

## **AC 2009-1410: A REMOTE- ACCESS ROBOTICS AND PLC LABORATORY FOR DISTANCE LEARNING PROGRAM**

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# **A REMOTE- ACCESS ROBOTICS AND PLC LABORATORY FOR DISTANCE LEARNING PROGRAM**

## **Abstract**

This paper describes an internet-based remote control automation laboratory which includes a robot and Programmable Logic Controller (PLC) unit developed at Elizabeth City State University (ECSU). The laboratory was designed in response to emerging internet – based technology in industries and educational application. Most engineering and technology courses are laboratory intensive and have been considered impractical for distance education. Furthermore, it has been determined that the laboratory requirement is a major obstacle facing non-traditional students desiring to pursue online degrees in engineering and technical disciplines. Offering internet based laboratories may eliminate this obstacle for distance learning program students. This concept is of particular interest in countries with large distances between major educational centers and those with limited budgets and facilities.

This paper illustrates a general architecture of an online laboratory. A Local Area Network (LAN) based “Host Computer” is set up in the laboratory and is connected to a robot, a PLC unit and a networked camera (Webcam). They are accessed and controlled via a remote computer through a secure “Virtual Private Network” (VPN) connection to the campus LAN.

## **Introduction**

This paper examines a concept of establishing a remote control laboratory. This laboratory is designed to increase the technical skills and knowledge of a large number of diverse undergraduate students in the area of PLC usage and robotics. Also it promotes the use of remote control laboratory and maximizes utilization of equipment and facilities.

Online enrollment in higher education classes has been increasing at a substantially higher rate than overall enrollment for several years. More than 3.5 million students took at least one online class in 2006 an increase of almost 10% from the previous year<sup>1</sup>. However, the teaching of technical disciplines often requires the use of costly laboratory materials which are frequently beyond the reach of some universities. Particularly, under developed countries, with insufficient budgets have the major challenge of absorbing the cost of remaining competitive in the critical technical field in order to train students to meet the future demand for skilled personnel in the workplace. In addition, in a traditional laboratory students are required to go to laboratory facilities according to a strict timetable. Consequently, in the interest of meeting the needs of students who desire greater accessibility to learning resources and the freedom to organize their learning activities, many colleges and universities are working toward the establishment of flexible laboratories. For these reasons, the need for virtual and remote laboratories via the internet arises for teaching distance learning courses. The online laboratory is a key aspect of distance learning in engineering and technology programs. The advance of internet technology tools developed in the 1990's has made it possible to access a facility or laboratory at distance. For example, some universities have changed traditional laboratory to the virtual one that take place in a traditional laboratory where some students can use the local lab workbenches and

others can perform the experiments remotely<sup>2-3</sup>. Also, an internet accessed robotic system can radically enlarge the number of students that can participate in practical robotics projects and it improves the quality of the learning environment provided by educators for these topics<sup>4</sup>. Another example of an online laboratory course, developed by the Technical University of Catalonia, is the Microcontroller Remote Lab for online teaching and interaction with microcontroller system via the internet<sup>5</sup>. While Web-based instruction works well for lectured courses, educational programs that rely heavily on a “hands-on” learning approach must develop more novel, and meaningful laboratory-level processes to be delivered over the internet. Today, an active focus area for many universities is to set up virtual and remote laboratories to extend modern e-learning environments with practical training aspects in many fields such as electrical and mechanical engineering<sup>6-10</sup>. Laboratory classes, which are an important part of engineering education, are often laboratory intensive. Virtual and remote laboratories provide an efficient way by providing remote access to a number of real experiments.

### **Architecture of the Online Automation Laboratory**

The main goal of this project is to design and implement an online automation laboratory that will provide hands-on lab experiences for engineering and technology distance learning students in areas of robotics and PLCs. The project starts with the designing and prototyping of an online robotics and PLC unit in three steps that include setting up the online laboratory unit with appropriate hardware and software, configuring the network connection, and testing robot and PLC units by programming them remotely.

#### **Step 1: Setting up the online laboratory unit**

Figure 1 shows the dedicated online robotics and PLC units located in an automation laboratory in the Department of Technology at ECSU. The online laboratory is equipped with a Scorbot-ER 4U robot<sup>11</sup>, an Allen Bradley SLC 500 PLC unit<sup>12</sup>, a Logitech web camera<sup>13</sup>, a LAN based host computer, and a Wide Area Network (WAN) remote computer. The remote computer can be placed anywhere on the network including LAN, university intranet, and the internet. The robot, PLC and web camera are connected to the host computer. The application software including RSLogix<sup>14</sup> and Scorbace<sup>15</sup> robotics software are only installed on the host computer in order to program the PLC and robot remotely. The remote computer acts as an authorized client to utilize the application software. Appropriate network connection software includes, the remote control desktop, LAN, WAN access software and VPN security software are installed on the remote computer. The host computer and VPN server authenticate user names and passwords that are utilized by a remote user to log on to the host computer. From the remote location, the remote user has access to the application software and other resources on the host computer through the internet in order to have control and program the robot and PLC units.



Fig 1: Online Automation System

### Step 2: Configuring the network connection

This step describes the networking and connecting of the host computer to the internet. Figure 2 shows prototyping of the system layout, connecting and configuring of equipment, and bringing the host computer online. The network configuration for host computer is changed from *Dynamic Host Control Protocol* (DHCP) to Static IPs that allows the remote user to make the connection. Cisco VPN Client software is loaded onto the remote computer and Cisco VPN Server software is loaded to the gateway router. The remote computer connects to the university network and host computer via a secure VPN tunnel.

### Step 3: Testing robot and PLC units using remote connection

The last step is to program and test the system remotely. The login processes from the remote computer to the host computer are depicted in figures 3a-3c. The process starts with connection of the remote computer to the internet to log on to the VPN server. The Cisco VPN Client icon opens to the screen where the authorized LAN is listed with its IP Address. Successfully logging on to the VPN server means passing the firewall and accessing campus intranet. After gaining access to the campus intranet, remote user will be prompted to log on again. This log on allows to user access to the host computer.

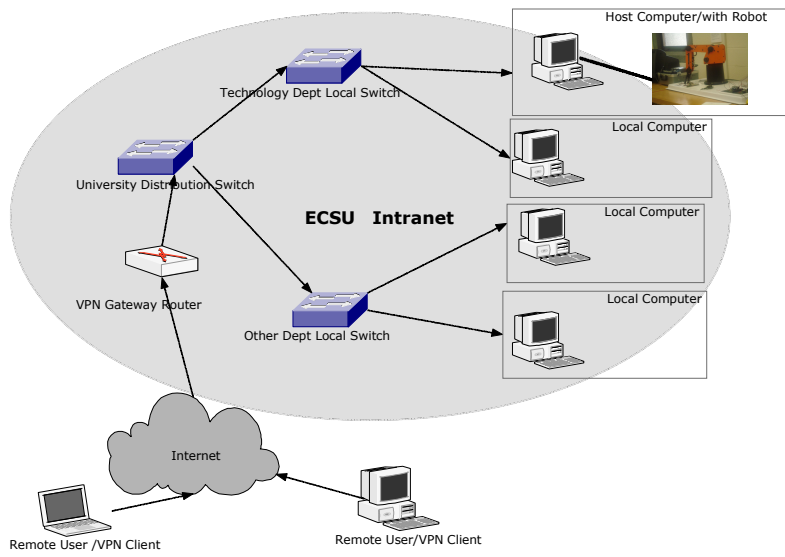


Fig 2: Network Structure of the Online Automation Laboratory

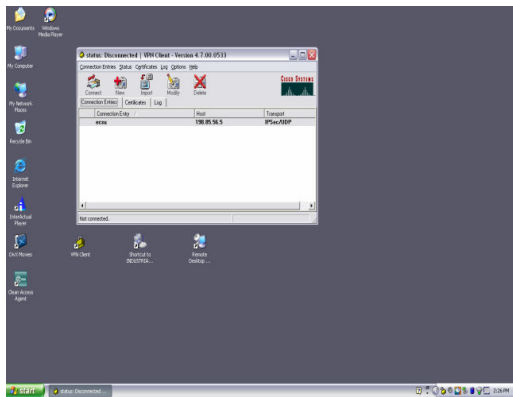


Fig 3a: Logging onto the VPN Gateway

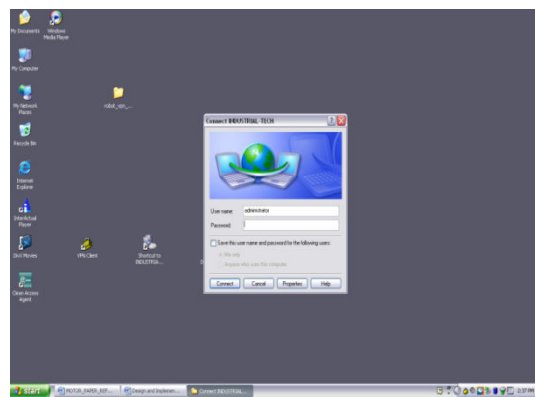


Fig 3b: Logging onto Work Group LAN

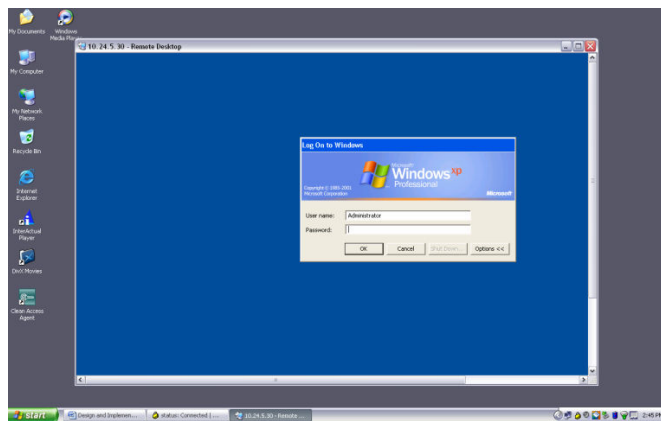


Fig 3c: Logging onto the Host Computer

At this time, the remote computer emulates the host computer when it is authenticated and granted access to the host computer's desktop located in the automation laboratory. Figures 4a and 4b show the desk top of remote computer that Scorbase and RSLogix software as well as web camera are utilized by remote user for programming and operating the robot and PLC remotely.

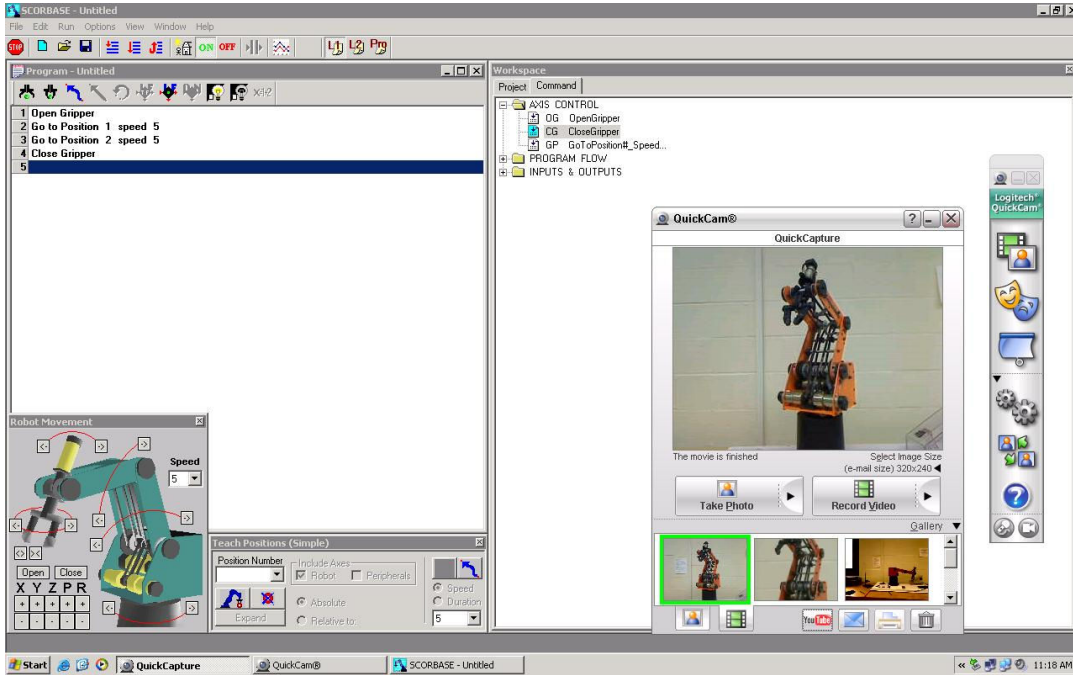


Fig 4a: Accessing to Scorbase Software

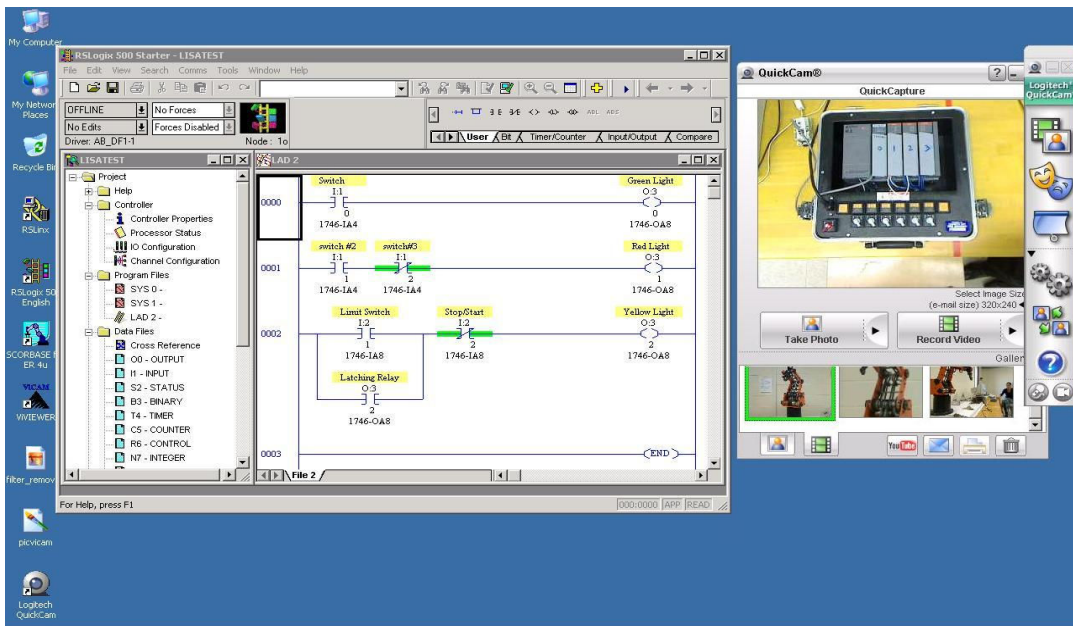


Fig 4b: Accessing to RSLogix Software

## **Feasibility and Assessment of Online Automation Laboratory**

Valuable data is collected in order to assess the functionality of an online laboratory. The adequacy of equipment and the speed of network play a major role in the implementation of a real-time remote access laboratory. There are several limiting factors that are explained as followings:

*Speed of network:* Currently, there are 100 Mbps wired connection between the LAN switch and host computer. The speed of the connection from remote to host computer is controlled by its slowest network element. This slowest element is the internet which typically has speed in the range of 1 Mbps to 10 Mbps depending on use of DSL or cable access connection.

*Computer:* A computer with Windows XP/ VISTA or competitive operating software are required for remote and host computers. It is advisable to use the fastest USB port in the host computer.

*IP addressing:* The host computer has to be configured with a Static IP address because it is necessary to log onto the host computer to obtain the IP address before it can be accessed remotely. A remotely accessed lab requires a Static IP address for each host computer. For security and stability, it is recommended expanding the usage of a Static IP over issuing several. One way to expand the usage of a single IP address is to set up a Virtual Local Area Network (VLAN).

*Latency:* Latency which is a time delay between the moment something is initiated, and the moment one of its effects begins or becomes detectable is a potential obstacle. The prototype automation system uses a remote computer connected to Internet Service Providers that produces a remote control latency of some 10 to 20 seconds. This delay is signal time elapsed between the remote computer and the automation system to complete a requested action. The time delay can be minimized by using an optimized host computer and automation system interface as well as using broadband connection. Latency of the network however is beyond the control of most online laboratory user and so always depends on the network transport system and networked distance between the remote user and the host computer. As an example, an average web page of 30-100 kilobytes will normally transfer fully in 10-30 seconds, over dialup modem. An extreme example of distance latency is the remote control of the Mars rovers where delays of some 16 minutes are encountered. Use of shortest path and highest network bandwidth/speed will minimize the delay.

## **Conclusion and Future Work**

Setting up and implementing an automation online laboratory can be successful and practical. The project success is evidenced in the fact that the remote user is able to connect and operate both the robot and the PLC units from a remote location.

Further investigation in improving the automation online laboratory can provide for easier use, more flexibility, and increase a speed in operation. For example, a dedicated server can be implemented to distribute data to each individual station. In addition, utilizing a camera with 360

degrees viewing capabilities will optimize visibility of experiment to the user. Each station can have its own revolving camera mounted on the ceiling above each station that gives a 360 degrees view of the entire station. Furthermore, the miniature camera can be installed directly on the robot arm so that the user can view the gripper of the arm in detail.

Further research endeavors can be conducted in the areas of the financial aspect of setting up the online laboratory. A pedagogical study and survey of current student interest would be useful, along with researching specific equipment needs in deciding on the scale of implementation. It would be prudent to involve other educational disciplines in assessing the networking needs on a campus wide level.

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