BLUETOOTH WIRELESS HOME AUTOMATION SYSTEM

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Abstract: Home Automation industry is growing rapidly; this is fuelled by provide supporting systems for the elderly and the disabled, especially those who live alone. Coupled with this, the world population is confirmed to be getting older. T*he smart home concept in the system improves the standard living at home* .Home automation systems must comply with the household standards and convenience of usage. This paper details the overall design of a wireless home automation system (WHAS) which has been built and implemented *with low cost and wireless remote control. The system intended to control electrical appliances and devices in house* or office using voice commands *with relatively low cost design, user-friendly interface and ease of installation.* The system has been tested and verified. The verification tests included voice recognition response test, indoor ZigBee communication test.

Keywords--*Home automation, Smart home, home appliances, Bluetooth,Android,* ZigBee transceivers, voice streaming, voice recognition

Introduction:

Bluetooth is essentially a detailed specification for short-range wireless communications using the unlicensed industry, scientific, and medical (ISM) 2.4 GHz radio band. Although Bluetooth technology is fundamentally a cable replacement system it provides a universal bridge to existing data networks and an ad hoc connection mechanism for a variety of devices in various configurations. The Bluetooth specifications have been devised with the understanding that removing the restraint of a cable and implementing a wireless link is only beneficial if the wireless technology is as economic and robust as the cable it replaces, or that the wireless link offers additional advantages.

The Bluetooth Special Interest Group (SIG)

The Bluetooth Special Interest Group (SIG), comprised of leaders in the computing, telecommunications and network industries, has specified Bluetooth's protocols and application profiles. The Group is driving the development of the technology and bringing it to market.

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The Bluetooth SIG includes promoter companies 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia, and Toshiba, along with over 2000 Adopter/Associate member companies.

Figure 1: Bluetooth topology showing how a piconet is created

Bluetooth devices that are within range of each other—a primary 0 dB link gives 10m range and 20 dB link gives 30m range—can establish connections on an ad-hoc basis and can form, disconnect, and re-form without user intervention. Two or more Bluetooth devices that establish a connection, and share a channel, form a small wireless network known as a piconet (**Figure 1**). The raw data rate is 1 Mbit/s with voice channels supporting 64 kbit/s and an asymmetric link of 721 kbit/s in either direction, while permitting 57.6 kbit/s in the return direction or a 432.6 kbit/s symmetric link. In a piconet, one Bluetooth device acts as a master, controlling all traffic in the piconet, while all other devices act as slaves. The master is defined as the device that initiates the connection procedure to establish a piconet. Only one master exists per piconet. The smallest piconet consists of just two devices (point-to-point)—one master and one slave. Up to seven slaves can be active in a piconet. Devices can be placed in a Park mode and a master can support up to 255 such devices (point-to-multipoint). A new device can use the User Service Discovery to determine what network services are available from the various connected devices.

Figure 2: A Bluetooth scatternet comprises a group of piconets that have overlapping coverage

A group of piconets with overlapping areas of coverage is called a scatternet (**Figure 2**). Each piconet is identified by a different frequency-hopping sequence. A Bluetooth device may participate in different piconets provided it is only active in one piconet at a time. A device can act as a slave in different piconets, but as a master in only a single piconet. For inter-piconet communication, a device selects the proper master identity and clock offset in order to synchronize with the channel of the desired piconet.

"Home Automation" concept has been existing for many years. The terms "Smart Home", "Intelligent Home" followed and has been used to introduce the concept of networking appliances and devices in the house. Due to the advancement of wireless technology, there are several different connections introduced such as GSM, WIFI, ZIGBEE, and Bluetooth. Each of the connection has their own unique specifications and applications. Bluetooth is being chosen with its suitable capability. Bluetooth with globally available frequencies of 2400Hz is able to provide connectivity up to 100 meters at speed of up to 3Mbps depending on the Bluetooth device class [1]. In addition, a Bluetooth master device is able to connect up to 7 devices in a "Piconet" [2]. The capabilities of Bluetooth are more than enough to be implemented in the design. Also, most of the current laptop/notebook or cell phones come with built-in Bluetooth adapter.

Project [3], [6-10] are Bluetooth based HAS (Home Automation System)design architecture. Where reference [6-8] proposed a Bluetooth based HAS that controls home appliances by a PC‟s GUI, but it does not provide portable remote function. For system [6-8], all the controls are performed only at the GUI on PC. [3], [9-10] are designed with cellular phone remote control to the system. Reference [3] implemented Arduino *Bluetooth Remote Home Automation System Using Android Application.B*luetooth board in their HAS project with cell phone remote control. The project stated as low cost HAS system but the cost of Arduino BT board is not the best cost efficient solution. Moreover, the cell phone control is implemented by Symbian OS application. It does limit the users of the system as the Symbian based cell phones in market nowadays are very less. While reference [9] did not mentioned the specific type of phone‟s OS implemented for their phone application. Meanwhile reference [10] mentioned the phone control is designed in JAVA application but it also did not mention the specific phone‟s OS for the application. From

the overall papers reviews, HAS according to [3-10] never mentioned about the existing physical electrical switches in their system. Without the switches on the wall, the designed system limited the control only at the GUI. This issue brings inconvenience to the people in the house.This designed system remains the physical switches with the modified low voltage activating method, in order to provide safer physical control to the user compared to the conventional high voltage switches. The Bluetooth connection in this system is established by Bluetooth module that directly receives/ transmits commands from/to smart phone or laptop/PC. For the GUI, Window OS on laptop/PC and Android OS on Smart Phone are chosen based on the high user distribution in current market. By considering the flexibility, the main control board is designed with wired and wireless connection. USB HID as secondary connection to the control board performs the wired connection. For the wireless connection, the main control board can be connected to either one of the laptop/PC or Smart Phone. Besides, the switches status on the board is synchronized in real time to all the connected GUI controllers. In terms of cost, this system implemented low cost microcontroller and Bluetooth module as the system main core. The total cost of one unit of this system hardware is estimated less than 30 USD. With this low budget, this system is still performed with powerful remote functions to make our life in home easier.

Fig 3: **Control Home Security, Monitoring and Automation (SMA)[3].**

The system is a 7-inch touch screen that can wirelessly be connected to security alarms and other home appliances. The home automation through this system requires holding and interacting with a large panel which constraints the physical movements of the user [4].

Another popular commercially available system for home automation is from Home Automated Living (HAL) [5]. HAL software taps the power of an existing PC to control the home. It

provides speech command interface. A big advantage of this system is it can send commands all over the house using the existing highway of electrical wires inside the home's walls. No new wires means HAL is easy and inexpensive to install. However, most of these products sold in the market are heavily priced and often require significant home make over.
The system consists of two modules:

i. Handheld Microphone Module which incorporates a microphone with RF module (ZigBee protocol) and voice recognition unit.
ii. Appliance Control Modules with relay controlling circuits.

The voice is captured using a microphone. Upon recognition of the commands, control characters are sent wirelessly to the specified appliance address. Consequently, appliances can be turned ON or OFF or controlled like increasing or decreasing the speed depending on the control characters received.

SYSTEM OVERVIEW

Fig 4 illustrates the overall control function of the Home Automation system(HAS). The system is directly installed beside the conventional electrical switches on the wall. The Bluetooth wireless connection enabled the system communicates with graphical user interface (GUI) on PC/laptop or smart phone without cable. The target home appliances are controlled by the system Main Control Board.This system provides three different types of physical control methods to the Main Control Board. The first physical control method is by pressing on the modified Low Voltage Activating Switches. The conventional high voltages switches will be replaced by the modified 5 Volt push buttons as the activating switches. The low voltage switch eliminates the risk of dangerous electrical shock by wet hand. The second and third control methods are performed as wireless remote control to the appliances. The second control method is by clicking on Window GUI on PC/laptop by using mouse or touch pad. This method provides facility to the computer user to control the home appliances without walk to the switches on the wall. Third control method is done by Android GUI installed in Smart Phone. The user can easily touch on the screen of the phone to control the home appliances. This portable method is able to assist the disabled people who have problem with locomotion difficulty.

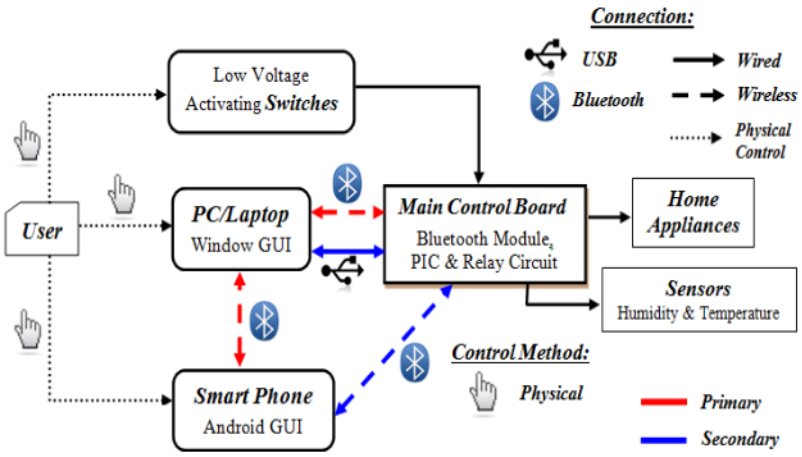

Fig 4. Functional Block Diagram of the System

The sensors that are connected to the main control board measure room temperature and humidity level in the house. The indication from the sensor is able to remind the user to switch on/off the heater, fan or air cond. in the house. The home appliance on/off status and temperature or humidity reading are synchronized to the two GUIs on personal computer or laptop or smart phone. The switches status and sensor reading are in real-time monitoring by the main control board. Any changes on the status or reading will be transmitted to the two GUIs.

After the smart phone‟s Bluetooth connection is connected to personal computer or laptop, the Window GUI will act as a server to forward or transmit any data from/to the smart phone and main control board. Some connection parts of the system are designed with two connections (Primary and Secondary) to the system. In case of issue on personal computer or laptop, smart phone can directly connect to main board. While in case of Bluetooth connection issue between personal computer or laptop and control board, personal computer or laptop can be connected to board by wired USB connection. The secondary connection acts as the backup solution in the system.

HARDWARE AND SOFTWARE DESIGN

This section mainly discusses about the hardware construction of main control board. Fig 2 demonstrates the hardware block diagram in the main control board. PIC Microcontroller, PIC18F2550 is chosen due to its capability to perform both serial and USB features to establish the Bluetooth and USB connection to the GUIs. For the sensor, HSM-20G Sensor Module is

chosen because it is the low cost 2-in-1 combination of humidity and temperature modules. For the Bluetooth module, low cost Cytron Bluebee Bluetooth module is chosen to establish the Bluetooth connection between main control board and the GUIs.

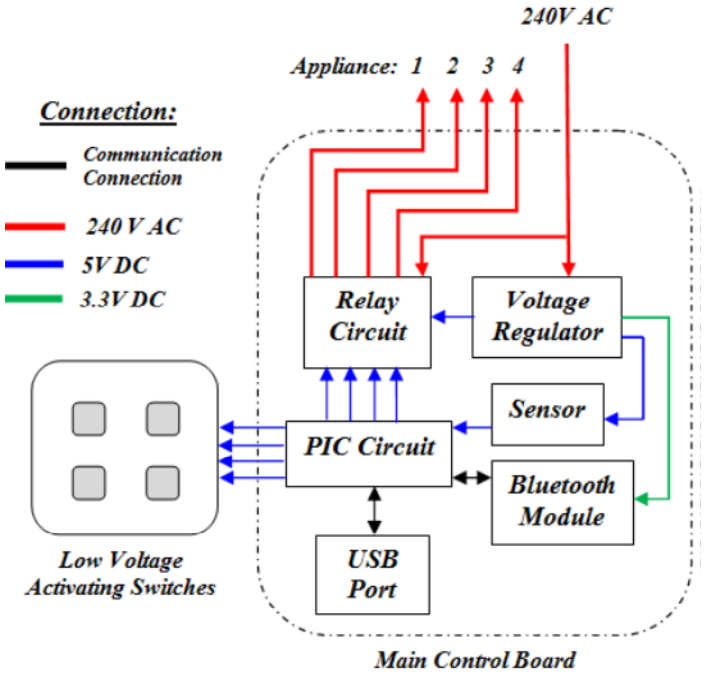

Fig 5:Main Control Board Hardware Block Diagram

The electrical current is directly connected to the main control board whereby it separates the regulator and relay circuit. The voltage regulator is constructed by common reliable regulator circuit which consists of transformer, rectifier and regulator. 5V and 3.3V DC output is regulated in order to fulfill the voltage needs of the specific components in the main control board. Moreover, the low voltage activating switches will replace the existing switches

The ease of installation is taken into account for this system. The system is designed to directly install beside the electrical switches on the wall. The installation of this system eliminates the complex wiring reinstallation and overhead wiring on the wall.

The existing switch connection is connected and controlled by the relay circuit inside main control board. Furthermore, multiple control boards can be installed in home. Bluetooth master device in PC/laptop is mostly able connect up to 7 devices in a „Piconet". With these simple and

low cost components, the main control board is constructed in pretty small size but still performs the strong functions and features of the system.

Software design section includes the main functions of the system designed in the PIC microcontroller and the two GUIs (Window and Android application).Fig 3 illustrates the process of the Low Activating Switches in the system. The switches detection function is performed by the microcontroller, PIC. The activating switches are designed by push buttons. Any input switch is pressed, it will interrupt the main function loop of the PIC. Then, the PIC will activate the relay and toggle the current appliance‟s switch status. At the moment, PIC also informs the change of switch status to all the GUIs that are connected to the main board.

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Window GUI is designed by an user-friendly interface. The four bulbs indicated the appliances status that connected to the system. User can simply click on the bulb to turn on/off the appliance. Control board „Connect‟ button is performed to establish connection to main control board by Bluetooth or USB. Phone „Connect‟ button is performed to establish connection between Window GUI and Android GUI. When the both connections are established, Window GUI acts as the server between main board and phone. All the data received from main board will be forwarded to the phone. Also, the data sent from phone will be forwarded to main board

CONTROLLED HOME AUTOMATION HANDHELD MICROPHONE MODULE

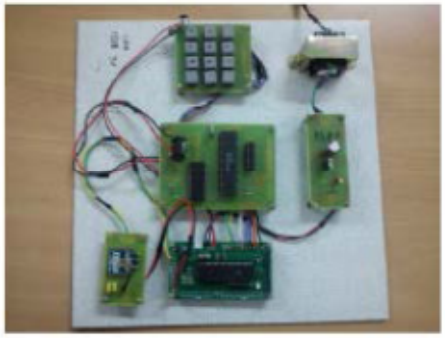

Fig 6: Microphone circuit board with Zigbee module and voice recognition unit.

The human voice is captured through micro phone. It is matched with the voice previously recorded in HM 2007. If it matches the corresponding signals are sent through Zigbee. Here HM 2007 is the voice recognition unit. Figure 6. shows the circuit board for microphone and voice recognition unit. On this board voice is recorded and saved and then recognized whenever a command is given through microphone. The speech recognition system is completely assembled and easy to use programmable speech recognition circuit. Programmable, in the sense that you train the words (or vocal utterances) you want the circuit to recognize. This board allows you to experiment with many facets of speech recognition technology. It has 8 bit data out which can be interfaced with any microcontroller for further development. Some of interfacing applications which can be made are controlling home appliances, robotics movements, Speech Assisted technologies, Speech to text translation, and many more. Once the speech commands are recognized, control characters are sent to the specified appliance address through ZigBee communication protocol. Each appliance that has to be controlled has a relay controlling circuit.

The voice recognition application is implemented through HM 2007 IC . The main program for this system is written by using the c programming language. The schematic diagram for this system which consists of all the components was designed by using the protease ISIS 7 professional editions**.** The main program was developed in the Kiel Integrated Development Environment by using the C programming language. The .c program was converted into .HEX file in this IDE and dumped into the ROM part of the AT89c51 micro controller. It consists of

HM 2007 IC , SRAM and keypad. In this unit voice is recorded and then recognized.The speech recognition system will process the signal and store the command in a static RAM IC.

CONCLUSION

In conclusion, this low cost system is designed to improve the standard living in home. The remote control function by smart phone provides help and assistance especially to disabled and elderly. In order to provide safety protection to the user, a low voltage activating switch is replaced with current electrical switches. Moreover, implementation of wireless Bluetooth connection in control board allows the system install in more simple way. The control board is directly installed beside the electrical switches whereby the switching connection is controlled by relay. Furthermore, flexible types of connections are designed as backup connections to the system. The connected GUIs are synchronized to the control board. They indicate the real-time switches status. The system is designed in user-friendly interface. It is easy to use interface on Window and Android GUI provides simple control by the elderly and disabled people. For future work, the Window GUI will be implemented with speech recognition voice control. The android GUI will be implemented as a remote Bluetooth microphone to the Window GUI. All the voice signal inputs to the smart phone will be transmitted to the Window GUI for signal processing. Also, the push buttons implemented in low voltage activating switches will be replaced by capacitive sensing switches. All the future work is expected without spend extra cost, even one cent from the current system. The prototype developed can control electrical devices in a home or office. The system implements voice recognition unit using HM 2007. The system implements the wireless network using ZigBee RF modules for their efficiency and low power consumption. The preliminary test results are promising.

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