THE DESIGN OF EMBEDDED WEB SERVER FOR REMOTE LABORATORIES MICROCONTROLLER SYSTEM EXPERIMENT

F. Yudi Limpraptono, Harry Sudibyo, Anak Agung Putri Ratna, Ajib Setyo Arifin
Department of Electrical Engineering
University of Indonesia
Jakarta, Indonesia
fyudil@yahoo.com; harisudi@eng.ui.ac.id; aapratna@yahoo.com; ajib@ee.ui.ac.id

Abstract— **Remote laboratories are innovations in educational technology which allows students to access and interact with laboratory equipment remotely via the Internet network. There are several advantages of using a remote laboratory is the laboratory's performance is better and more efficient because of laboratory equipment can be used by students throughout the day for 24 hours. This paper presents a new design remote laboratory-based embedded web server for practical microcontroller systems. This system has several advantages compared with traditional remote laboratory based on computer server, which are small size, low power consumption, low cost and easy installation and maintenance. Design an embedded web server using 8 bit microcontroller AT89S52. The system consists of a computer server, some experiment module microcontroller system and some embedded web server for controlling modules. The computer server is used as a web server remote lab gateway that serves as a homepage and user management. Embedded web server serves as the user interface to control the lab module microcontroller via the internet. Experiment module is evaluation board AT89SXX microcontroller and is equipped with some I/O circuit. Users can perform remote process on experiment module that is: upload binary files to the target board, observing the changes via a web cam and can interact with the target board through a virtual I/O. Embedded web server is working with pure HTML instructions so that the system is more secure because it only uses port 80 only. Design remote labs are multiuser, so that at the same time can be used by more than one user.**

Keywords—Remote laboratories; Embedded Web Server; Microcontrollers

I. INTRODUCTION

Because of accelerated development in electronics and computer technologies, microcontroller-based devices and appliances are found in all aspects of our daily life. Microcontrollers play an important role in many areas i.e.; motor control devices, electricity home instruments, security systems, elevator control systems, illumination control systems and belt conveyor systems. Nowadays microcontroller education and microcontroller experiment set design are still under interest. Therefore microcontroller education is became a vital course of the electric-electronic engineering education [1]. Laboratory experiments play important role efficient learning in technical and engineering education [2].

Remote labs is web-integrated systems that can be accessed through a unified interface by web browser. By providing distance users a way to share resources and tool, they may cause cost reductions and provide rich educational content to users [3].

There are several advantages the use of remote laboratories where laboratory performance will be better and more efficient because of laboratory equipment can be used by students throughout the day for 24 hours. Remote laboratory created an autonomous learning [4]. Remote laboratory is also allows use by handicapped students, and support resource sharing and collaboration between laboratories [5]. Particularly in Indonesia remote lab system must be developed, with the aim to share the laboratory (collaboration) between colleges. Remote Lab can also be used to support the implementation of teaching and learning at the Open University in Indonesia.

Various webs programming technology has been applied to provide a comfortable environment remote laboratory, such as:

1. Web Lab based on a specific Client/Server TCP/IP application. In this case, the design of the remote client first implies the elaboration of a Client/Server program using the TCP/IP protocol [6]. Programming this application could be complicated since the control of all the operations falls within the scope of the activities of the programmer; on the other hand, this programmer has the total control of the application and must do everything. The application has two parts: the client and the server parts. The problems with this strategy would be:

- Quality and maintenance of the application strongly depend on the programmer.
- All the security strategies fall on the programmer and this is a powerful and at the same time risky business.
- Any change in the hardware, in the TCP/IP protocol, the use of primitives, etc., will cause a change in the code.

- All of the above conditions advise us that the specific Client/Server strategy should only be used in specific and particular cases. [5]
2. Web Lab implemented as a Web application. Instead of designing a Client/Server application, where the programmer is responsible for everything, here the programmer must use as many of standard services offered by Internet as possible. Consequently, in this case the designer has the responsibility of building all the above mentioned services for the Web page, worrying about the users and their profiles instead of the services associated with them. The quality of these services is the responsibility of the operating system or Internet [5].
3. Web Lab implemented as a Windows Terminal Server. This strategy is based on the use of the Terminal Server facility of the windows operating system (or another similar application such as VNC) [7]. Under this strategy, the designer does not have to deal with the Client/Server communication, since it is done by means of the Terminal Service facility (or by means of the VNC application). The risk is evident: the student "could delete files" or undertake any hazardous action on the remote machine. However, the Terminal Server allows for the definition of user profiles [5].
4. Implementations based in real time distributed environments, for example, CORBA. The main advantage in this case is that we have at our fingertips the power of the CORBA environment, but perhaps this could be also a disadvantage [5].
5. Web Lab implemented based in Lab View. This is a widely used solution, and the main advantages are their power, knowledge and availability in university environments already oriented to the design on Web Labs. Its main drawback is that there is little free software available and the cost of it is really quite high [5].

From some strategy in building a remote laboratory that has been submitted, entirely computer-based server, where the investment cost hardware and software license and maintenance costs are factors that need consideration. Various technologies have been applied such as Sockets, Applets, Ajax, Corba, Lab View and others, each still has its advantages and disadvantages. There are several issues such as interoperability where systems run only on one platform, the issue of user friendliness that the user is still busy with the installation of several programs the client side, the issue of securities where a system requires a port other than port 80, the maintenance issues that require special skills, issues of scalability where the server only provides services on a single user at any given time [5].

From the problem above, to answer some of the issues that often arise in a remote lab, this research will be proposed remote labs based embedded web server. The advantages possessed by the system are the efficiency of cost and ease of installation process [8]. In addition, because of the embedded web server implementing the HTML programming for the entire process so the port used is port 80 only, so that would answer the issue of security.

II. DESIGN OF REMOTE LAB SYSTEM

This paper proposes a remote laboratory experimentation microcontroller system based embedded web server. Design of Remote Lab System Diagram is shown in Figure 1.
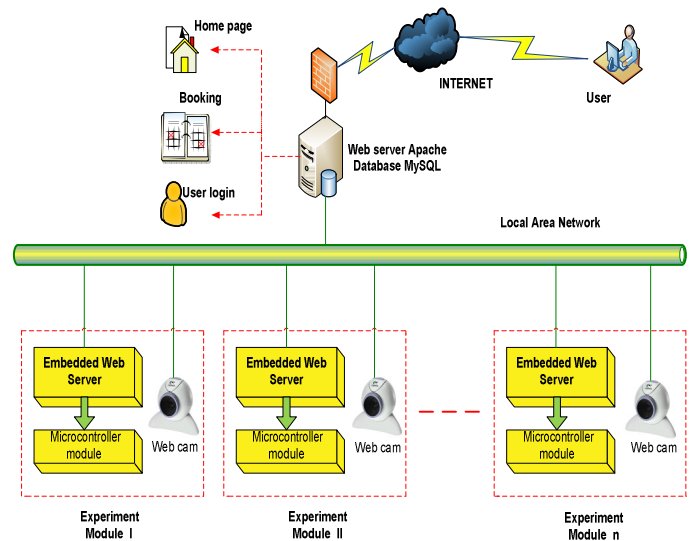

Figure 1. Design of Remote Lab System

Block diagram in Figure 1, consist of five major components: Web server as a remote lab gateway, internet, intranet network (LAN), a remote experimental module based embedded web server and remote client computer side. Number of experimental module that installed in the system can be more than one, so that the remote lab can be accessible by more than one user.

Web server remote lab gateway use program application Apache Web server and MySQL database server, two application is a freeware application that is widely used on web servers today. Applications can run on open source operating system and Windows operating system. The functionality of the web server is:
- Contains of a remote-lab Homepage, which provides information, tutorials and procedures for the use of remote labs.
- Contains a user registration services and booking process for the use of remote labs.
- Perform user authentication for remote access microcontroller systems module.
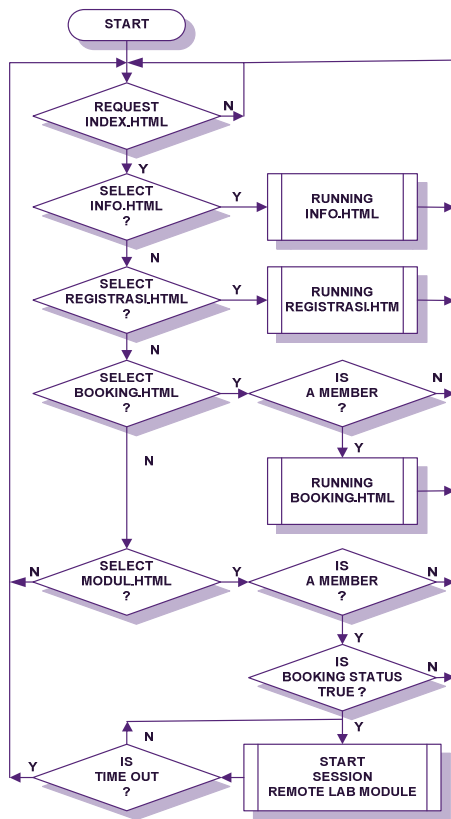
Figure 2. Flow Chart Remote Lab Gateway

Flow chart system is shown in figure 2. This can be explained as follows:

- If the user entered into the main web page (index.html), then the user will be faced with several choices of menus that contain information on general information about the remote lab and some tutorials procedures relating to laboratory microcontroller system.

- If the user selects the menu registration, the user must fill out the registration form as complete as possible and proceed with the click submit. The system will provide delivery confirmation via email to the user.

- Booking menu is the menu to reserve a place or time of execution of the microcontroller system lab. Booking menu can only be accessed if the user has become a member and login on to the system. In booking menu the user will determine the schedule of lab work that they want, because the remote lab is active for 24 hours. The process of untimed practice for 2 hours for each user. Menu module can be accessed by users who have become a member through the login process and already booking process to the system. If the requirement is true then the user has access to experimental module that has been provided. Users will enter into a web page from the Embedded Web Server and can perform remote process on existing equipment that is: start the upload binary files

to the target board, observing the changes via a web cam and can interact with the target board through a virtual I/O. The system will provide time for 2 hours and if you pass this time then the session will be closed.

III. DESIGN OF HARDWARE

A. Embedded Web Server

Embedded Web Server is built using 8-bit microcontroller MCS-51 family (AT89S52). AT89S52 facility consists of 8 Kbyte internal code memories, 256 Byte internal RAM, a 32-bit I/O, a serial port and a few interruptions hardware. Microcontroller system must equipped with an external supporting components that use external data memory (RAM) for 8Kbyte (6264), expansion I/O by using the PPI 8255, the LCD display as a monitor and RS232 chip to meet the needs of EWS. In addition, for the system to be accessed through computer networks will be needed serial to Ethernet converter, the system uses WIZnet WIZ110SR. Block diagram of the Embedded Web Server shown in Figure 3.
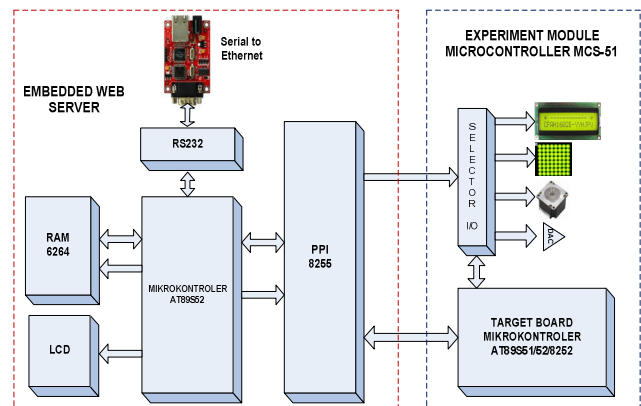

Figure 3. Block Diagram EWS and Experiment Module

B. Experiment Module

Block diagram of the Experiment module shown in Figure 3, consists of a microcontroller AT89S51/AT89S52 and comes with some equipment input output (I/O) for the learning process of programming a microcontroller such as ADC, DAC, LCD displays, stepper motors, DC motors, Matrix LED. Selector I/O function to select I/O device that will use the experiment, because the number of ports I/O microcontroller is limited so the use of the port should take turns and to control the selection of I/O can be performed by the user through the menu on web pages.

IV. DESIGN OF SOFTWARE

A. Embedded Web Server

The functionality of the Embedded Web Server in the remote lab system will be explained below:

- Serving the web service requests from a client, by accommodating the data sent by the client computer and translate that data with a parser program, then determine the instructions in the form of GET or POST. Response to the form of delivery to the client web page or activity changes in the I/O on the EWS.
- Accommodate binary files uploaded by the client and download the file to the target board in a serial (ISP).
- Providing a web page as a virtual input or output. As an example of a virtual input is a few buttons found on the web page, which can be used as a virtual keypad by the user in interacting with the target board.
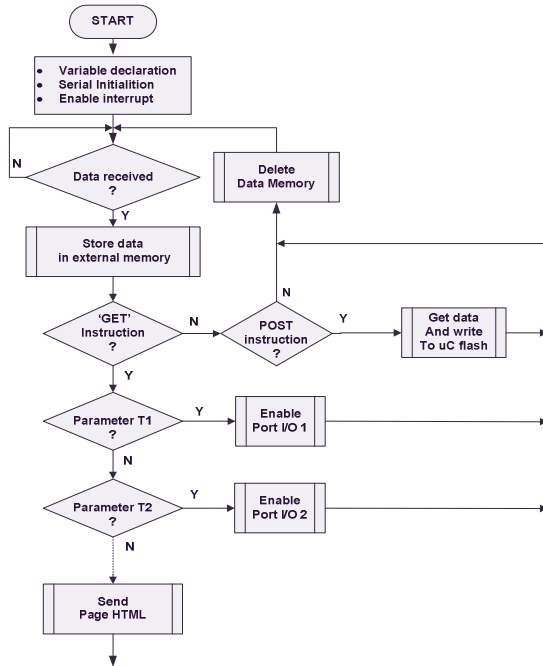- Controls the I/O selector on the target board.

Figure 4. Flow Chart Embedded Web Server

B. Target Board

The core of the target board is a microcontroller system AT89S51/AT89S52 which has facilities in circuit programming (ISP) for programming the internal code memory. Flash memory AT89S52 chips can be programmed approximately 1000 times. Flash memory programming process will be conducted by EWS if it receives a binary file from a client. Figure microcontroller AT89S52 ISP connection is shown in Figure 5.
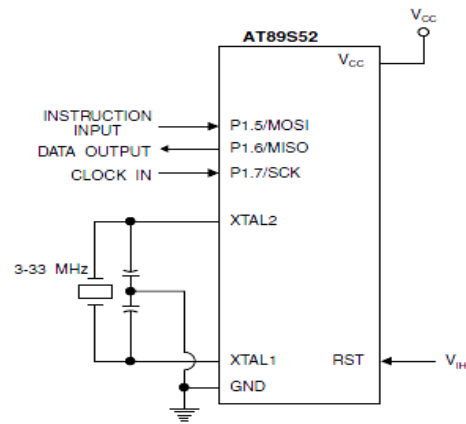

Figure 5. Flash Memory Serial Downloading [10]

The Code memory array can be programmed using the serial ISP interface while RST is pulled to V_{CC}. The serial interface consists of pins SCK, MOSI (input) and MISO (output). After RST is set high, the Programming Enable instruction needs to be executed first before other operations can be executed. Before a reprogramming sequence can occur, a Chip Erase operation is required. The Chip Erase operation turns the content of every memory location in the Code array into FFH. Either an external system clock can be supplied at pin XTAL1 or a crystal needs to be connected across pins XTAL1 and XTAL2. The maximum serial clock (SCK) frequency should be less than 1/16 of the crystal frequency. With a 33 MHz oscillator clock, the maximum SCK frequency is 2 MHz [10].

To program and verify the AT89S52 in the serial programming mode, the following sequence is recommended [10]:

1. Power-up sequence:
   a. Apply power between VCC and GND pins.
   b. Set RST pin to "H".
2. Enable serial programming by sending the Programming Enable serial instruction to pin MOSI/P1.5. The frequency of the shift clock supplied at pin SCK/P1.7 needs to be less than the CPU clock at XTAL1 divided by 16.
3. The Code array is programmed one byte at a time in either the Byte or Page mode. The write cycle is self-timed and typically takes less than 0.5 ms at 5V.
4. Any memory location can be verified by using the Read instruction which returns the content at the selected address at serial output MISO/P1.6.
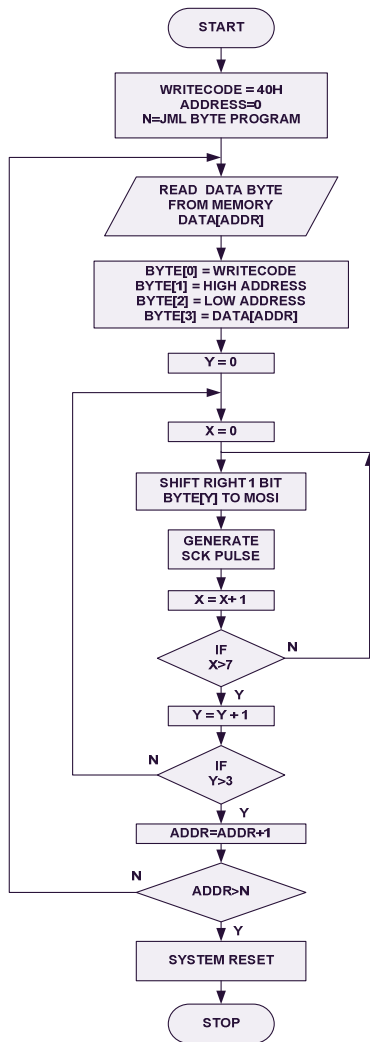5. At the end of a programming session, RST can be set low to commence normal device operation.

Figure 7. Flow Chart Flash Memory Programming (ISP)

V. CONCLUSIONS

The design of the system has proposed is expected to answer the issues that often arise in the implementation of the remote lab:

- Implementation of Embedded Web Server on the remote lab will provide advantages in cost efficiency because the required hardware and software is much cheaper than using a PC server, as well as the power needed is very small and the dimension of equipment are also smaller, easy installation and easy maintenance.

- Because the Embedded Web Server working with pure HTML instructions that opened the port is port 80 only, so that the firewall is safe.

- Remote labs are multiuser, so that at the same time can be used by more than one user; the number of users depending on the number of experimental module is installed.

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