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DESIGN & IMPLEMENTATION OF A WIFI BASED SMART HOME SYSTEM USING LPC1769

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Abstract— This paper presents a design and implementation of new smart home system that uses Wifi technology as a networking solution connecting its parts. With the development of ubiquitous computing, smart home services will no longer be limited within the house limits, but also the extends throughout the geographical constraint, and the service will support the activities of each and every member of house even out of home. The proposed system consists of three main parts- Intelligent monitoring and control module, web server and control device. Using the system user can monitor the status of smart appliances, control the power status of smart appliances, and control the device status according to the particular device configurations. By the control device (smart phone) with Wi-Fi, the user can control the working status of smart appliances. The system consists of a Web-server based on PHP, intelligent monitoring modules using an LPC1769 and the Android compatible Smart phone app. The proposed system is extendable since it allows configuration of new devices.

Keywords—- Smart home, Wifi, LPC1769, Android smart phone, Web server, HTTP, Web pages.

1. INTRODUCTION

Home automation has an important role in today's human life and it improves the quality of people's life by facilitating a comfortable and safe environment. In international markets Internet based home automation systems is one of the most popular system. This paper presents a low-cost internet based Smart Home System, which uses wifi technology for communication and an Android based application for control of home appliances. With the help of Smart home system the user can supervise household appliances remotely and realize real-time monitoring of home security status through mobile phone. Users can exchange information with home appliances and can monitor and control equipment to perform their command remotely.

This system uses android smart phone to monitor and control the various house parameters given its advantages over using a dedicated pc. Wifi technology is used as the network infrastructure for communicating between the different parts as there are advantages of high reliability, easy configurability, system extendibility and good adaptability. The home appliances are connected to the basic I/O ports of the embedded system board and their status is continuously updated to the server. Authentication techniques are implemented so that only authorized user can access home appliances. The core component of the system is an ARM Microcontroller. Android is open source software and provides access to lots of useful libraries and tools. The application and system is completely user friendly. Any smart phone user can easily run the application in his/her mobile without any prior training. The designed system has the option for adding more relays to get control over more appliances if he/she wants. So altogether the system is a modern smart home system which can give us the experience of smart living. The system updates the household data to the remote server, allowing the user to control the household devices easily and remotely.

Section 2 gives an overview of the proposed system, its architecture, the technologies used and why they are chosen. Section 3 discusses about the design and implementation of the system from both hardware as well as software point of view.

2. SYSTEM OVERVIEW

The structure of the system and the related technology are described in fig.2.1

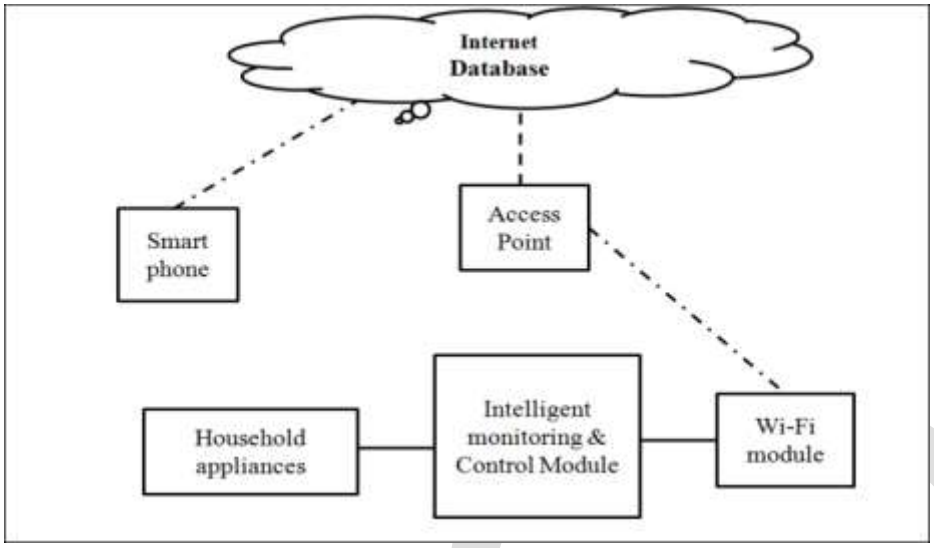

Fig 2.1: Basic block diagram of Smart home system

The system includes main control devices such as mobile phone, wireless communication system, intelligent monitoring terminal, a web server. Users can log on through the main control equipment and send commands to control household appliances, look up the state of household appliances. It is the core of the whole system to download control data from the database by phone, and then send them to the smart appliances.

The proposed system is a distributed home automation system, consists of web server, intelligent monitoring and control modules and control devices. Intelligent monitoring and control module is an ARM microcontroller to whose input/ output ports the different home appliances are interfaced. For embedded networking the controller is interfaced with a wifi module via UART which can access internet through a central access point. Web server can be easily configured to handle any number of intelligent monitoring and control module. The intelligent monitoring and control modules in turn control its alarms and actuators according to the control information passed from web server. Server used here is an apache web server. The web server software is developed using PHP technology. System can be accessed from the web browser of any local PC in the same LAN using server IP, or remotely from any PC or mobile handheld device connected to the internet with the android application installed in it.

Wifi technology is selected as be the networking implementation that connects between web server and controller modules. Wifi is chosen to improve system security (by using secure Wifi connection), and to increase system mobility and scalability. Even if, we need to add new intelligent control modules out of the coverage of the central access point, the problem can be solved by adding repeaters. The main functions of the web server are to manage devices, control, and monitor system components that enable intelligent control modules to execute their assigned tasks (through actuators).

The serial communication interface UART is used for transferring data between ARM controller and Wi-Fi module. UART interface provides the advantages like less cost, simplicity and is highly reliable for data transfer between controllers. UART is an abbreviation of universal asynchronous receiver and transmitter which is usually used in conjunction with communication standards like RS-232. UART takes data in bytes, and using the internal 8 bit shift register converts the data into parallel form and then transmits the individual bits sequentially. For fast processing, most UART chips have a built in buffer which is 16 to 64 kilobytes in size. This buffer is used for caching data that is coming in from the system bus while the data that is going out to the serial port is still being processed. The concept of Flow control is a very important aspect of serial communication. It is the capability of a device to tell another one to stop sending data for a certain time. The commands Request to Send (RTS), Clear To Send (CTS), Data Terminal Ready (DTR) and Data Set Ready (DSR) is used to enable flow control. The UART is an asynchronous mode of transmission that is no clock signal is transmitted between the sender and receiver, instead the communication configuration (baud rate, number of data bits, parity bit present or not, number of stop bits) is agreed in prior to the transmission and special bits are transmitted for achieving synchronization. LPC1769 provides Four UARTs with fractional baud rate generation, internal FIFO, IrDA, and DMA support. To do the UART programming, we basically need to do two things. First we need to set up the UART and then provide an interrupt handler function to specify what to do when there are data bits to be received, when transmit buffer is empty and when errors occur.

On power on the wifi module scans accessible channels to detect active networks in areas where beacons are located for transmitting. A network is then selected which will be in ad hoc mode. After this section it verifies itself with the access point (AP) and joins it. Even though a station is already a part of a network it still tries to detect new networks and the reason for such behaviour depends on the willing to associate with the strongest signal and if this occurs the current network disconnects itself and joins the new network. Power in Wi-Fi stations can be saved by setting a station in to sleep mode. Wi-Fi devices can be at two different state and those are awake or doze. When a station is located in doze state it cannot transmit or receive. The power consumption is then reduced at this state. The power management is handled by two modes in Wi-Fi devices and these are active mode (AM) and power save (PS) mode.

The basic communications that take place in the system is as shown in fig 2.2

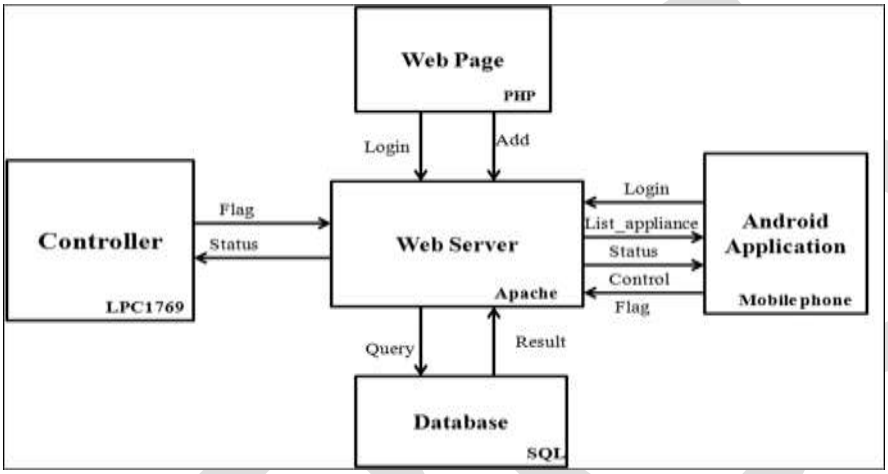

Fig 2.2 Basic communications in proposed system

The microcontroller will interact with the web server repeatedly over a fixed interval of time and check for any updates. If a user logs in to the server via android application he can access the appliances under his ownership and change its status. Once the power state of an appliance is updated by the user, a flag will be set for the corresponding house in the database. The microcontroller will be continuously checking this flag. When it reads the flag status as set, the microcontroller will retrieve the power status of appliances. This will be received in JSON format. The embedded software will decode the JSON encoded data and tabulate the power status for each appliance. Then it will send control signals to the output ports to make the corresponding changes to the actuators. A webpage interface is also provided with administrator permission.

3. PROPOSED SYSTEM DESIGN AND IMPLEMENTATION

As mentioned earlier the smart home system consists of mainly three modules- intelligent monitoring and control module, the web server and the control module (Android mobile phone). Let's see each in detail.

I. A. CONTROLLER DESIGN

The microcontroller used is LPC1769. It is an ARM Cortex-M3 processor, running at frequencies of up to 120 MHz. The LPC1769 microcontroller is interfaced with a wifi transceiver module (ESP8266) for enabling wifi access to the embedded system. UART interface is used for data transmission between both devices. Then for the communication to work both devices have to agree upon a baud rate. Baud is a measurement of transmission speed in asynchronous communication. Once the UART registers are set and baud rate is agreed we can start transmission between the wifi module and microcontroller. For viewing the transmissions and receptions here I have used another UART port of LPC1769 and microcontroller. For viewing the transmissions and receptions here I have used another UART port of LPC1769 and connected it to a terminal program in a personal computer. For this we have in-built facility in LPC1769 trainer kit. The FT232R in the trainer board is an USB to serial UART interface and it is made use of for this purpose. Then the code is edited such a way that all the transmissions and receptions gets printed to the PC so that could be kept track of.

An access point for internet is set up, secured with WPA/WPA2 PSK and configured with an ssid and password. Microcontroller is embedded with code to set up the wifi module, connect it to the internet via the access point and access a web page. It makes use of HTTP requests such as GET, POST etc

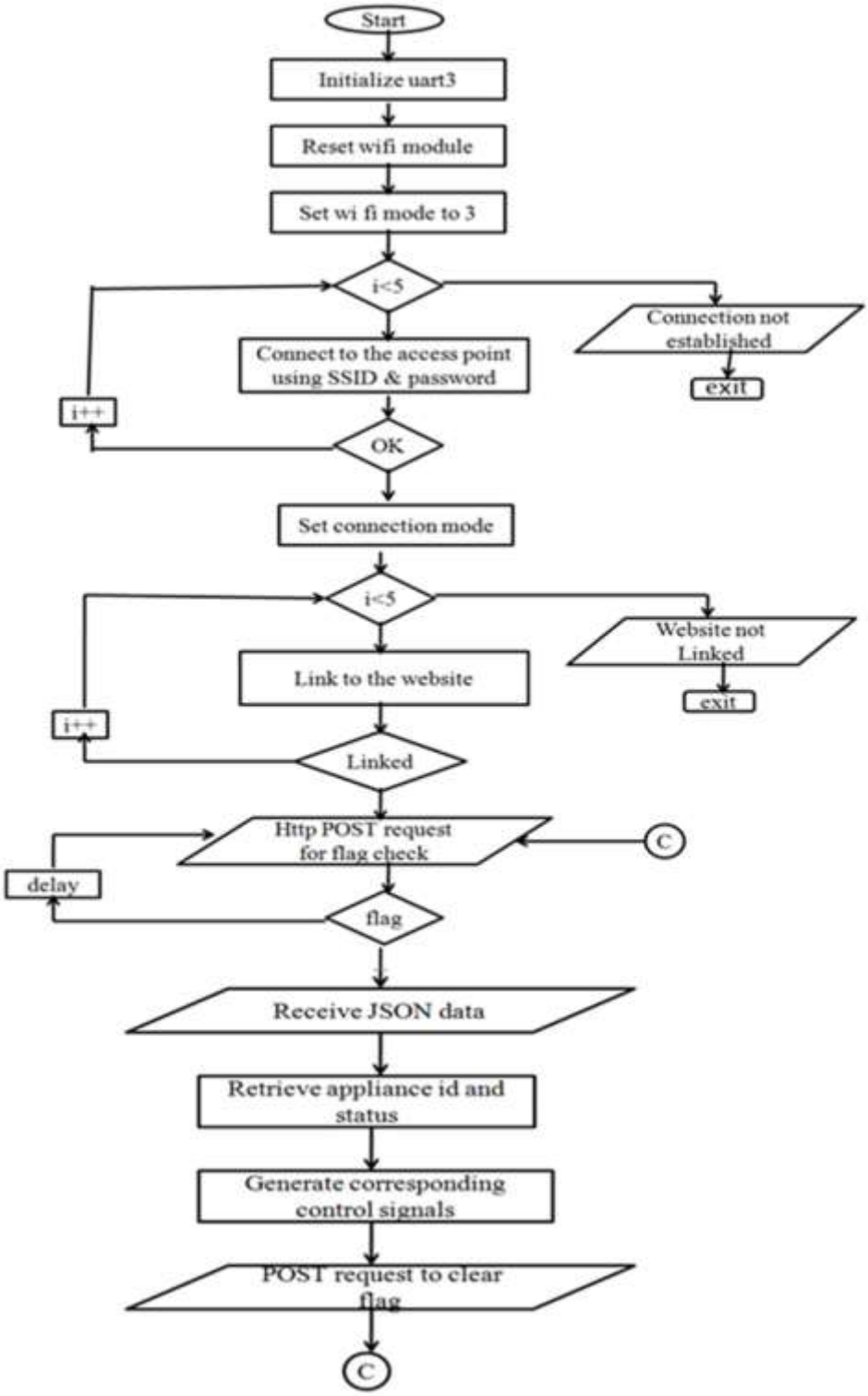

Fig 3.1: Embedded software

Fig 3.1 shows the flowchart for the embedded software for hardware interface module. The required UARTs are initialized. Then the baud rate is set. The wifi module is set up for its operation by sending AT commands. Once the wifi module establishes connection with the internet using HTTP request methods command is send to link with the URL of our web server. Once the server gets linked the code will jump into a continuous loop for checking the update flag. If the flag is clear it will wait for a delay and continue the process. If the flag is set, it will retrieve the appliance status from the server; make corresponding updates to the actuator ports. Then command is send to clear the flag and the flag checking loop is entered again.

B. SERVER DESIGN

The server is designed in PHP using XAMPP Version: 5.6.3. It consists of an Apache module and mySQL. The database structure is defined and corresponding tables are created in mySQL. It consists of tables for maintaining information on- Access key, User, House, Ownership, Appliance, Device state list. Queries are written in SQL for serving the mobile application(Login, Logout operations, API key generation, List houses and appliances, Update status and set flag), embedded controller(Status update and flag check, Clear flag) as well as the webpage (Administrator login and logout operations, Add, remove or edit user/house/appliances/ownership/device states).

An additional webpage interface is also provided for the web server with only administrator permissions. Administrator; who will control the access and permissions policy of the system, and can add and delete user accounts, anything that a general user can perform, the administrator can also perform. The web page is created using PHP,

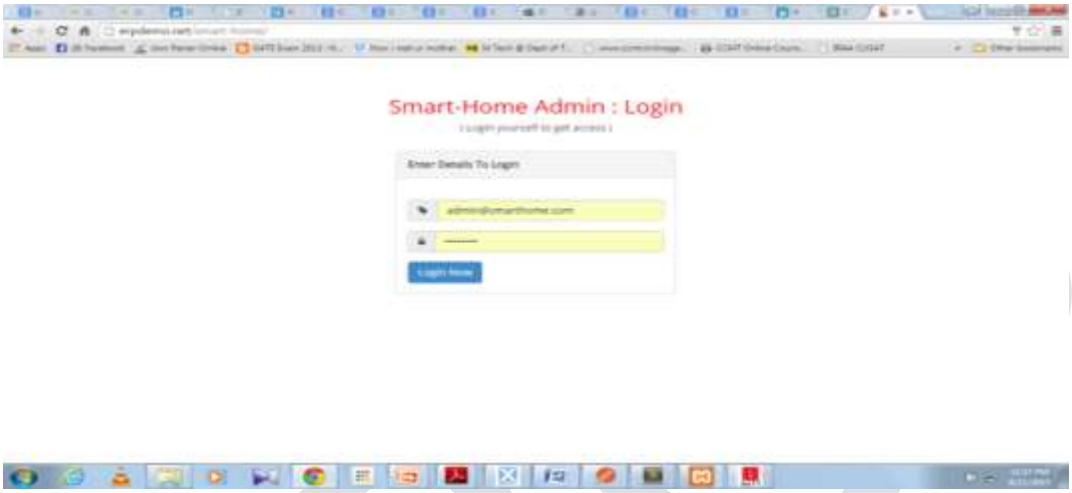

Fig 3.2 Login of web page

C. ANDROID APPLICATION DESIGN

The Android application is designed using Eclipse Juno IDE. Android is an open-source development platform for creating mobile applications. Android applications consist of loosely coupled components. An application manifest bounds these components and describes each component and their interactions with each other. Every Android project will consist of a manifest file named AndroidManifest.xml, and will constitute the basic building block of project. We should also create user interfaces for the application that are stylish at the same time easy to use.

The Android application opens to a login screen consisting of fields for username and password and a login button. For secure access md5 password encryption is used. On pressing the login button the data entered in fields will be send to the URL for web server. If the username and password matches with the data in the database, access will be provided and the user will be logged in. Once the user logged in, it will retrieve the houses owned by the user from the database and display it as shown in figure 4.4.1. The user can select the house by clicking on it. Once a house is selected it will list the equipments under the house name along with a toggle switch for power on and off. It will also list the device state. This can be used to switch on and off the appliances and also for changing the device states. For example, the different device states for a light are dim and bright.

Fig 3.3 GUI for Android application

5. CONCLUSION

In this paper, a wifi based smart home system which can be controlled remotely using an android application is proposed and implemented. The security of the system is ensured by user authentication and encrypting. The hardware interface module is implemented on an ARM controller. The Android based smart home app communicates with the web-server via internet. The smart home app can be installed in any android devices, and control and monitor the smart home environment. The android application consists of a user friendly GUI which makes it convenient to use for anyone. Addition or removal of new devices made easier with the help of a web interface. A low cost smart home system has been developed which eliminates the requirement of a dedicated PC as processing operations are done by the microcontroller. Presently the system is implemented with a single hardware interface module but the server is designed such that it can be handle more number of modules.

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