

AC 2007-894: A DATABASE AND USER INTERFACE DESIGN FOR A REMOTE ACCESSIBLE ENGINEERING LABORATORY

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A Database and User Interface Design for a Remote Accessible Engineering Laboratory

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Abstract

In an effort to further improve learning effectiveness and flexibility for engineering and technology students, Kimmel School graduate students are implementing a remotely accessible engineering laboratory based on previous research results [1], [2]. Designing a remote-accessed engineering laboratory can eliminate the unnecessary need for transportation of laboratory equipment, reduce the cost of software licensing, and provide flexible scheduling for student laboratory exercises.

The overall project involves four major components: remotely controllable lab equipment, information transfer over the networks, student knowledge assessment tools, and a relational database and user interface design. Our paper focuses on the design and educational values of a relational database and user interface.

Introduction

Through the use of teleconferencing, a relational database and user interface can be used to link two or more sites together for instruction [3]. For operations such as distance learning, a relational database and user interface is critical for effective communication. Communications infrastructures, such as the internet, could be utilized to fit the project's application. In the future, remote learning technologies will be highly utilized and much more complex [4]. The internet and wireless networks are advancing technologies for the electronics information industry [5]. The web offers a cost effective, accessible and reliable communications medium [6]. Consequently, the technology could have more advanced functionality, satisfying the requirements of a distance learning project. The use of the internet has allowed remote education to excel to a new level of quality [7]. By adding laboratory experimentation to remote education, the experience can be greatly improved [6]. Remote laboratory experimentation allows flexible laboratory time. If a student is separated from an instructor by either space or time, the student can participate in a course on-line [8].

Figure 1 shows a system block diagram of the project. Database development is essential to the success of this project. Two databases were designed in this project using MySQL Front, an open-source product. The first database stores data for the pre-lab exercises and tutorials that help fulfill the students' learning objectives. This database also consists of several fields that will contain the student scores from the pre-lab exercises for assessment purposes. The second database contains the student information, which includes student name, student ID, lab number, and the time elapsed for conducting a laboratory experiment. This information will be used to provide statistical data to assess the students' learning effectiveness over time.

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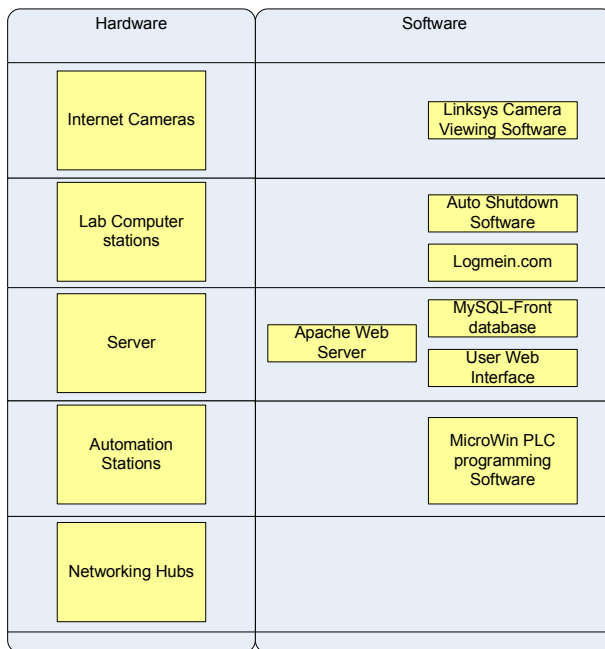


Figure 1. Hardware and Software Block Diagram

The purpose of the user interface is to guide the student through a set of preliminary tests related to a selected lab and to allow the student to perform the laboratory experiment from a remote location, upon successful completion of the tests. In this paper, an example user interface is presented in which the student is provided access to three different labs.

The user interface consists of a series of web pages and acts as a liaison between the student and the databases, as well as a gatekeeper between the student and the lab equipment. Upon successful login, the student will be directed to a welcome page. This stage includes an overview of the lab and records student information. Once this stage is completed, the student is directed to the background theory test associated with the selected lab. If a student passes the background theory test, he/she will be further directed to the pre-lab knowledge test. If a student does not pass the background theory test, he/she will be directed to the course material review, after which the student will be allowed to re-take the background theory test. A student who does not pass the pre-lab knowledge test will be directed to a review of the lab material. After such review, the student will be directed to re-take the pre-lab knowledge test. Upon successful completion of both the background theory and the pre-lab knowledge tests, the student is granted access to begin laboratory exercises. Flow diagrams of the lab and test portions of the user interface are shown in Figure 2. In this paper, we will report our findings from this applied research project. Educational merits will be discussed, and preliminary assessment results will be addressed.

Educational Merits and Assessment

This project requires the combined knowledge learned from two distinct graduate courses. Database design and implementation is acquired from a Data Acquisition course. This provides the advantage to create a more applicable, user-defined database to satisfy the requirements for

the engineering distance learning environment. The other course that provided crucial knowledge for the completion of this project was Telecommunication and Network Systems. This course provides the ability to comprehend how data is transmitted between a web browser and a database. Consequently, the understanding of the knowledge from these two courses presents a more proficient approach to the problem, which allows a more feasible engagement of the task.

General Design Methodology

Database Design

One of the most critical foundations for the initial stage of a database design is to plan and map out the entire structure. This encompasses designation of all tables and fields. Once all the parameters have been established, the aforementioned elements of the database can be created. The database software used for this project was MySQL Front. The actual database design was accomplished using the GUI of this software to set up tables and fields. Each field has its own data type which is established here. Figure 3 shows a sample record of the performance of four students in a MySQL Front database. As can be seen by this diagram, the database stores a record of student test scores. Figure 4 shows a sample MySQL Front database table. This table is used to design a user database and includes the data name and data type of each field in the database.

Two databases were designed in this project, including *users* and *questions*. The *users* database contains information for the students, including their ID numbers, passwords, test scores, time-and-date stamps, and the status of each lab. The *questions* database includes the answers for all the tests of the three labs. These two databases are relational; they interact with each other for recording and storing information accordingly to the students progresses. The *questions* database stores data for the background theory and pre-lab exercises that help fulfill the students' learning objectives. The time elapsed for conducting one lab is also recorded by using a time-and-date stamp implemented with PHP code. This information will be used to provide statistical data to assess the students' learning effectiveness over time.

User-interface Design

The user-interface consists of a series of web pages. This interface acts as a liaison between the students and the databases, as well as a gatekeeper between the students and the lab equipment. PHP script was used to link web pages with the database. PHP is a general-purpose scripting language that is especially suited for web page design. Using MySQL statements, data can be effectively inserted or modified depended upon user input.

The purpose of the user interface is to guide the student through a set of preliminary tests related to a selected lab and to allow the student to perform the laboratory experiment from a remote location, upon successful completion of the tests. Figure 2 shows the lab and test process flowcharts for the user interface. Upon successful login in Figure 5a, the student will be directed to the welcome page shown in Figure 5b. This stage includes an overview of the lab and records the student's information.

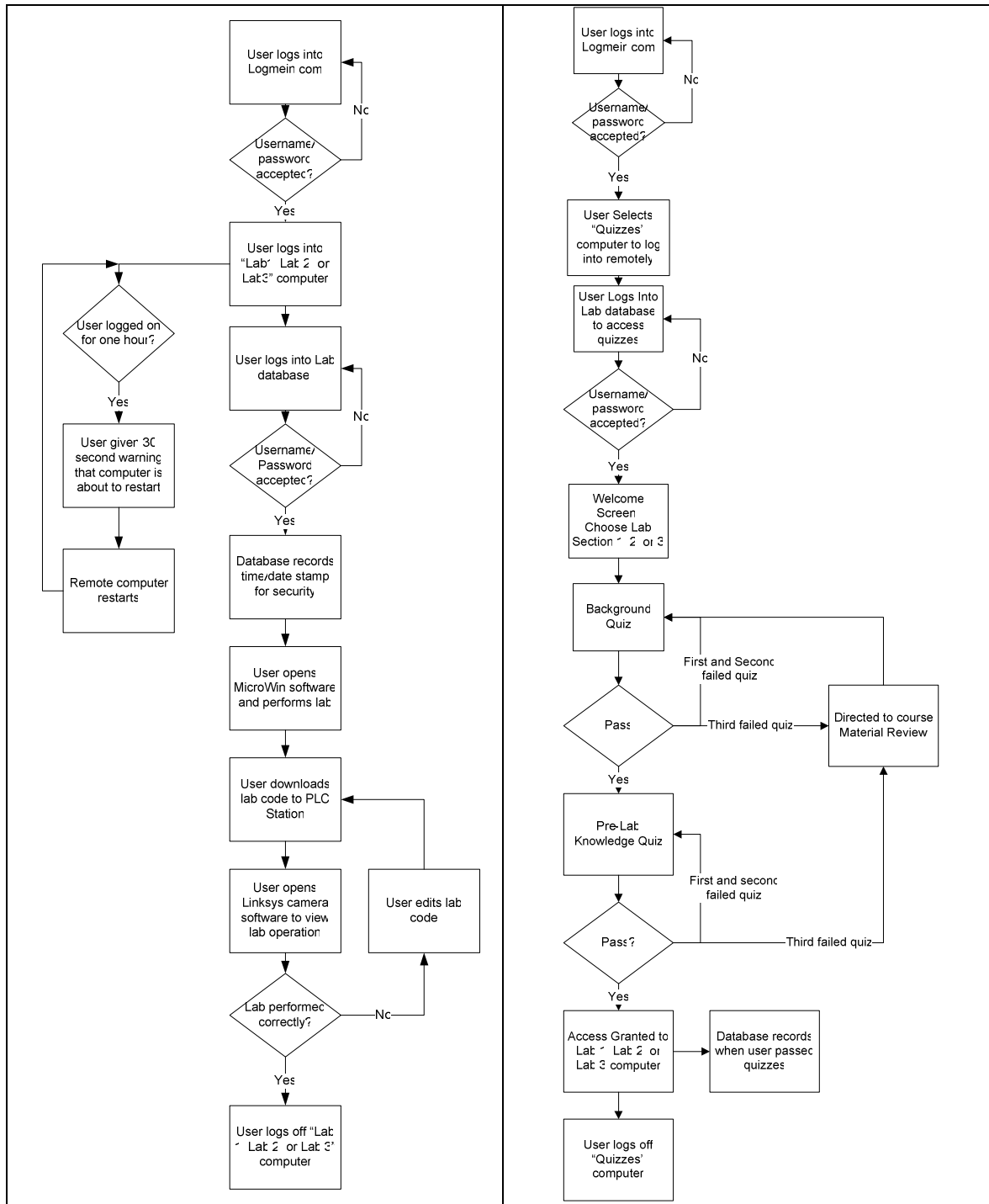


Figure 2. User Interface Flowcharts. (a) Lab flowchart, (b) Quiz flowchart.

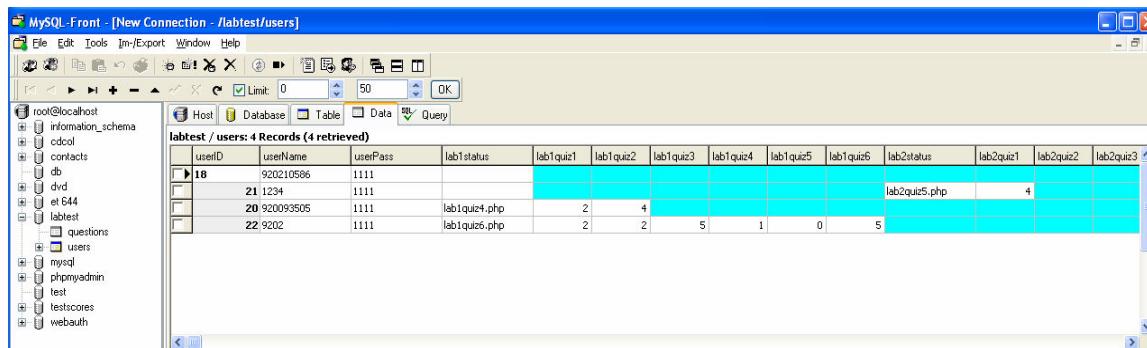


Figure 3. MySQL Front Database

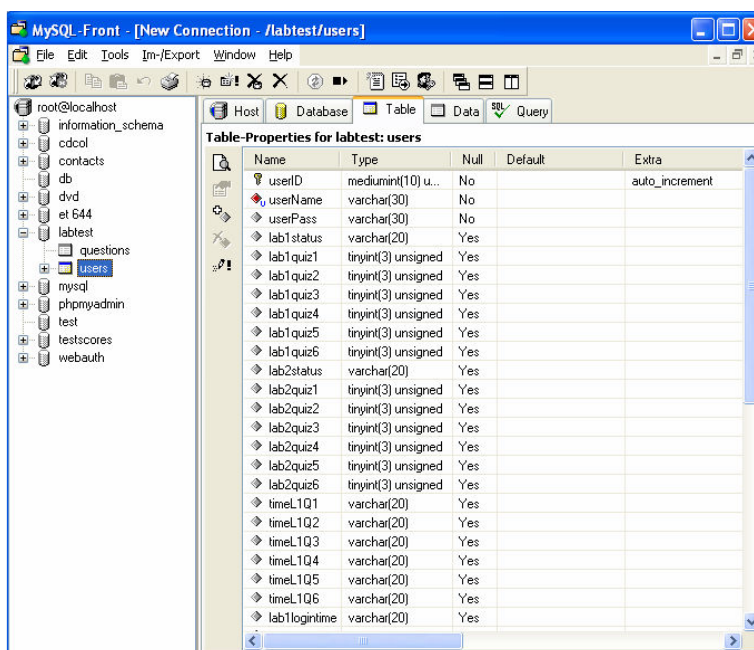


Figure 4. MySQL Front Table Design

Once a student has selected a lab from the Welcome page, he/she is directed to the corresponding background theory. If a student passes the background theory test, he/she will be further directed to the pre-lab knowledge test. If a student does not the background theory test, he/she will be directed to the course material review, after which the student will be allowed to re-take the background theory test. A student who does not pass the pre-lab knowledge test will be directed to a review of the lab material. After such review, the student will be directed to re-take the pre-lab knowledge test. Upon successful completion of both the background theory and the pre-lab knowledge tests, the student is granted access to begin laboratory exercises.

The relational database and user interface permits multiple students to log in from different remote sites and take the background theory or pre-lab knowledge test at the same time. The relational database and user interface does not allow a student to remotely take control of lab equipment while another student already has control.

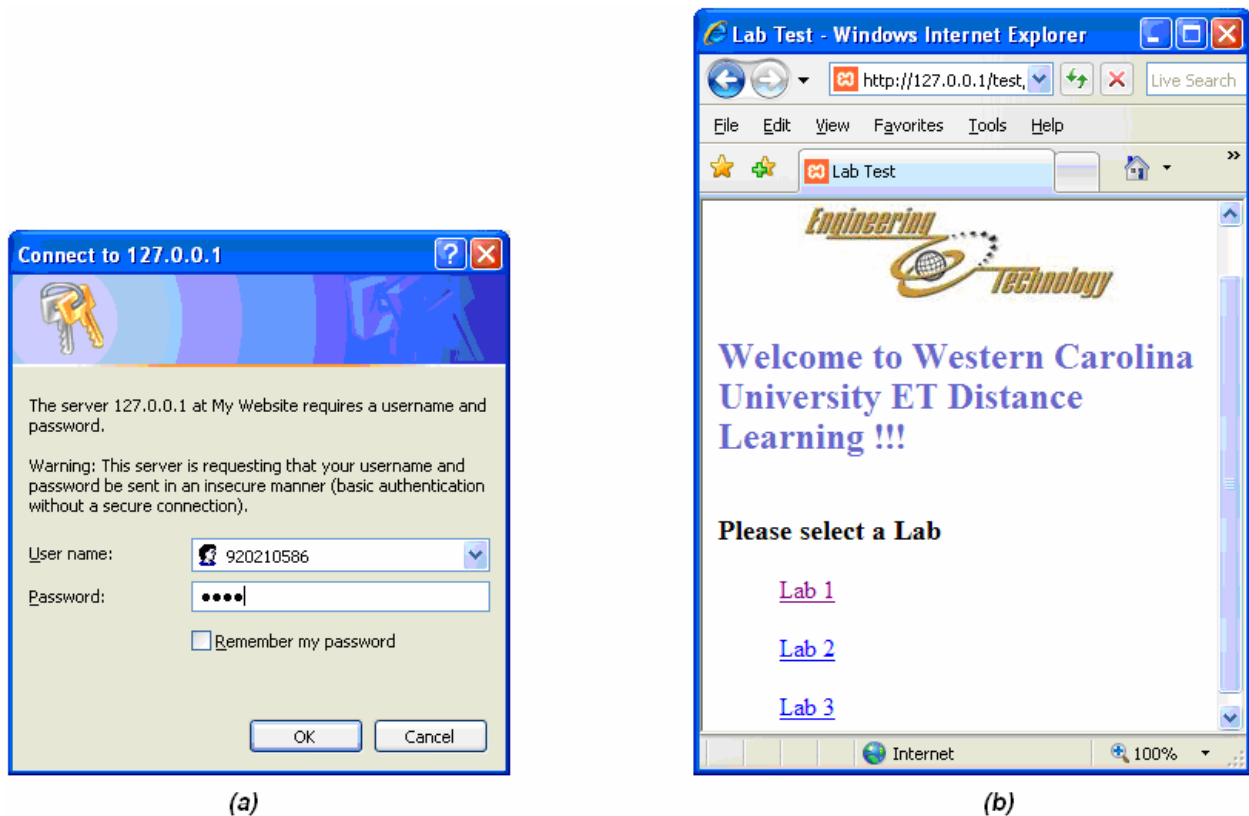


Figure 5. (a) Student Login page, (b) Welcome page

For administrative purposes, an administrator login page, shown in Figure 6, is created to provide instructors of the course to view database contents without having to manually go through the database itself. For security reasons, this page is password protected. One of the items that instructors are allowed to view is the time and date at which each test was taken and the test scores of each student. The screen in which instructors use to view the test score information is shown in Figure 7.



Figure 6. Administrator Login Page

11/09/06 14:57

Engineering Technology

Welcome to Western Carolina University ET Distance Learning !!!

Student Name	L1_Qz1	Qz1_Time	L1_Qz2	Qz2_Time	L1_Qz3	Qz3_Time	L1_Qz4	Qz4_Time	L1_Qz5	Qz5_Time	L1_Qz6	Qz6_Time
920210586	4	11/09/06 14:55	2	11/01/06 14:02	1	11/01/06 14:02	2	11/01/06 13:42	0	11/01/06 13:43	1	11/01/06 13:43
920093505												

Figure 7. Student Scores Table for Administrative Purpose

Implementation Results and Findings

For testing purposes, the implementation of the user-interface was conducted using the local-host. In order to be able to run software over the internet in real-time, a web server that supports PHP is required. It was chosen to use the Apache HTTP server. This is an open-source product that supports PHP script. To implement software control on the local-host, the software XAMPP Control Panel was used to acquire connection between the MySQL database and the user-interface. By running XAMPP for Apache HTTP server and MySQL, the connection is established between the web pages and the database. Figure 8 shows the XAMPP Control Panel.

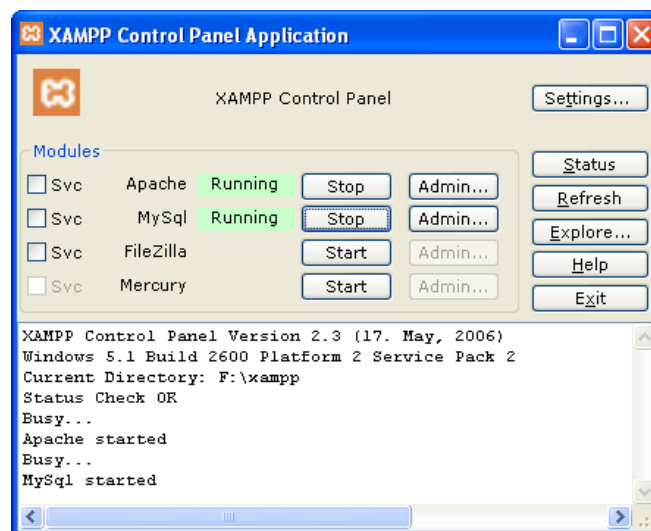


Figure 8. XAMPP Control Panel

After the connection had been established, a local-host (127.0.0.1) was used to go through the processes of login, creating account, and taking the tests. By doing so, the results were displayed and stored in the database for administrative access.

When students finish and pass all the required tests in a satisfactory manner, they are given a link, and directed to internet software for real time control over laboratory equipments. In this project, the remote access software, *LogMeIn* (available from www.logmein.com), is used to login to lab equipment application software. Before a student is granted control of the laboratory equipment, they are required to login once again using their student ID and password. A pop-up window is displayed for authentication purpose and to record date and time information. After this step, the student is allowed to take full control over the laboratory equipment. Further information concerning the software and hardware interface used to accomplish remote control of laboratory equipment can be found in [9].

Testing of the user interface and relational database was performed using a local host as well as with a remote host. Preliminary testing results are satisfactory; the gate-keeping function worked well under certain circumstances. Students were able to log in, take the preliminary tests and take control of the laboratory equipment.

Several security issues were encountered in testing the user interface and relational database. The first issue was the use of the back button using an internet browser. The back button feature had to be disabled; otherwise a user could take a test, and then go back and take the test again. This was disabled using some HTML code. Unlimited use of the URL was another security issue. The problem was that a user could type the address for any test into the URL and take the test, defeating the purpose of having a controlled environment in which to take the tests. The solution to this problem was the use of specific HTML code. Another security issue that was encountered was a user function. Essentially, a student could create a false account, take all of the tests and find out the answers. To resolve this problem, the student would be assigned an ID and a password by the administrator. To do this, administrative security measures had to be put into place. These security measures prevented unauthorized persons from gaining access to the database.

Future Work / Conclusion

Future work includes improving the security and gate-keeping functionality. Database design will be implemented in a more efficient manner. Test questions will be randomly generating using a question database/test bank. Therefore, the design of test web pages will be much simpler once only one web page is needed to display various sets of questions. A more user-friendly administrative function, focusing on easier access of the student scores will be designed. Finally, an alert-email will be sent to notify the professor when a student fails all of the pre-lab and background theory tests. Therefore, he can contact the student to ascertain what the problem is and to determine the student's progress on the project.

In conclusion, the user-interface and database provide means for gate-keeping, storing and accessing data information, and the overall implementation of this Remote Accessible

Engineering Laboratory project. We have learned a great deal by doing this project, for instance, database design, PHP programming, SQL programming and creating a web-based user interface.

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