

# **AN UNDERGRADUATE LABORATORY FOR WEB-BASED INSTRUMENTATION AND CONTROL**

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## **Summary**

The objectives of this project are to demonstrate that (a) it is practical and feasible to offer engineering undergraduate students a course on Web-based Instrumentation and Control (WIC) that involves recent technological innovations; (b) the proposed course can be effectively conducted with two integrated components: classroom lecturing and hands-on practice through a remote setting; and (c) the course materials can also be offered after modification to gifted high school students and, thus, be used as a vehicle to attract students to engineering disciplines.

Since July 1, 2002 (the official starting date of the project), we have been actively involved in developing the WIC Laboratory. After the laboratory is set up, it will have 10 workstations that are inter-connected via campus LAN. Each workstation will consist of a PC, a data acquisition board, and other instruments. A web server and a process server will run on every workstation. A number of web cameras will be installed in the lab. Students will be able to conduct WIC experiments, and Internet users will be able to navigate to the lab site to witness the progress of the laboratory development. We plan to offer an undergraduate course on WIC in the coming summer semester.

## **A. Introduction**

The rapid growth of the World Wide Web provides tremendous commercial opportunities. International Data Corporation has projected that 46 million Americans will buy \$54 billion worth of goods annually by 2002 using the Web. Morgan Stanley Dean Witter estimates sales of anywhere between \$21 billion to \$115 billion annually by 2005 [1].

While e-commerce is starting to take off at a rapid pace, network infrastructure is also following suit. In a recent issue of IEEE Spectrum [2], Dutta-Roy states, “Networking technologies start to invade the home to carry phone signals and TV programs, link computers and peripherals, and tap into the Internet.” Figure 1 (next page) demonstrates a networked home. Household electronic devices such as lights, appliances, climate-control systems, and surveillance cameras are linked to the Internet through wire or wireless networks. It is predicted that Internet-connected home area networks will soon penetrate domestic life.

In the public domain, Taylor and Dalton in [3] reported a project in which robots were operated through the Internet to perform a function of a robotic tour guide. The robot, Minerva, has a user interface that is replicated on the web page to allow web users to control the location of the robot as well as the camera’s viewing angle (by a majority role).

Due to the rapid growth in the Internet over the past decade, trained professionals in all aspects of Internet programming are in high demand. This is especially true for those that have expertise in developing systems of Control Over the Web (COW). Materials that fit classroom teaching and lab experimentation for undergraduate students in this area are, on the other hand, very scarce.

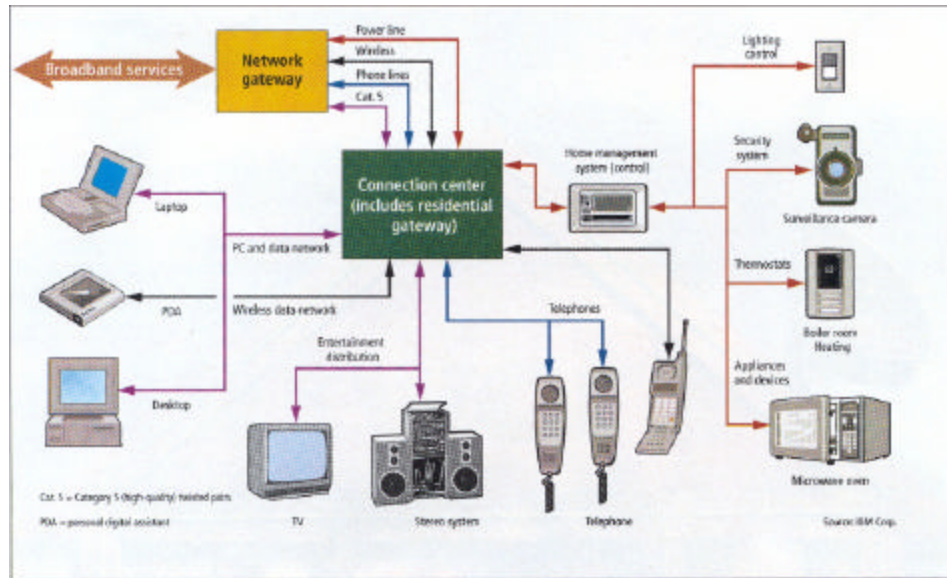


Figure 1. A conceptual home networking system (from [2])

The goal of this study is to prove the concept of offering an undergraduate course with a companion lab that teaches students to design and develop web tools for WIC. The following objectives are being pursued:

- Demonstrate that it is practical and feasible to offer engineering undergraduate students a course on WIC that involves recent technological innovations.
- Demonstrate that the proposed course can be effectively conducted with two integrated components: classroom lecturing and hands-on practice through a remote setting.
- Demonstrate that the course materials can also be offered to gifted high school students and be used as a vehicle to attract students to engineering disciplines.
- Disseminate the project findings through conference presentations and scholarly publications, and further through the preparation of a textbook based on the lecture notes and lab materials.

## B. Detailed Plan

### B.1 Sketch of Web-based Instrumentation and Control

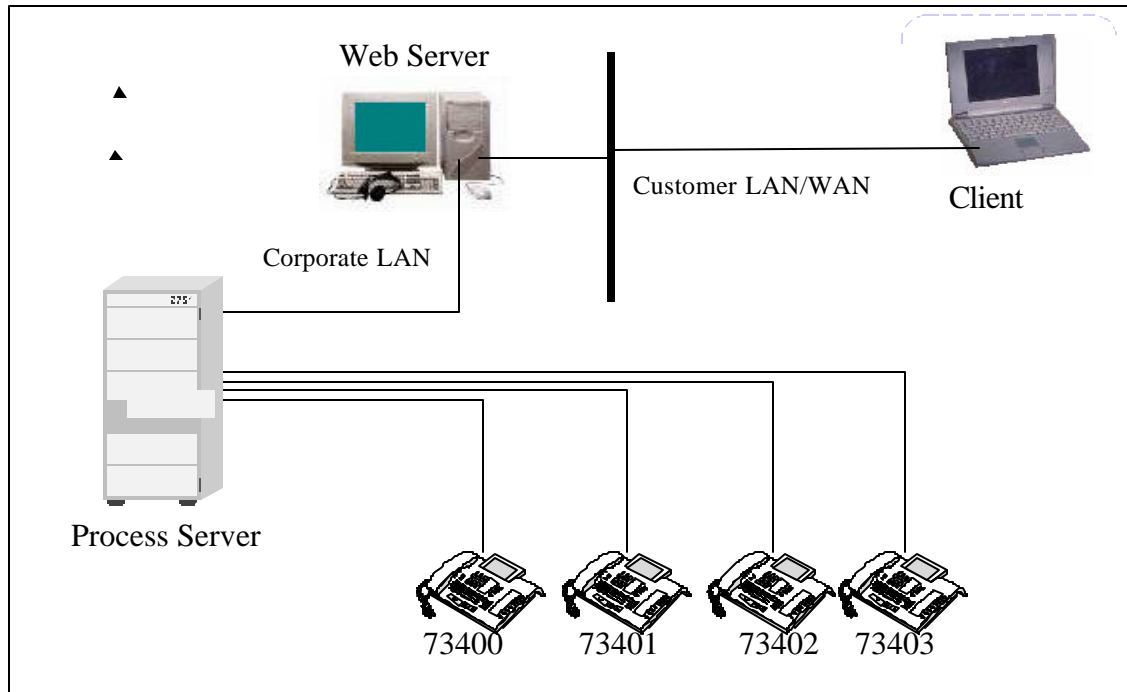


Figure 2. A typical web-based application (note that the numbers are extensions)

The Internet can be used as the infrastructure for industrial applications. A Web-based application (an example is illustrated in Figure 2) normally has the following elements:

- A computer that serves as a web server, where the HTML and scripting programs reside.
- A computer that serves as a process server, where the programs that compute business logic reside. It connects to the web server on one side and process hardware on the other. The web server and the process server sometimes can be a single computer or two separate computers.
- Process hardware that gets the job done at the remote side (shown in Figure 2 as phone sets; control cards inside the Process Server are not shown).

- Client computers with which users access a web site. They are connected to the web server through either the Internet or a corporate intranet.

We will discuss the feasibility of training an engineering student to be prepared for the design and implementation of web-based commercial/industrial applications by presenting the curriculum development plan in the next section.

## **B.2 Development plan**

A course with a lab will be offered in the coming summer semester. The course has three credits, two for lecture and one for lab experimentation. The lab portion of the course consists of seven experiments and a project. Each experiment requires approximately two weeks of lab time. Students need to do some preparation before the lab and write a report upon completion of the lab.

In terms of the lecture material, the course will address the following issues:

- Web Programming Environment
- Web Programming Tools
- Monitoring Processes Over the Web
- Control Processes Over the Web
- Security and Fault Tolerance
- Case Studies

The following considerations play a role in the preparation of the course/lab development plan:

- *The courses/lab will be multidisciplinary in nature.* In order to develop a web-based industrial application, students will need to master relevant knowledge from various

engineering disciplines. More specifically, students will need to understand the interactions among client computers, web servers, process servers, and process plants. They will be required to implement software components that perform specific engineering tasks. Further, issues that are unique for web-based applications will be addressed in depth. These include unpredictable time delay, security, and fault tolerance required for a reliable system over the Web.

- *The materials offered in the lectures will be platform independent.* While in the lab, students will practice on a particular realization of the concepts taught in the classroom. Using materials that are platform independent will prepare the students to be more versatile and, thus, more competitive in the job market. On the other hand, in a university, we have to make a choice among various development environments in order to establish a lab that provides excellent educational tools in an affordable manner.
- *Most of the process-related labs and projects will be open-ended.* This will encourage students to find more effective solutions. For instance, there are many important issues involved in applications. These issues cannot be possibly solved in the course. However, any attempt by students to attack some of the issues will be promoted in the class.
- *The lectures and labs will be highly correlated.* This is done in order to reinforce concepts students have learned in the classroom and will be critical to student learning, as the lab is a companion part of the course. Experiments will be arranged in a sequential order. This way, students will apply what they have learned to the later experiments.

- *The lab will promote both individuality and team spirit.* The experiments designed in the courses will enhance the student's ability to solve problems independently, while the term projects will promote a spirit of teamwork. To achieve this, we will require that students perform lab experiments individually and term projects with groups.
- *The lab will provide remote accessing capability.* Students will be able to complete most of the assignments at home with a computer, while achieving the objective of testing their implementation using devices in the lab. This will be feasible because most of the web project development tools now allow developers to work on a project in either the master mode or the local mode. In the master mode, students must work on the web server computer. On the other hand, in the local mode, the students can work on any computer that has a network connection and a simplified development environment. A significant portion of the labs outlined later of this section can be conducted in the local mode. This will stretch the boundary of the lab beyond the university campus.

The lab consists of about six experiments and a project that is chosen by the students. The experiments and projects focus on essential aspects of web-based applications such as multi-tier architecture, object oriented programming, client side and server side scripting, database management, and realization of business logic with platform independent components.

### **B.3 Equipment used**

The following equipment will be used to develop the lab/course:

- Computers with network cards
- MS Visual Studio.Net
- Data acquisition and control cards

- Toy robots
- Web cameras bundle

To train students in web application development, we interconnect all the stations through a local area network. Students can conveniently test their work with a set of network computers. A typical scenario is that a student develops a web project, including the software component that realizes business logic on one computer. He/she then installs the process component in another computer, which has necessary hardware for business related processing. Finally, he/she launches the web browser from yet another computer, as shown in Figure 2.

We expect that the class will be popular among students. We intend also to offer a summer dual-enrollment course for both undergraduate and gifted high school students.

As to the choice of development environment, MS Visual Studio.Net (free educational licenses) is a comprehensive programming tool, which, among other things, comes with Web Programming Languages. With Internet Information Server (comes with Window XP), students can simulate their implementation in a realistic environment. Once mastering these and other tools used in the course sequence, the students are expected to be extremely marketable.

Motion control cards and network cameras will be used in the real-world experiments and term projects. We plan to purchase a number of turnkey systems as processes. For instance, web cameras made by InetCom include a complete turnkey system of video transmission that is ideally suited for the laboratory.

We select some toy robots as the control targets due partly to their functionality and popularity among engineering students and partly to their low cost. Some of toy robots are especially helpful to designing term and senior design projects on the subject of WIC.



Students can focus on issues important to WIC such as supervised control under large time delay.

### **C. Evaluation plan**

The course is scheduled for Summer 2003. To ensure that the program will be successful, we will implement the following evaluation plan:

- We intend to invite a representative from the Department Industry Advisory Board and a faculty member from the college to evaluate the project.
- At the beginning of the project, we will design a list of evaluation questions and will refine it during the project. The questions will be related to both the project's implementation and its success/failure in terms of the objectives of the project.
- Part of the evaluation questions will be distributed to students in the middle semester of each term and part will be distributed at the end of each offering. Relevant questions will be also presented to the evaluators. Data will be statistically analyzed and tabulated, and will be reported in the next presentation.
- At the end of each year, with the help of the evaluators, we will critically judge the progress of the course by monitoring the enrollment, students' enthusiasm and responses, impact on other courses, etc. Based on the input of students and colleagues, appropriate measures will be taken to implement improvements.

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