

# Remote Laboratories Multiuser based on Embedded Web Server

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**Abstract**—This paper presents a new design of remote laboratory multiuser based embedded web server that is used for the lab microcontroller system. Architecture of Remote Lab System consists of a computer server, two experiment module microcontroller system and two embedded web server for controlling lab modules. The computer server is used as a web server remote lab 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. The novelty of the system proposed is the remote laboratory architecture is multi user, and embedded web server designed more intelligently that function as lab modul controller, such as ability to send log event data to database server and ability to send message to chat applications. This research activity has resulted a remote laboratory based on embedded web server, the system is multiuser so that at the same time can be used by more than one user. Test result, the system can work quite well.

**Index Terms**—Remote Laboratories, Embedded Web Server, Microcontroller

## I. INTRODUCTION

Remote labs is web-integrated systems that can be accessed through a unified interface by web browser[1]. By providing distance users a way to share resources and tool, they may cause cost reductions, and accessing some more specialized learning resources that not available locally [2].

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 for 24 hours. Remote laboratory created an autonomous learning [3]. Remote laboratory is also allows use by handicapped students, and support resource sharing and collaboration between laboratories [4]. 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[5].

From some strategy in building a remote laboratory that has been submitted, generally computer-based server, where the investment cost hardware and software license and maintenance costs very expensive. Various technology in webs programming have been applied to provide a comfortable environment remote laboratory, such as : socket, applet, ajax, corba, labview etc. [4].

Web technology based on embedded system grown rapidly in the post PC era. The application of embedded web technology in the remote monitoring system has given rise to changes in technology in the field of industrial control [6]. By implementing a web enable controller to the system can replace the computer as a web server, so it will lower the cost of system [7].

From the problem above, this research will be proposed remote labs based embedded web server. Embedded web server has many advantages, such as small size, low power consumption, low cost and flexible designed. In short, it's easy to implement, and it is an effective way of leading Internet into embedded system[8].

## II. DESIGN SYSTEM

### A. Design of Remote Lab System

Design of Remote Lab System diagram is shown in Figure 1, the system consists of a computer server, two experiment module microcontroller system and two embedded web server for controlling lab 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.

Design an embedded web server using 8 bit microcontroller AT89S52. Embedded web server use the HTTP standard protocol to transmit web pages from the embedded system to the web browser, and to transmit HTML form data from the browser back to the device. The devices require a network interface such as Ethernet or RS-232, TCP/IP software, embedded Web server software, and the Web pages (both static and generated) that make up the device-specific GUI.

Embedded web server main function is to control the experiment module and as an interface between the user and experiment modules. Additionally Embedded web server can sending log report to the database server and sending a message to the chat application.

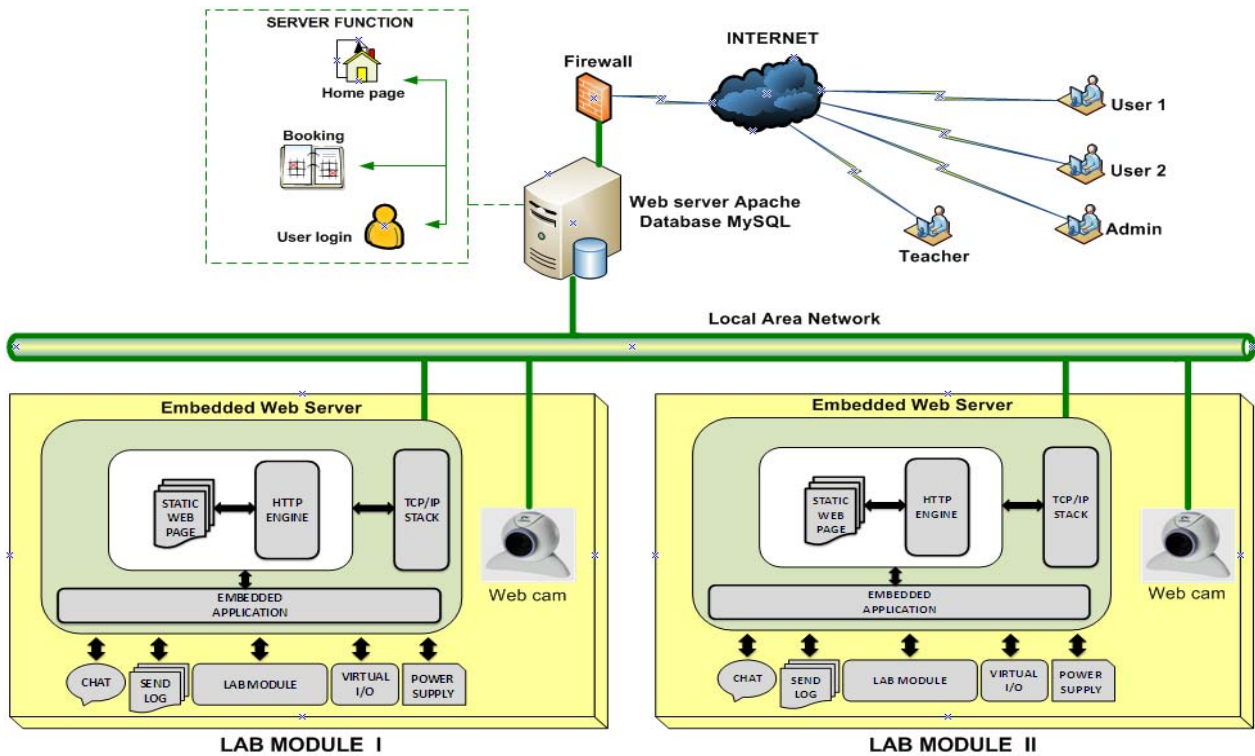


Figure 1. Design of Remote Lab System

B. Use Case Diagram

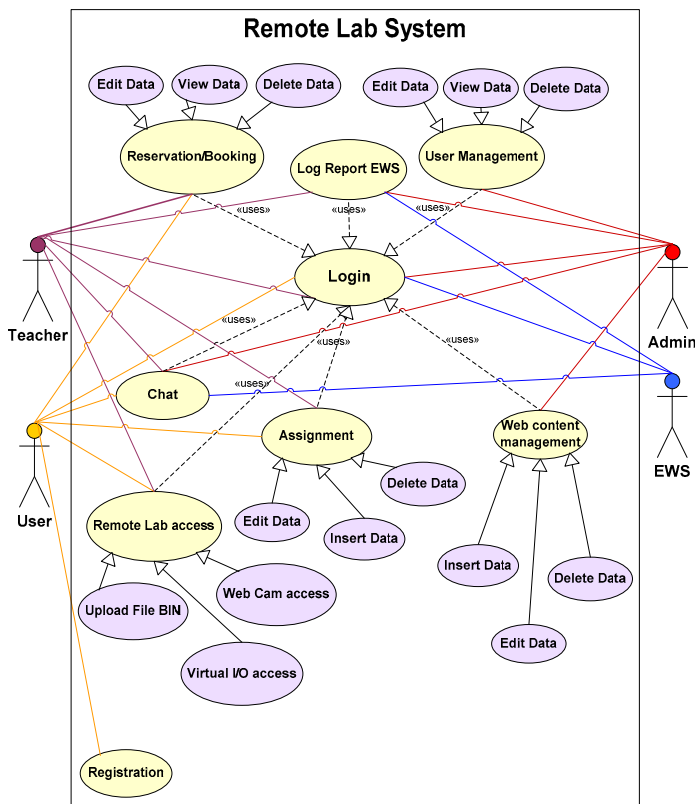


Figure 2. Use Case Diagram

Use case modeling for the behavior information system to be created. Use case describe an interaction between one or more actors with the information system is planned. Planning a remote lab system can be described by use case diagram in Figure 2. There are two main components, namely the use case diagram defining the actor and use case. Actors are people, process or other system that interact with information systems. Use case is the functionality provided as a system of units exchanged informations.

Description of the definition of an actor in a remote lab system can be described as follows:

1. Admin is an actor (person) in charge and have access rights to perform operations user data management, web content management, log embedded web server (EWS) data management, and can communicate via a chat application with remote lab users.
2. Teacher is actor (people) who have access rights to perform operation management tasks (assignment), view the EWS log report, can also perform remote lab access operations for the purpose of learning. Teacher can also communicate with the user and admin via a chat application.
3. Users are actors (people) who have access rights to perform operations remotely access the lab with the requirements to register first and charging assignment given by the Teacher. Users can also communicate with the Teacher and Admin via chat application.
4. EWS is an actor (system) who have access rights to perform of sending event log to the database server, and capable of sending log messages to the chat application.

Description of use case definition in the remote lab system can be described as follows:

1. Login is the process of checking user permissions, which serves to select who has access to system functions on the remote lab.
2. User management is a process for the management of user database which includes edit data, add data, view data and delete data.
3. Web content management is process for managing remote lab web content include edit content, add content and delete content.
4. Registration is the process for adding new user data that will be using a remote lab.
5. Reservations is the process of booking time for the lab activities, including the insert data, edit data, delete data and view data.
6. Assignment is a process to manage the practical assignment given by teacher include add data, edit data and delete data. In addition it is also used for the user to submit the practical assignment.
7. Remote Lab access is a process to access the lab module includes a binary file upload, access virtual I/O and access the webcam.
8. Chat is a process for communication between actors, the chat application will be active if you do the login.
9. Log EWS report is a process to store and display the log event data sent by the embedded web server.

C. Activity Diagram

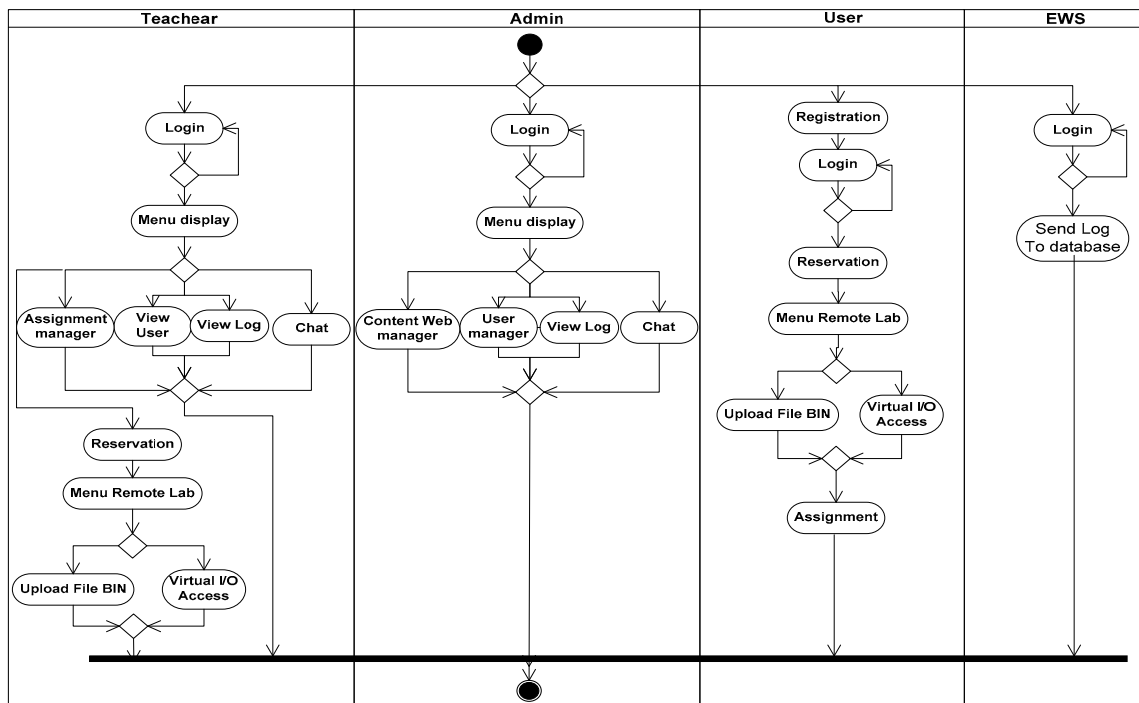


Figure 3. Activity Diagram

Remote lab system activity diagram shown in figure 3. In the activity diagram is divided into 4 parts (swimlane) according to the number of actors involved in the system.

D. Deployment Diagram

The design of the deployment diagram is shown in figure 4. Deployment diagram showing the configuration of components in the execution of the application. The diagram consists of three packages, namely client, server and remote lab. The client package contains one node is a web browser application, server package consists of two nodes, namely node Apache web server and MySQL database server node, remote lab package consists of two nodes, namely node node embedded web server and lab modules.

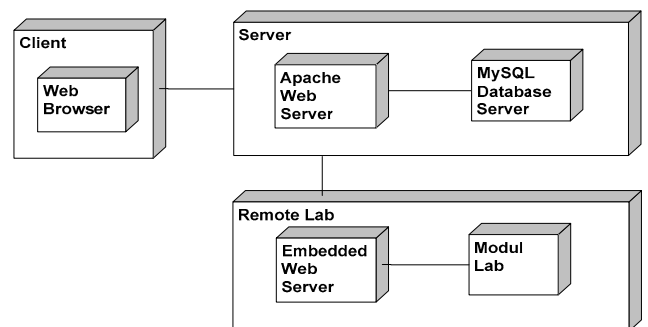


Figure 4. Deployment Diagram

### 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 memory, 256 Byte internal RAM, a 32-bit I/O, a serial port and a few interruptions hardware. To meet the needs of the EWS software then microcontroller system equipped with an external supporting components that use external data memory (RAM) for 8Kbyte (6264) and RS232 chip. 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 5. following.

#### B. Experiment Module

Block diagram of the Experiment module shown in Figure 5., 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 , LCD displays, stepper motors, and display LED. Input port facilities are provided in the form of the 4 virtual keypad input, generated by the embedded web server. A virtual keypad button keys displayed on web pages EWS.

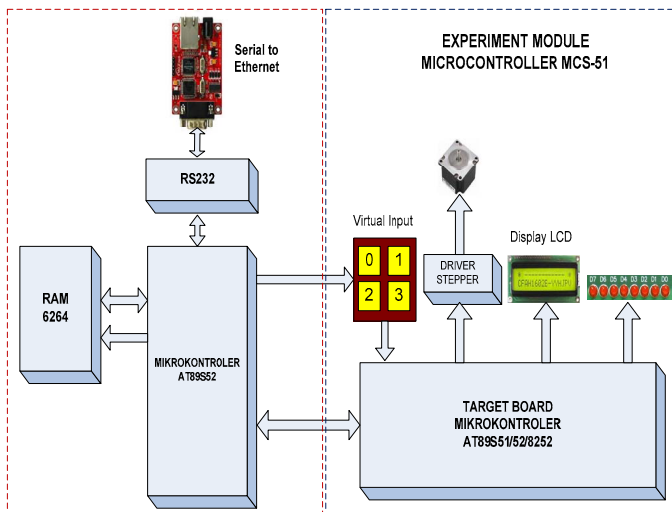


Figure 5. Block Diagram EWS and Experiment Module

### VI. 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 and translate that data with a sentence 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 . 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.

The flow chart of embedded web server shown in Figure 6.

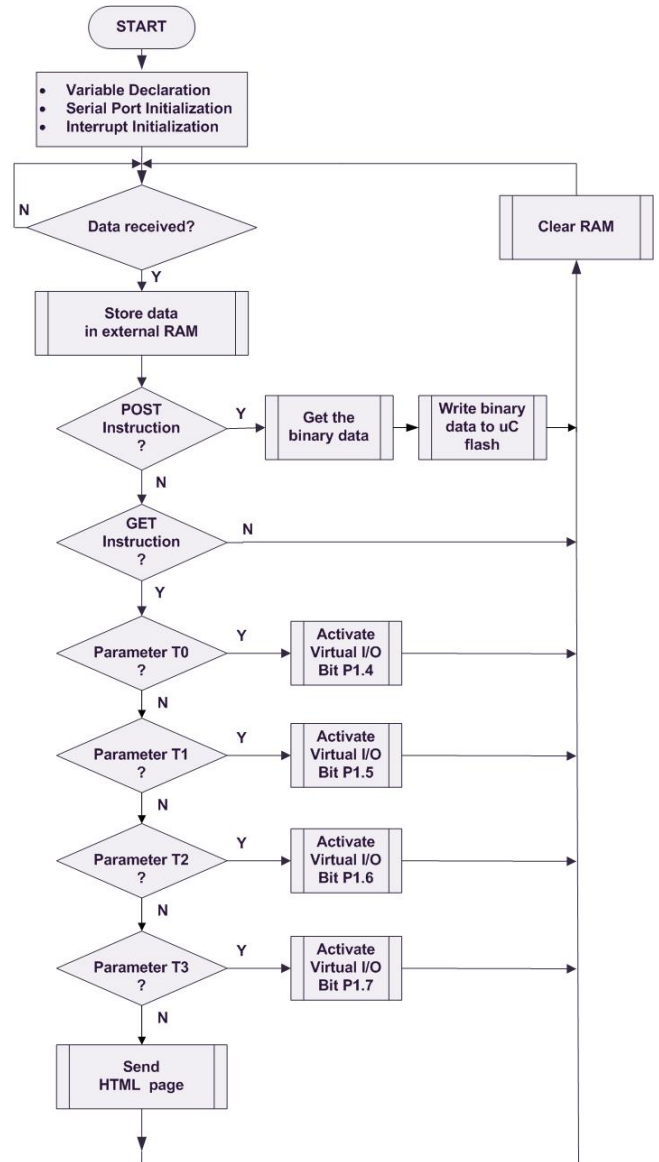


Figure 6. Flow Chart Embedded Web Server

#### 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 receive a binary file from a client. Figure microcontroller AT89S52 ISP connection is shown in Figure 7.

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 [9]. Timing Diagram Flash Memory Downloading shown in Figure 8.

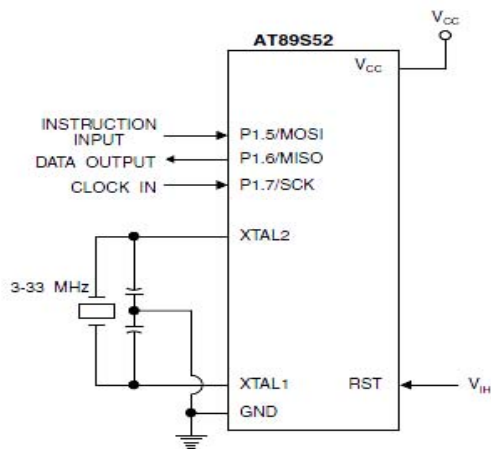


Figure 7. Flash Memory Serial Downloading [9]

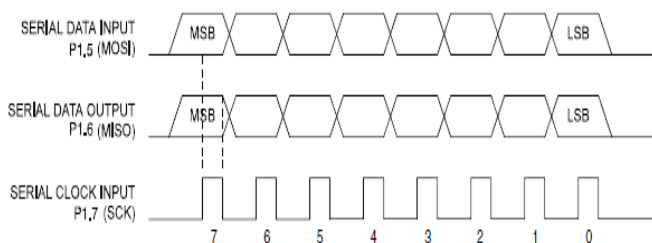


Figure 8. Timing Diagram Flash Memory Downloading [9]

Flow Chart Flash Memory Programming (ISP) shown in Figure 9. To program and verify the AT89S52 in the serial programming mode, the following sequence is recommended [9] :

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.

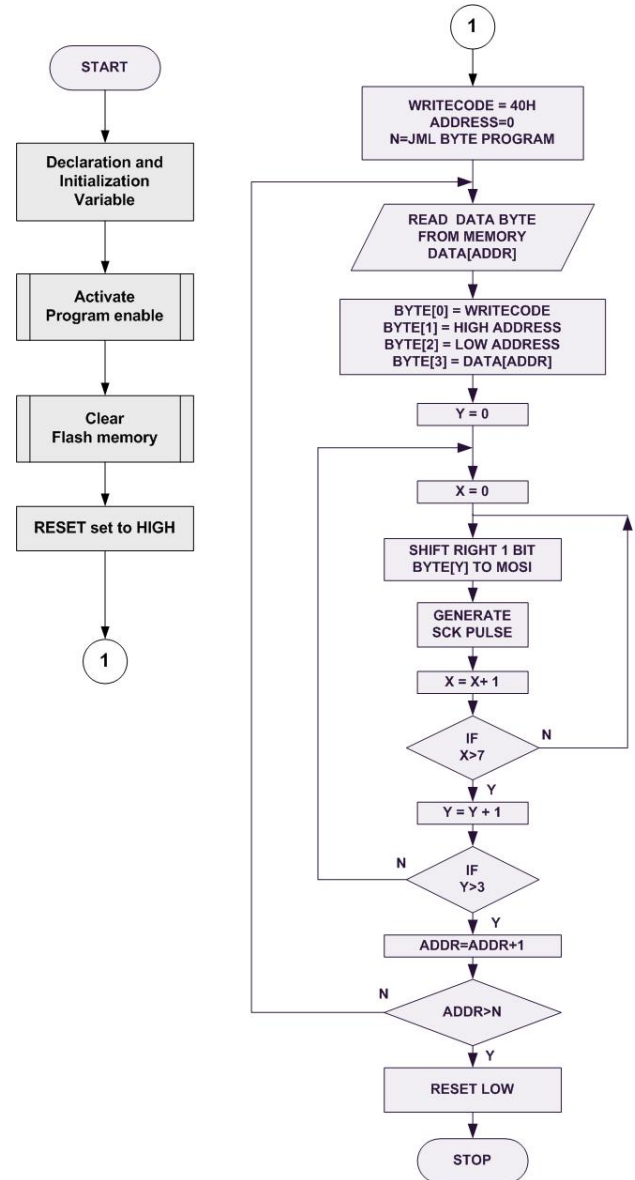


Figure 9. Flow Chart Flash Memory Programming (ISP)

## VII. RESULT AND DISCUSSION

This research activity has resulted a remote laboratory multiuser based on embedded web server used for MCS-51 family microcontroller system experiment. In a remote lab design, a prototype is limited only consists of two lab modules, so that at the same time there are only two users can access the lab module simultaneously.

Each user must register and reservations to be able to access the lab module. After the successful login, the user can perform flash memory microcontroller programming remotely and can interact with the

microcontroller using the virtual I/O are provided. User can observe the changes of the I/O module lab through streaming video sent by the IP Cam. Each user can access the lab module for 2 hours. System provides a chat application so that users can perform communication with another user, a teacher or administrator.

Testing of embedded web server provides the results of an embedded web server that can run well on some kinds of web browsers such as Mozilla Firefox, Internet Explorer, Google Chrome and Opera.

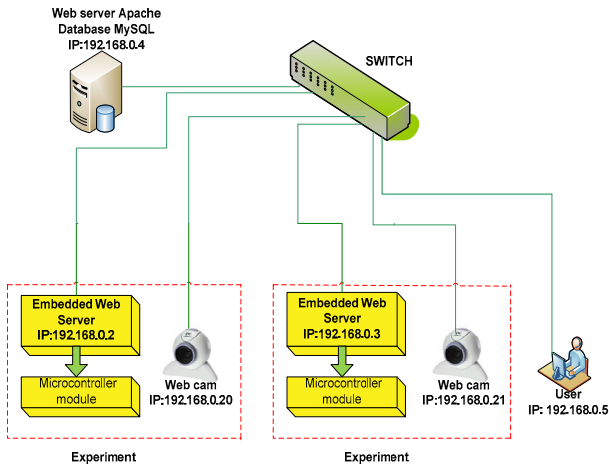


Figure 10. Testing Diagram



Figure 11. Remote Lab System photo

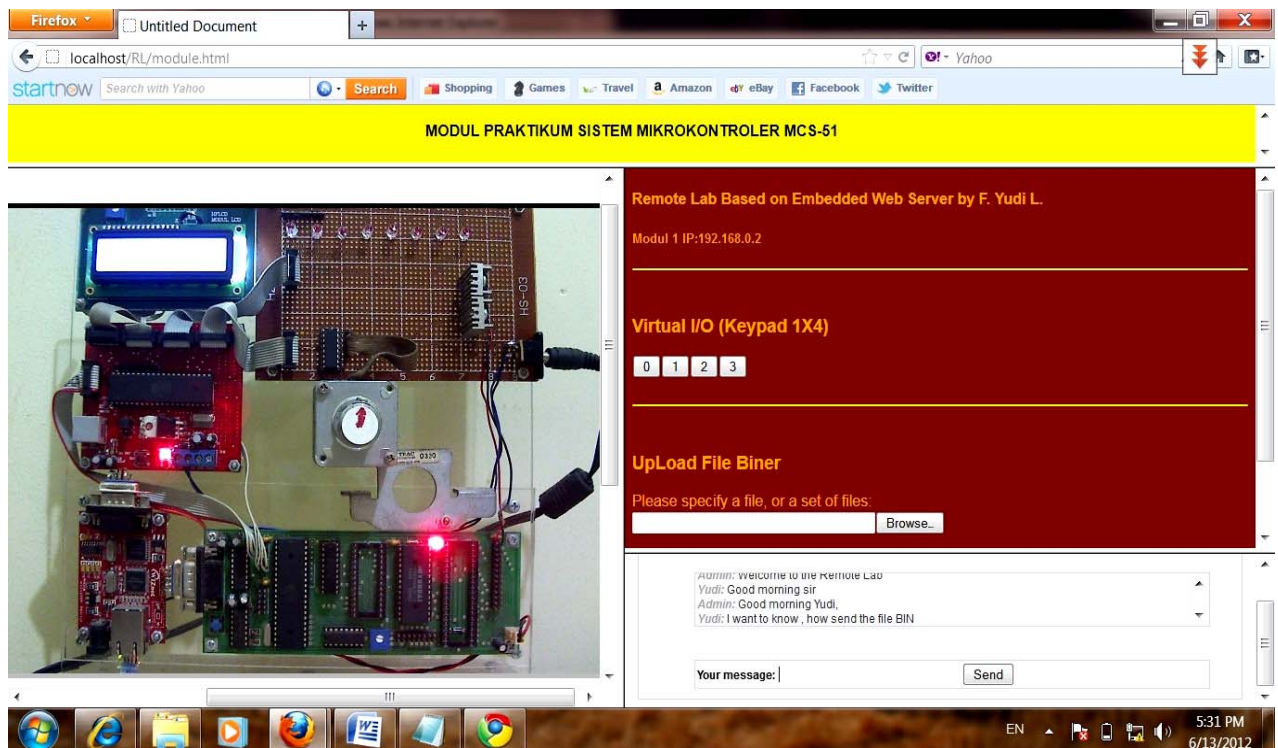


Figure 12. Display Web Remote Lab Test Result

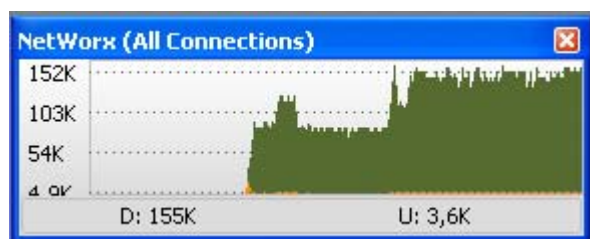


Figure 13. Bandwidth Test

### VIII. CONCLUSION

Embedded web server can replace the task of computer server to control the remote lab system, with the ability and performance not inferior to a computer server. The intelligently embedded web server has designed, contribute to the operation and monitoring of the remote laboratory much easier, and more efficient in cost, power and dimension.

### ACKNOWLEDGMENT

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