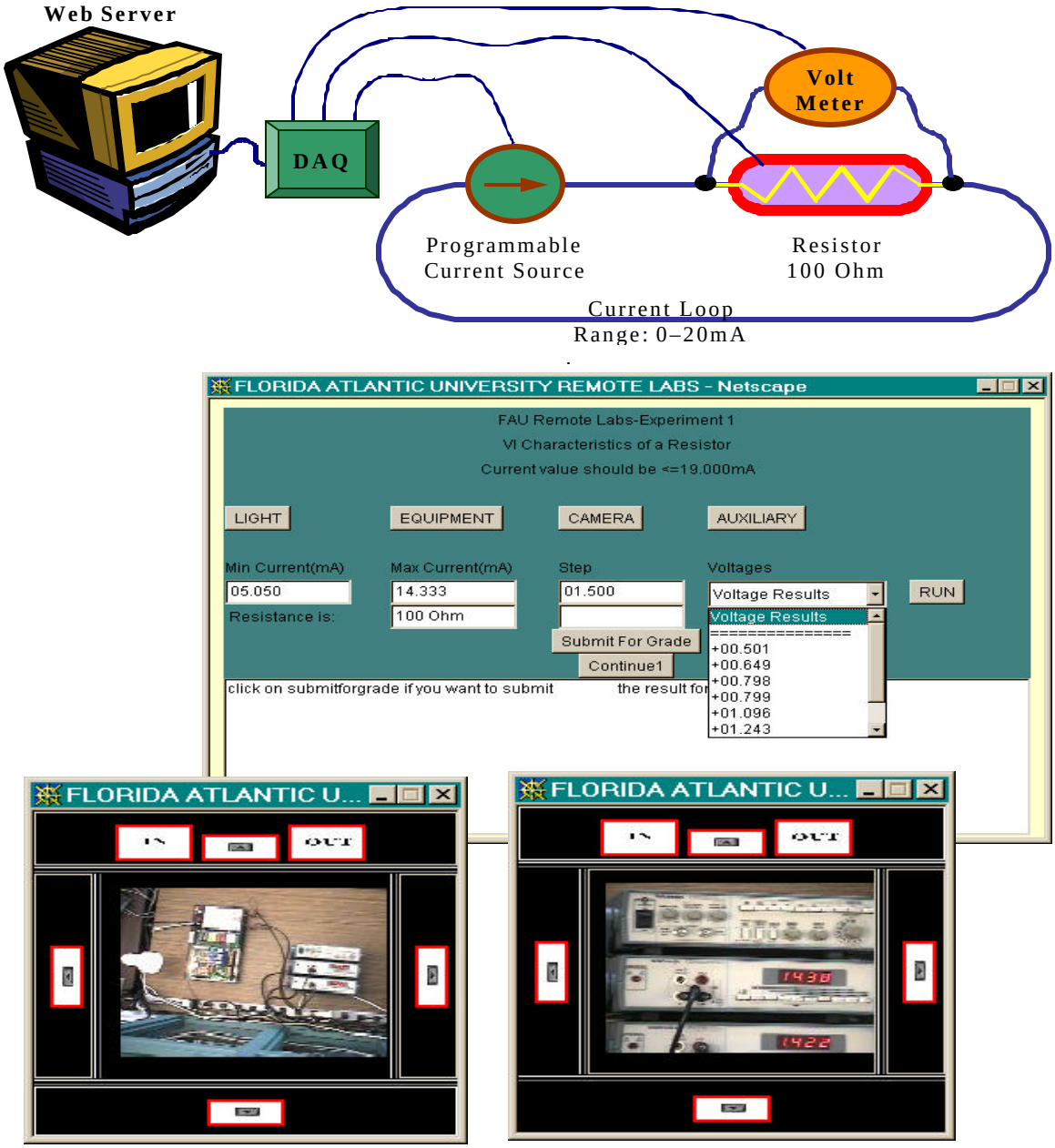

FIGURE 1

ELECTRICAL ELEMENT CHARACTERIZATION EXPERIMENT