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Real-Time Monitoring and Controlling of Remote Electrical Device Using Microcontroller and Android Smart Phone via Internet

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ABSTRACT
Smart phone can provide a vital role for controlling remote electrical devices easily. This paper represents a system to control household appliances (e.g. lights, fans, pumps, AC, etc.) by using Android smartphone via internet from any place in the world. This system includes an Android application, a microcontroller (ATmega8) with a Bluetooth module (HC-05) and a cloud-based application to provide an easier access to the remote electrical devices to the user. The cloud-based application also includes a logging facility to allow only authorized users to control the electrical appliances. We have tested the system in an Android smartphone running on Android 4.2.

Keywords: Android, Cloud computing, ATmega8, Real-time.

1. Introduction
With the advancement of technology and the continuous improvement of people's living standard, people are in pursuit of automated, intelligent, and convenient home control systems. Home automation is one of the most exciting developments in technology for the home that has come along in recent years. It is mainly the automation of the home, housework, or household activity. It may also include centralized control of lighting, heating, ventilation, and air conditioning of appliances, and other systems to provide improved convenience, comfort, energy efficiency, and security. It can be helpful to the people to access home appliances while away from their home and can incredibly improve the lives of the disabled. The home automation systems can be separated into two categories: locally controlled systems and remotely controlled systems. Locally controlled systems allow users to control their system from within their home via a stationary or wireless interface. Remotely controlled systems allow the users to control of their system from their mobile device, personal computer, or PDA via internet. Because of the popular usage of computers and high share rate of smart phones in the market [3], computers and Android smartphones are mostly chosen to design the home automation systems. However, there are some problems in the computer [1] monitoring system, such as inconvenience to carry, high cost, limited monitoring range and so on. Therefore, it is a good choice to design a system based on mobile phone. With the rapid development of 3G wireless technology and a variety of smart phones, smart home is no longer confined within the house. With smartphones based on Android platform [2] and mobile internet, people can monitor and control the home environment wherever they are.
Electrical safety and warnings were always a matter of great concern during the utilization of home appliances. Some people are not aware that without carrying out a safety inspection based on the visible indication could initiate fault and produce an electrical hazard. Any unusual electrical condition can occur due to certain fault conditions, for example- overloaded circuit of the appliance, damaged insulation, and misused of extension cords. Therefore, it is necessary to monitor the condition of appliances whether being at home or away. The internet based home automation system with real time monitoring facility can be much helpful to solve such problems.

In this study, we have developed a smart home monitoring system for monitoring and controlling electrical appliances in a residential environment. With this system, it is possible to check the real time status and control the electrical appliances via laptop, PDA (Personal digital assistant), mobile phone, or web interface. The system intelligently controls power consumption of all appliances connected to the smart home network, also contributing to energy savings in the household.
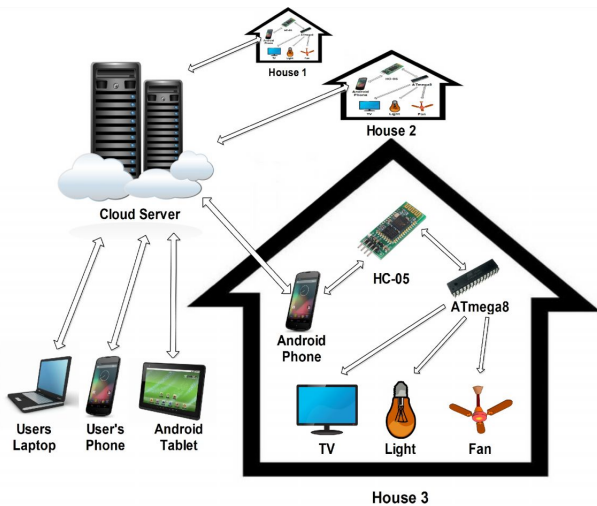
2. Working principle
This system includes two Android smart phone, a microcontroller (ATmega8), a Bluetooth module (HC-05), five relays, a Cloud-based application, and an Android application. This Android application has two options, Device side, and User side. User can control the remote electrical appliances by using the Android application or by using the web interface of the smart home automation system at anytime from anywhere of the world via internet. For this privilege, an active data connection is required in user's phone. User can also use this facility through laptop, tablet, or desktop computer.
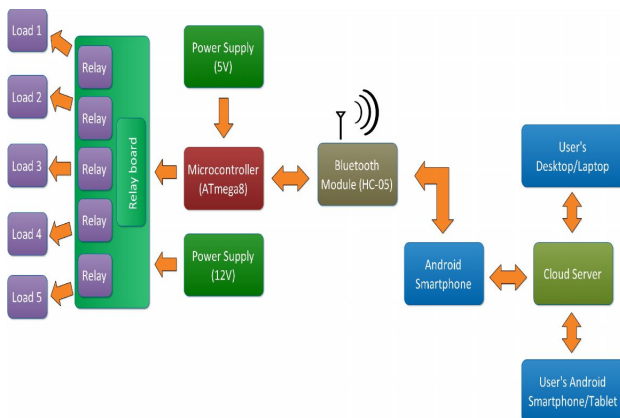
The working steps of the system are given below.

   1. When user touches on the icon of one or more electrical devices in the Android application to make it ON or OFF, the application sends a data to a particular server [7]. There is a web interface and a cloud based processing system in the server. For monitoring and

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controlling the electrical appliances through laptop or desktop user needs to visit the system's website [8]. After successful login to the website, user can see the real time status of the electrical devices. Then the user can easily turned ON or OFF the electrical appliances according to his/her needs.

2. When the server receives data from the phone or command in the webpage, it sends a data to the Android phone, which is connected to the system at home via internet.

3. Receiving the data from the server Android smartphone transmits the data to the microcontroller via the Bluetooth module (HC-05).

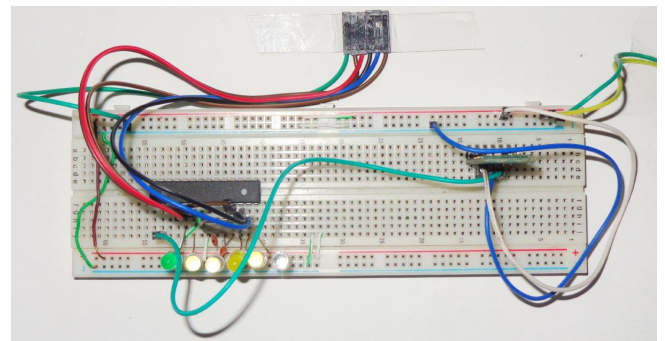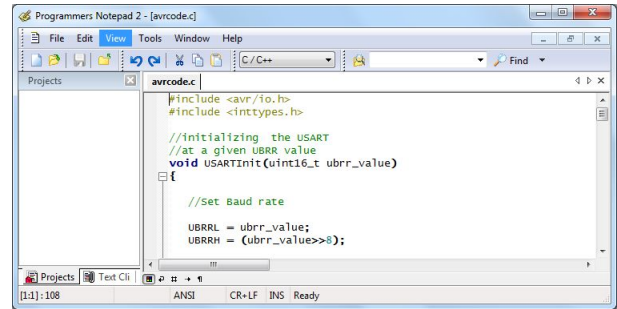4. Then the microcontroller will turn the electrical appliances ON or OFF according to the data.

5. The microcontroller receives the present status of the devices via ADC (Analog to digital converter) and sends it to the server via Bluetooth module, Android phone, and internet [9]. Application installed on the Android phone or tablet checks the status of the device in a time interval by connecting to the server.
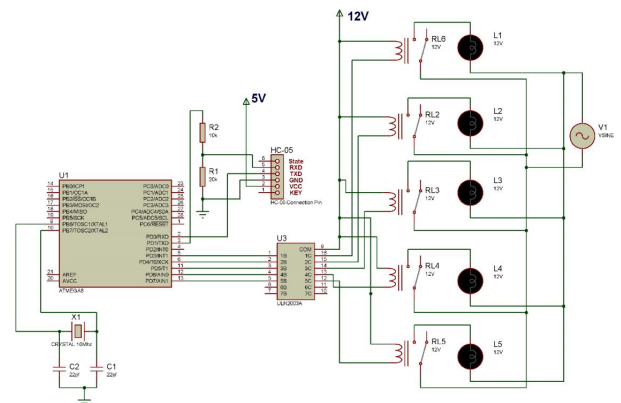

Fig.1 Operational diagram of the system.

3. Functional block diagram
Based on the working principle described in section 2, Fig. 2 shows the functional block diagram of the entire system.

Fig.2 Functional block diagram of the system.

4. Hardware design and implementation
The main hardware components that make up the smart home automation system are Android smartphone and the microcontroller board. Other components are Bluetooth module and relays. These components are connected to the microcontroller board. We have implemented the code in C programing language by using WinAVR.

Fig.3 Coding of microcontroller program using WinAVR.

Fig.4 Experimental setup of the microcontroller board.

4.1 Microcontroller Board
An ATmega8 microcontroller does the operation of making the devices ON or OFF. A Bluetooth module (HC-05) is connected to the microcontroller, which communicates with the Android phone [4]. From the Android phone microcontroller gets the command for switching the device ON or OFF.

Fig.5 Circuit diagram of the microcontroller board.

4.2 Relay board

In relay board, there are five relays for five electrical appliances [10]. A 12V dc power supply is given to the relay board.
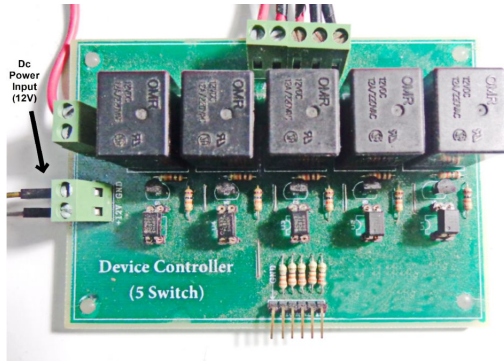

Fig.6 Relay board layout.

5. Software design and implementation

Android being truly open, developers can easily develop their required application on this platform. Developers are provided with four development components of Android: Activity, Service, Broadcast Receiver, and Content Provider [6]. Besides, Android uses XML document to design user interface, which helps the developers to design the application very easily. With the MVC (Model view controller) pattern, Android implements separation of the user interface design and writing code. The Android SDK provides a wide range of useful libraries, tools, and APIs, which is necessary to develop applications on the Android platform using the Java programming language. We use Android Software Development Kit (SDK) for developing the application of this home automation system. The application provides a friendly interface of the home automation system and users can easily check the real time status of the electrical appliances and control the appliances according to their needs.
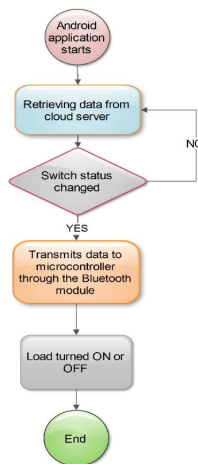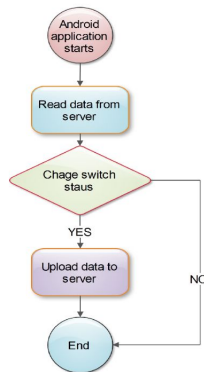

Fig.7 Flowchart of the device side and user side.

When user opens this application, a homepage will be presented to the user with the following options,
- Device side
- User's side

5.1 Android Application's Device Side
The Android provides full safety of the electrical appliances by providing logging facility for the users. Entering the exact username and password, the user has to start the device side part of the system. If logging info of the user exactly matches with the records of the web server, the user will be displayed the Bluetooth connectivity activity and has to choose the proper Bluetooth module (such as HC-05) and connect the Android phone with the Bluetooth module. Now an activity with the proper status of the electrical appliances will be displayed. To start receiving the data from the server, the user has to press the "START" button. The status of the different switches is mainly retrieved from the server. When the status received by the server is "ON", the application sends the data to the microcontroller through the Bluetooth module and the appliance with the proper switch number will be turned ON by the relay and if the status received is "OFF" and the appliance connected with the microcontroller is ON then it will be turned OFF.
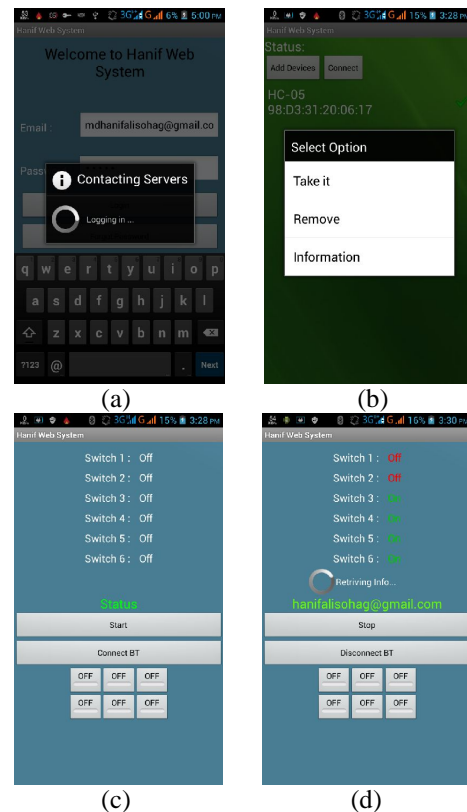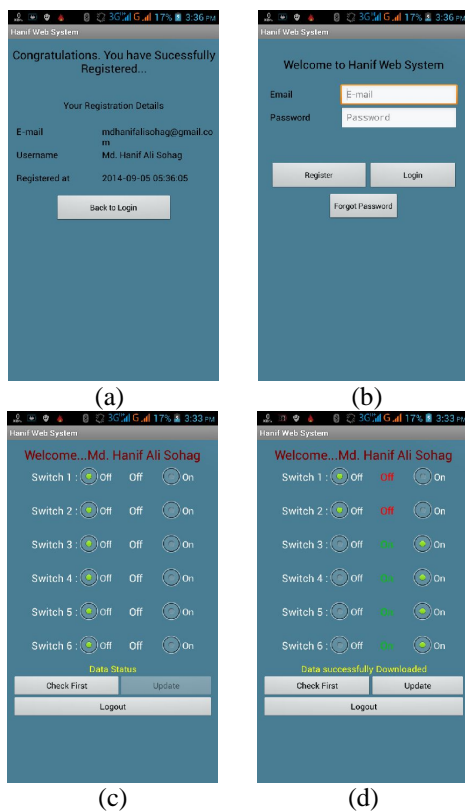

Fig.8 Screen shots of some processes, (a) Logging to the server, (b) Connecting to Bluetooth Module (HC-05), (c) Devices status, (d) Receiving information from the server.

The device side of the application also provides the control of the electrical switches through the Bluetooth if there is no net connection or the user is at the home.

5.2 Android Application's User's Side

In the user's side part of the Android application, logging and registration facility is provided for the user. The user must have to register for the first time to start the system. After successful registration, the user has to enter the correct username and password to log in to the cloud server through the Android application. If everything goes well a screen with the status of the electrical appliances will be displayed to the user. To check the real time status of the appliances connected with the system, the user has to press the "Check first" button. After checking the status, the users can now easily change the status of the appliances by checking the radio buttons "OFF" or "ON" and pressing the "Update" button.

(a) (b)

(c) (d)

Fig.9 Screen shots of some processes, (a) Registering to the server, (b) Logging to the server, (c) Devices status, (d) Devices status changed.

5.3 Web Part

The implementation of the smart home automation system involved several languages and software. The languages used to suit the development of the interface are HTML, PHP and MySQL. For designing the web interfaces and providing a user friendly interface to the user, the HTML language is used. For communicating with the web server from the Android smartphone, PHP is used. PHP is also used with MySQL database engine

for data storing. The web server stores the user records and serves to the other components in the system. Cloud Platform based web server is used for supporting the bidirectional communication between local device and web server and also mobile device and web server.

6. System's Web Interface

The system can be monitored and controlled through the Web interface [5]. As a part of the system, we have designed a web based GUI for the smart home automation system and users can easily access the system through the laptops, PDAs or any multimedia mobile phone having internet facility.
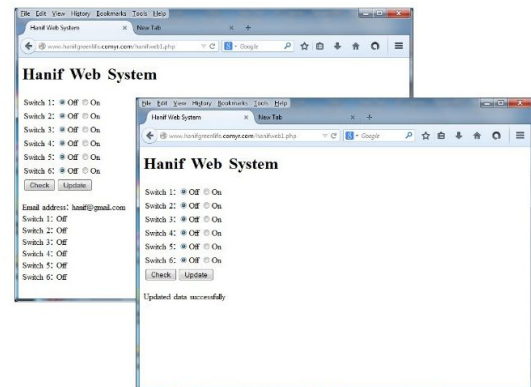
Fig.10 Screen shot of the web site of the system.

7. System Prototype

The system has three components. Those are a local device to transfer signals to home appliances, a web server to store customer records and an Android mobile running the Android application. When microcontroller receives a signal, it will turn the electrical appliances ON or OFF according to the user command.

(a) (b)
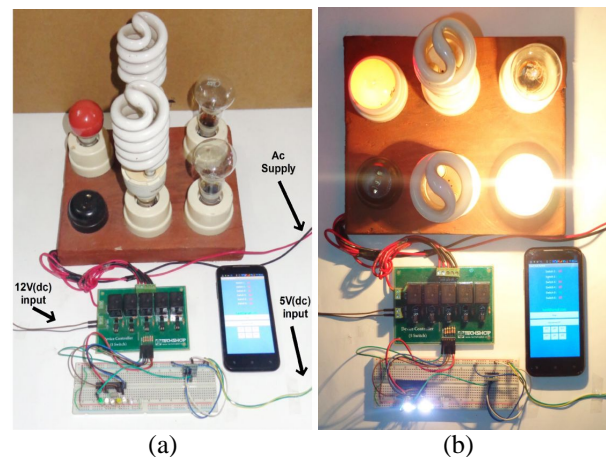
Fig.11 Developed prototype, (a) All bulbs are OFF, (b) Second and fifth bulbs are ON.

In Figure 11, five relays are used for five bulbs. Android phone communicates with the microcontroller via Bluetooth module. This android phone runs the device side of the application. In Figure 11(a), all bulbs are OFF by sending

commands from the user's phone, microcontroller turns the second and fifth bulb ON

7. Conclusion

The paper presents the design and implementation of a wireless home automation system and interfacing them to the web server based network using the Android smartphone. With the help of Android client, the web server, and the control protocols, a user can control the home appliances and monitor the status of each appliances at anytime from anywhere via internet by using a user-friendly interface. Compared with common used home automation systems based on Client/Server structure, this system does not need a dedicated IP address and server, so the home gateway maintenance issues is reduced. When the proposed design was applied to home appliances, it was found to function successfully. The obtained results confirm the feasibility of the proposed home automation system.

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