

# **AC 2010-1159: A LABVIEW-BASED INTEGRATED VIRTUAL LEARNING PLATFORM**

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# A LabVIEW-based Integrated Virtual Learning Platform

## 1. Introduction

With the current economic downturns where educators are constantly confronted with further budget cuts, fewer resources, and larger class sizes, online (or web-based) learning is receiving more attention than ever before. One key advantage of online learning is that it can provide direct delivery of education at anytime from anywhere to anyone, and thus, enhancing institutional learning to wider student population when resources are limited<sup>1</sup>. Furthermore, various research results have indicated that online learning and training are in fact as effective as traditional face-to-face learning, at least in terms of measurable academic achievements<sup>2,3</sup>.

Advances in computer, communication technologies, and interactive multimedia on the World Wide Web (WWW) continue to expand the effectiveness of online and web-based learning<sup>4</sup>. Today, vast number of educational software tools and packages are available to educators in order to expand their course delivery beyond traditional face-to-face classrooms. The Adobe Connect<sup>5</sup>, Centra system<sup>6</sup>, Blackboard, and WebCT are just a few popular examples to mention. Unfortunately, high cost and lack of adequate IT support in many cases prohibit utilizing and incorporating these tools in the discipline-based classes.

Another major issue with many of the existing content management educational tools is that they cannot be easily customized such that existing lectures, simulation applets, and laboratory activities can be utilized. For example, popular tools such as WebCT or Centra, don't even support remote laboratory capabilities. In fact, to the best of our knowledge, there is no commercially available tool that offers a *unified platform* to support diverse learning tools, such as video conferencing and chatting, configurable remote laboratory, simulation modules, and downloadable course lectures with different formats.

Motivated by such shortcomings, we have developed an integrated distance learning platform that enables course material sharing and collaboration between various institutions and instructors in order to provide a cost-efficient and flexible learning and training delivery to multiple remote users. In this paper we describe basic features of our prototype platform called the *Integrated Virtual Learning Platform* (IVLP). A unique characteristic of IVLP is that it is entirely based on LabVIEW software, providing a user-friendly and configurable distance learning development environment. A key advantage of IVLP is that it offers remote access to a collection of online learning tools, such as laboratory experiments, lectures, simulation applets, and tests, while allowing remote students to chat in real-time and participate in virtual face-to-face communication with the instructor. We emphasize that IVLP is still in its prototype stage and requires further testing and enhancements and this paper only reflects our initial results.

The rest of this paper is organized as follow. In Section 2 we briefly describe the basic course delivery model used in IVLP. In Section 3 we describe the architecture and then we go over the layout and implementation of IVLP and provide details about individual modules of the system.

## 2. IVLP Delivery Methodology

The Integrated Virtual Learning Platform is a pilot project developed by the Advanced Internet Technology in the Interest of Society Laboratory (AITIS Lab) at Sonoma State University<sup>7</sup>. The IVLP is a *hybrid* web-based delivery system that combines traditional online learning with virtual face-to-face delivery and virtual hands-on laboratories. In the following paragraphs we describe the course delivery methodology adapted by IVLP and elaborate on its features.

The entire IVLP platform was designed using the LabVIEW software. LabVIEW is a graphical programming language that has become the de facto industry standard for controlling instrumentations. A major advantage of LabVIEW is that it provides a convenient way to setup a PC as a server and establish client/server environment with a few mouse clicks. Hence, an instructor with limited IT support, and networking and programming knowledge, can easily setup the IVLP and create LabVIEW-based laboratory modules as needed. Although, in order to run IVLP the user must have LabVIEW software, the remote student only requires the *LabVIEW Run-Time Plug-in*. This program is provided free of charge by National Instrument and it is automatically downloaded when the remote client logs into the system.

A key feature of IVLP is its modular architecture. Thus, as shown in Figure 1, individual contents can be designed independently and located in different sites. The modular architecture of IVLP enables collaboration of multiple institutions with different resources in order to create the suitable learning environment for targeted remote students.

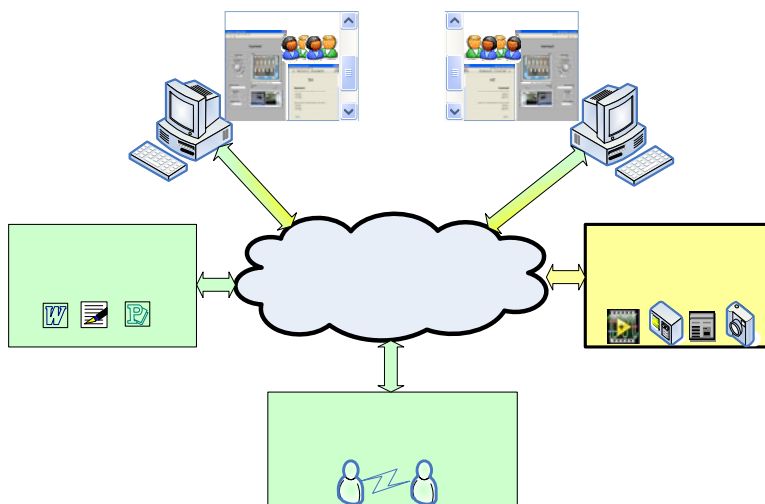


Figure 1: IVLP modular architecture provides a collaborative environment between sites.

A critical feature in any effective online course delivery system is its enhanced interactivity. The design of IVLP incorporates virtual face-to-face methodology and real-time chat session to enhance online learning experience. Thus, remote students can conveniently communicate with their instructor and receive proper instructions regarding assignments and remote laboratory activities. The chat sessions allow the host to e-invite participating students to a virtual conference or lecture as needed.

An attractive feature of IVLP is its ability to support real-life demonstration of laboratory activities to remote students. In such applications, the lecturer provides background and theoretical information followed by laboratory demonstration. Via the video conferencing capability of IVLP, remote users can watch the presentation and eventually take over the control of laboratory equipments and perform the experiment on their own.

IVLP is a general-purpose online platform and it can incorporate any compatible application-specific remote laboratory or simulation applet. Thus, rather than adapting new lecture materials or virtual experimentations premade in a commercial software package, individual instructors can retrofit their old proven lectures and laboratory activities and make them available to multiple remote users using IVLP. This can be done by upgrading the lab setup such that all instruments can be controlled by a computer via LabVIEW applications.

### 3. Application Architecture

IVLP is a client/server application which can be designed using a central server or multiple distributed servers. Currently we have only implemented IVLP on a single server running Windows XP and LabVIEW 2009<sup>8</sup>. This architecture is shown in Figure 2. In this architecture, the central server is configured as the LabVIEW Web Server and the IVLP applications are invoked from the server. As shown in Figure 2, the client can gain remote access to the instruments through the LabVIEW Web Server via the *virtual instruments* (VIs) of the IVLP application. A VI in LabVIEW programming is an intuitive interface for writing and executing programs.

As shown in Figure 2, the client database also resides on the web server. The client database is used to store clients' profiles and can be created autonomously using any programming tools, e.g., SQL. The client database is also used for authentication and allowing clients to save files in their profiles. An important feature of IVLP is that it allows collaboration among users at various locations. Thus, multiple users can conveniently store shared modules, such as tests, quizzes, and lectures, in a shared directory on the web server.

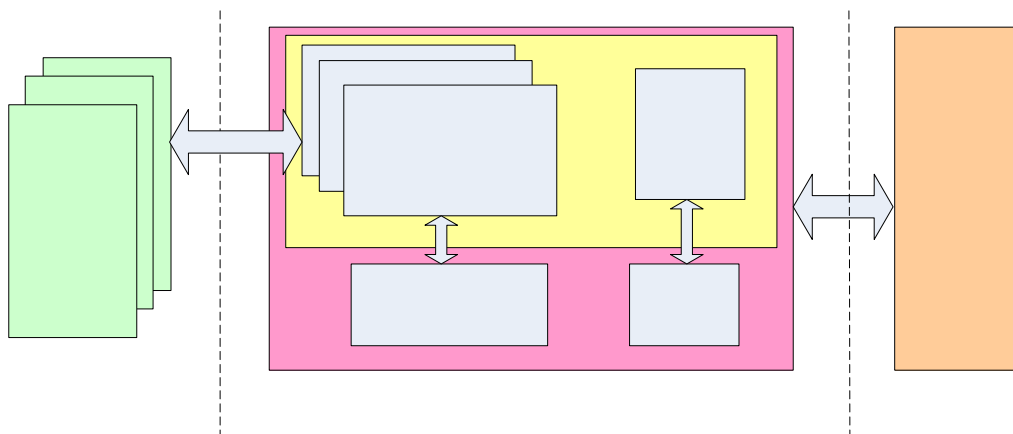


Figure 2: LabVIEW-based Client-Server Architecture.

#### 4. Application Layout

Figure 3 depicts the application layout of IVLP. As shown in this figure, the IVLP application combines a hierarchy of independent modules. Each module in the application is a VI that is independent of its hierarchy and could be easily used at any level as presented in Figure 3. All the VIs are developed using LabVIEW programming. The motivation for using LabVIEW was to allow users with limited programming skills to easily create a new set of virtual experiments.

The IVLP's modularity allows creating fast and effective virtual laboratories and integrating all teaching tools together, while adding new features. As a result, IVLP provides a unique educational experiment for students to have remote hands-on, read about the theory, enhance their understanding via simulators, and test their knowledge at the end.

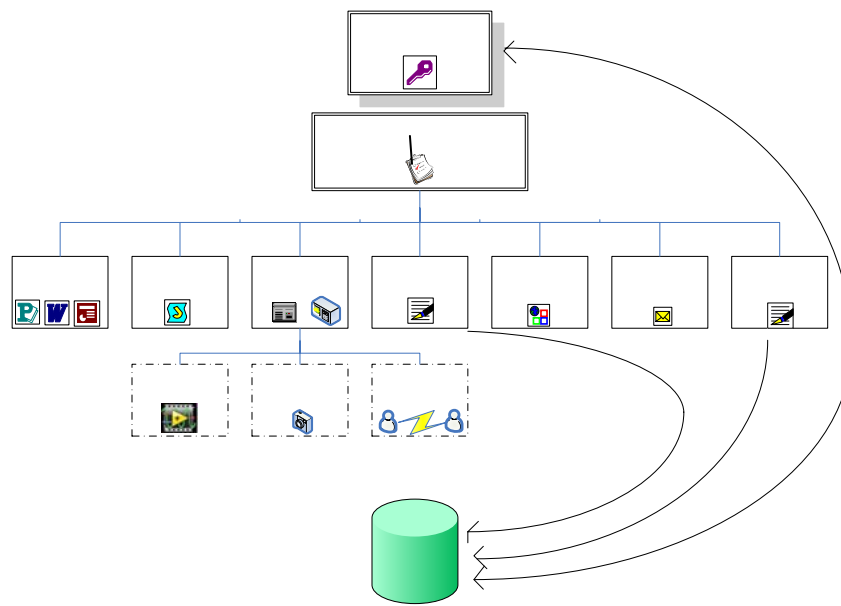


Figure 3: IVLP Application Layout.

#### 5. Implementation

In order to fully utilize features of IVLP, the server and client sites must be properly configured. Table 1 describes all the components required to be installed and configured on the server and client sites. We note that in the rest of this document, *user* refers to the instructor or IT administrator at the server end and *client* refers to the remote student at the other end.

On the server end of the IVLP application the user must make sure that LabVIEW is configured as the Web Server to allow remote connections and the application VI has been published from LabVIEW's Web Publishing feature. Publishing a VI refer to creating a web link for the application VI for remote client access through the web server. In order to provide a consistent web link for the application, IVLP requires a static IP address for the server which hosts the application. Moreover, the user has to configure appropriate firewall settings to allow access through the network.

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On the Client end, when the client accesses the application for the first time through the browser, the browser automatically installs two ActiveX plug-ins for IMAQ on the client PC along with LabVIEW's Run-time plug-in. ActiveX controls are small programs, or *add-ons*, that are used on the Internet and enhance browsing experience by allowing animations.

Table 1: System configuration.	
Server	Client
<b>HW Requirement:</b> PC Server with a static IP address and High-Speed Internet	<b>HW Requirement:</b> PC with High-Speed Internet
<b>SW Requirement:</b> LabVIEW 2009 installed with: <ul style="list-style-type: none"> <li>➤ Measurement and Automation Explorer</li> <li>➤ NI-VISA</li> <li>➤ NI-IMAQdx</li> <li>➤ NI Signal Express</li> <li>➤ NI-488.2</li> <li>➤ LabVIEW Run- Time 9.0</li> <li>➤ Instrument I/O Library Suite</li> </ul>	<b>SW Requirement:</b> <ul style="list-style-type: none"> <li>➤ A PC with LabVIEW supported browser e.g. Internet Explorer</li> <li>➤ LabVIEW Run-time plug-in</li> <li>➤ Two ActiveX plug-ins for IMAQ Support</li> </ul>
<b>Configuration:</b> <ul style="list-style-type: none"> <li>➤ Enable LabVIEW's Web Server</li> <li>➤ Publish Application VI from LabVIEW</li> </ul>	

In order to gain access to the IVLP applications over the internet, the client needs a browser, Server's IP address, and login-ID/password. Once the login and password values are checked and authentication is verified, the client is presented with the main menu to make a selection from different available modules. Selecting any application from the main menu, as shown in Figure 3, invokes a new application module in a separate browser window of the remote client.

## 6. Application Modules

In the following paragraphs we elaborate on various VI modules provided by the IVLP application. Each individual module is a LabVIEW VI. Thus, each interface can be further enhanced through standard LabVIEW features for creating more effective visualization and learning environment.

**Login:** This module provides authentication process to IVLP and allows the client to access the IVLP applications. Once the remote client logs onto the system from the Login VI, the system authenticates the login name and password and prompts the client about his/her last activities. After authentication, the client gains access to all the applications, as depicted in Figure 3.

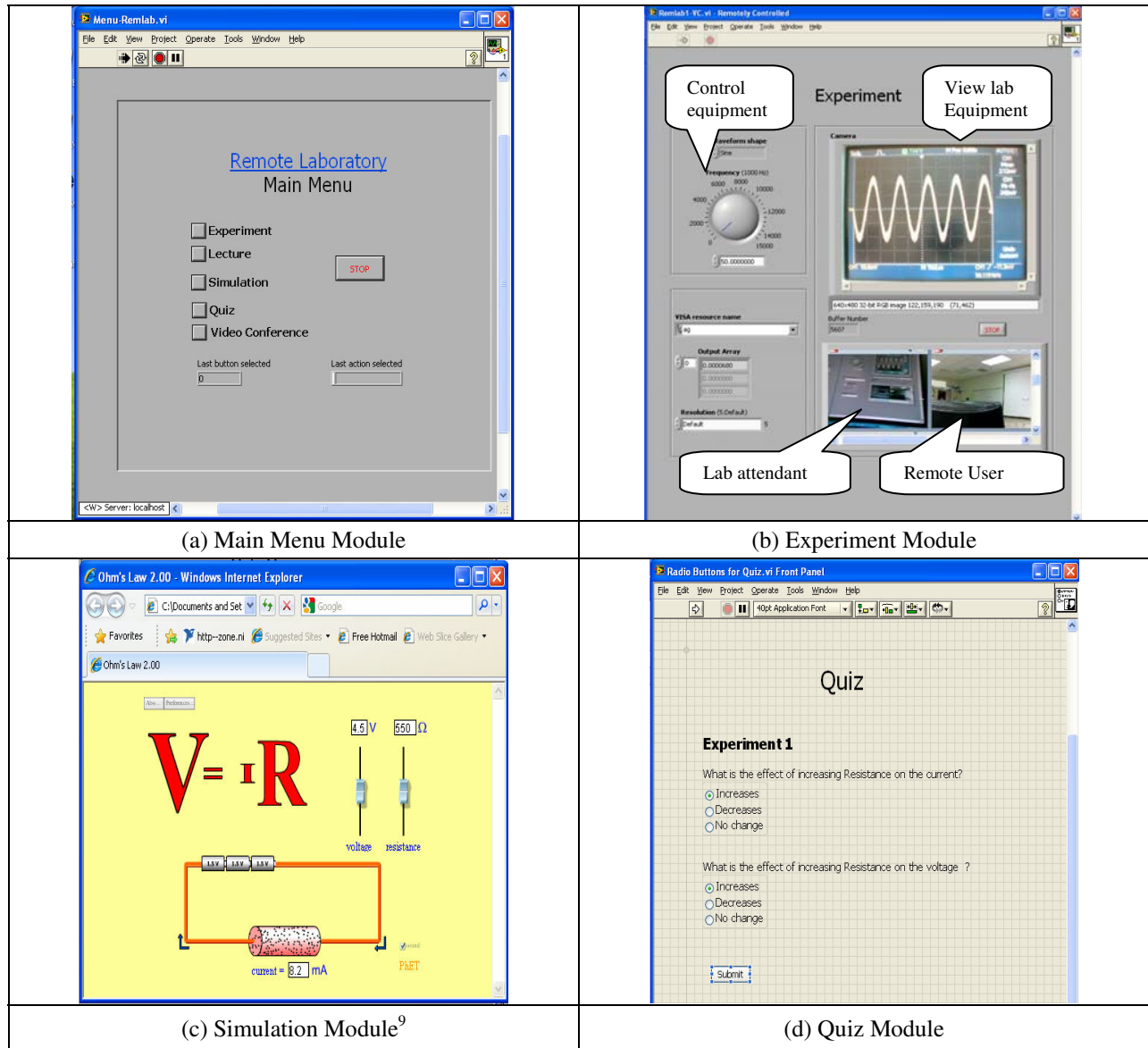


Figure 4: IVLP Application Modules Examples

**Main Menu:** As shown in Figure 4(a), this module links the remote client to different application options. The clients can also log out from IVLP applications from this interface. Upon selection of each application from the menu, the appropriate module will be invoked in a new browser window.

**Lecture:** This module provides background lessons and describes the main objectives of the simulation module and remote experiment. The Lecture module can incorporate various file types including PDF, MS Word, Excel, or PowerPoint. This makes IVLP a flexible platform, in which users can easily create their own learning tools and be able to integrate various online materials.

An important feature of IVLP is that, by exploiting powerful LabVIEW features, it allows embedding the source application into the VI module. Consequently, for example, when a PDF file is invoked in the Lecture module, the user will have full access to Acrobat Reader and all its features (e.g., zooming in and out, page up and down and print) from the VI module.

**Simulation:** Many studies have shown that through simulation, students can actively learn about the related theory relevant to their particular course<sup>10</sup>. A unique feature of IVLP is that it provides embedded simulation tools that can be invoked from the Main Menu. Figure 4(c) shows an example of a java-based simulation applet which is developed by University of Colorado at Boulder<sup>9</sup> and we obtained it from their website. This applet allows students to observe the effect of Ohm's Law by changing values of Resistance, Current, or Voltage. Depending on the nature of the course, various online applets can be incorporated in IVLP.

**Experiment:** Using this module the remote student can control laboratory instruments and perform the laboratory experiment. By design, IVLP offers access to only one user at a time. Thus, when one user is connected to the application other successive attempts to access the application are queued on the web server and the remote clients are notified once the control is released.

The Experiment module also allows an instructor to conduct live lecture or demonstration through its supporting video capacities. In that case, instructor has the full control over the VI and remote students may watch the experiment in the Experiment window.

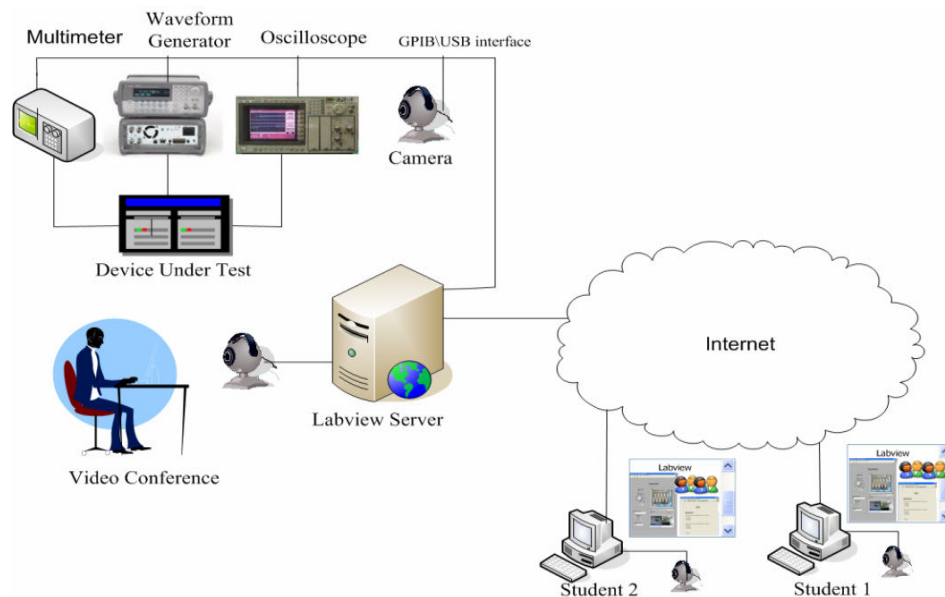


Figure 5: LabVIEW-based Integrated Virtual Learning Platform (IVLP).

Figure 4(b) shows an example of a virtual instrument we created to control a Waveform generator and a Multimeter. In this demonstration, we created an experimental to measure the response of a Device under Test (DUT) using a HP 33120A waveform generator, Agilent 34405A multimeter, and a Tektronics TDS 2210 oscilloscope. All devices were interfaced with



the LabVIEW server, as shown in Figure 5. A USB camera was installed in front of the scope to view its screen. As depicted in Figure 4(b), by using the knob on the remote virtual instrumentation the remote student can change the amplitude and frequency of the input signal into the DUT and observe the output signal through the camera. This example is a simple demonstration of the capabilities of the IVLP in terms of remote control of instruments and enabling its video conferencing feature.

**Quiz:** The quiz module can be designed to provide an assessment about the level of understanding of the students as they go through various exercises in IVLP. When this module is invoked, the remote student will be prompted with a series of multi-choice questions. Figure 4(d) depicts an example of a simple quiz module. In this case, the remote student can select the answer for each question by checking the appropriate radio buttons. Following clicking the Submit button, the results are recorded in a file in the user profile directory for later review by the instructor.

**Video Conference:** In order to create an effective remote laboratory experience, IVLP provides multi-dimensional video capabilities, as shown in Figure 3. Video conferencing can be accessed from the Main Menu or Experiment module. The IVLP video Conferencing module is essentially provided by accessing a separate Video Conferencing<sup>11</sup> application from within LabVIEW. This feature allows video enabled live conversation as well as chat with a group of users and private chat between selective users. This is an effective environment for instructors to carry out live demonstrations from the Experiment module while conducting distance learning. IVLP also provides video capability for viewing instruments by remote clients. This feature can be invoked from the Experiment module and is installed on IVLP web server.

**Request for New Experiment (RFNE):** As we mentioned before, a unique feature of IVLP is allowing multiple users in different institutions to design and offer various aspects of an integrated learning platform. Thus, through a collaborative effort, one site can only provide the lecture contents while another site can offer the test equipment interfaces and access to the actual instrumentations. Through RFNE feature, remote clients or users can request new laboratory experiments; they can describe the setup and specify a time slot to access the server. The RFNE was designed by embedding *gmail* (Google Mail) interface into virtual instruments.

**Report:** IVLP offers a number of database features which can be utilized for viewing student performance and their progress. Such information can also be used for improving and changing simulation and laboratory experiments. All of these features are readily available to users through IVLP and require very little prior knowledge about databases and data management. The Report module can be accessed from the Main Menu and it is developed by using LabVIEW Report Generation Toolkit for Microsoft Office which provides tools for creating and editing reports in Microsoft Word and Excel from within LabVIEW.

## 7. Future works

As mentioned before, IVLP is a hybrid web-based delivery system which offers flexible features and applications for effective distance learning. In this section we briefly describe our future plans to improve and enhance IVLPs' features.

1. By design, IVLP allows only one user to have control over the application modules. In the future we plan to add a time-out feature to limit user access to IVLP to eliminate long idle connections.
2. In this phase of the project we focused on development of IVLP using a central server. In the distributed IVLP design, we plan to support multiple seamless experiments from different sites. This is particularly useful when different institutions are collaborating together and each institution has limited test equipments.
3. A major area of improvement in the future will be adding security features to the client database. For example, we plan to add *permissions* to user profiles so only assigned instructors can have access to student records or specific students can have access to certain applications.
4. Another area of improvement in the future is to revise the Quiz module structure. Currently, the Quiz module is implemented using static values for Q&A, so questions must be manually entered. In the future, we intend to make this module more interactive such that questions and answers can randomly be selected from an existing file created by the user. We also intend to attach a time stamp and User ID to each quiz to improve the testing environment.
5. As of now, we have not performed any traffic monitoring to evaluate the traffic volume passing through the IVLP web server. It is our intention to examine the volume of the traffic for maximizing the network performance.

## **8. Outcomes**

In this paper we focused on reporting our preliminary results of developing the first IVLP prototype. At this point, we must emphasize that more data is required to reflect the definite impacts of this project on engineering and science students. So far, we have not launched the project among a wide number of students. We intend to use this pilot project in Spring of 2010. As of now, only limited numbers of students have actually utilized the IVLP system and, overall, we have received positive feedback from them. In two cases, our students have reported minor software bugs which we have corrected. However, in the past several semesters we offered our students the option of running two laboratory experiments in the Linear Systems class. This experiment dealt with Fast Fourier Transform and required students to use a spectrum analyzer, a signal mixer, and a signal generator. Based on their feedbacks, most students were satisfied with the remote laboratory setup and expressed relief in being able to complete the laboratory online.

## **9. Conclusion**

In this paper we introduced a LabVIEW-based hybrid integrated distance learning platform that enables course material sharing and collaboration between various institutions and instructors in order to provide a cost-efficient and flexible learning and training delivery to multiple remote users. A key advantage of IVLP is that it combines traditional online learning with virtual face-to-face delivery and virtual hands-on laboratories. More work is required to fully expand features of IVLP. In the next phase of IVLP development, we intend to develop several complete course modules and collect more student feedback.

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