

# An Overview of Home Automation Systems

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**Abstract**— Home automation system achieved great popularity in the last decades and it increases the comfort and quality of life. In this paper an overview of current and emerging home automation systems is discussed. Nowadays most home automation systems consist of a smartphone and microcontroller. A smart phone application is used to control and monitor the home appliances using different type of communication techniques. In this paper the working principle of different type of wireless communication techniques such as ZigBee, Wi-Fi, Bluetooth, EnOcean and GSM are studied and their features are compared with each other so the users can choose their own choice of technology to build home automation system. Moreover in this research work the survey of different home automation systems is discussed and their advantages and drawbacks are also highlighted.

**Keywords**—Home Automation System; Bluetooth; GSM; ZigBee; EnOcean; Internet of things (IoT)

## I. INTRODUCTION

Home automation system is growing rapidly, they are used to provide comfort, convenience, quality of life and security for residents. Nowadays, most home automation systems are used to provide ease to elderly and disabled people and they reduce the human labor in the production of services and goods [1-2]. Home automation system can be designed and developed by using a single controller which has the ability to control and monitor different interconnected appliances such as power plugs, lights, temperature and humidity sensors, smoke, gas and fire detectors as well as emergency and security systems [3]. One of the greatest advantage of home automation system is that it can be controlled and managed easily from an array of devices such as smartphone, tablet, desktop and laptop [4]. The rapid growth of wireless technologies influences us to use smartphones to remotely control and monitor the home appliances around the world [5-6]. Several home automation systems use smartphones to communicate with microcontrollers using various wireless communication techniques such as Bluetooth [7], GSM [8], ZigBee [9], Wi-Fi [10] and EnOcean [11]. Smartphone applications are used to connect to the network so that the authorized users can adjust the setting of system on their personal devices. Different type of home automation systems offer a wide range of functions and services, some of the common features are appliance control, thermostat control, remote control lighting, live video surveillance, monitor security camera, real time text alerts [10-13].

This paper describes the implementation and working principles of some existing home automation techniques and it compares their cost, speed, real time existence and other functionalities. There are different home automation technologies accessible in market but guidelines about these technology is very low, in this research work a comparison of some existing home automation technologies is discussed so users can choose their own choice of technology. This paper also discuss the comparison of some popular home automation techniques and highlight their advantages and drawbacks.

The rest of this research paper is organized as follow. In section II, methodologies of some popular home automation systems are discussed. Section III highlights the advantages and drawbacks of discussed papers. Finally, in section IV conclusion and the future work is discussed.

## II. METHODOLOGIES

### A. Bluetooth based home automation system

Home automation systems using smartphone, Arduino board and Bluetooth technology are secured and low cost. A Bluetooth based home automation system proposed by R.Piyare and M.Tazil [14]. The hardware architecture of this system consists of the Arduino BT board and a cell phone, the communication between Arduino BT board and cell phone is wirelessly using Bluetooth technology. The Arduino BT board has a range of 10 to 100 meters, 3 Mbps data rate and 2.4 GHz bandwidth. In this system home appliances are connected to the Arduino BT board via relay. The cell phone use a software application which allows the user to control the home appliances. Moreover, this system used password protection to make system secure and allow only authorized user. It has the advantage to easily fit into an existing homes and automated system. The main drawback of system is that it is limited to control the home appliances within the Bluetooth range. Fig. 1 illustrates the block diagram of Bluetooth based home automation system.

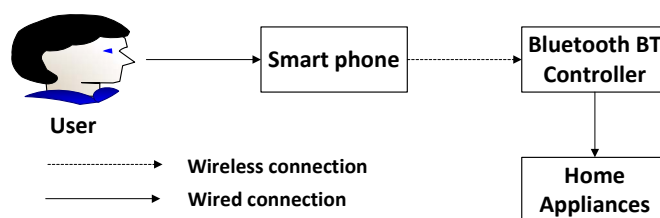


Fig. 1. Block diagram of home automation system

Similar research was carried out by [15]. A low cost and user friendly, smart living system is presented which also use android application to control home appliances. The wireless connection between android device and home appliances is developed via Bluetooth technology. It also provided security and alert system for proposed smart living system.

### B. Voice recognition based home automation

A voice recognition based home automation system proposed and implemented by a researcher [16]. The hardware architecture of this system consists of Arduino UNO and smartphone. The wireless communication between the smartphone and the Arduino UNO is done through Bluetooth technology. Android OS has a built-in voice recognizing feature which is used to develop a smartphone application which has ability to control the home appliances from user voice command. This application converts the user voice command into text, then it transmit that text message to Bluetooth module HC-05 which is connected with Arduino UNO. One advantage of voice controlled home automation system is that user only pronounce the appliance name in smartphone microphone and telling it to switch ON or OFF the appliances, in this way the users can control home appliance easily without any effort. A voice recognition application provided a user friendly interface to users and it has ability to add more home appliances into the system. This home automation system can be used in every building using electrical appliances and devices. The main drawback of system is that it has limited range due to Bluetooth, its range can be extended using internet instead of Bluetooth but this solution will not be cost effective. This system also failed to work efficiently in a noisy environment. The block diagram of voice recognition based home automation system (HAS) is shown in Fig. 2.

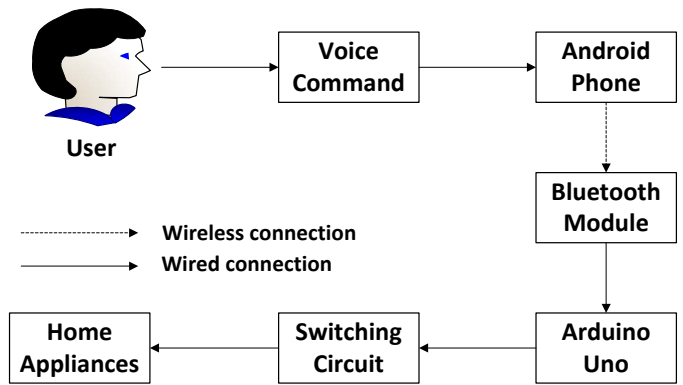


Fig. 2. Block diagram of the Voice controlled HAS

In [17], another voice recognition based home automation system is designed by using GPRS technology. This system allows the user to control home appliances using voice commands. In this system machine learning classifier Support Vector Machine (SVM) is used for speech recognition.

### C. ZigBee Based Wireless Home Automation System

ZigBee based wireless home automation system has also been studied [18], it consists of three main modules, handheld microphone module, central controller module and appliance controller module. Handheld microphone module use ZigBee protocol and central controller module are based on PC. In this system, Microsoft speech API is used as a voice recognition application, wireless network is established using RF ZigBee modules due to their low power and cost efficiency. The system recorded voice at a sampling frequency of 8 KHz where as human voice highest frequency is 20 KHz. Most important part of this system is encoding which was done at frequency range between 6 Hz to 3.5 KHz. Differential pulse code modulation (DPCM) is used for compressed data from 12 bits to 6 bits. These data bits were sent from the microcontroller to the RF ZigBee module at the maximum baud rate of 115200 bits/s. The ZigBee communication protocol offers maximum baud rate of 250 Kbps, but 115.2 Kbps was used for microcontroller for sending and receiving data. This Automation system was tested using voice commands of 35 male and female with different English accents. Each person recorded 35 voice samples so total 1225 voice commands were tested and system correctly recognized 79.8% of them. Speaker accent, speed and surrounding noise affected the accuracy of the system. Accuracy of this system is limited in the range of 40 meters while recognition system is accurate, up to 80m when given a clear line of sight transmission. Fig. 3 illustrates the block diagram of ZigBee based home automation system.

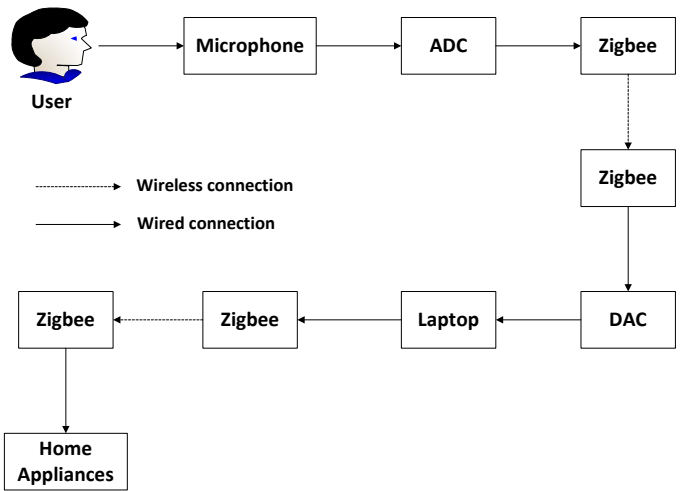


Fig. 3. Functional block diagram of ZigBee based model

Another ZigBee based home automation system proposed and implemented by researchers [19]. This home automation system has two modes of operation in terms of total power consumption, one of them is measurement mode and second one is the current sensor mode. The Java platform is used for monitoring real time power. Further, the performance of overall system has been analyzed by using different

performance metrics such as Round Trip Delay (RTD) time, the Latency and Received Signal Strength Indicator (RSSI).

#### D. GSM Based Home Automation System

A smart home automation system implemented by using Global System for Mobile communication (GSM) [20]. The hardware architecture of the system consists of GSM modem, PIC16F887 microcontroller and smartphone. The system used a GSM modem to control electric appliances through SMS request. PIC16F887 microcontroller interfaced with a GSM modem and it is used to read and decode the received SMS to execute the specific command. Home appliances are connected with PIC16F887 microcontroller via relays. RS232 is used for serial communication between GSM modem and PIC16F887 microcontroller. The GSM modem response time is less than 500 microseconds. The whole process of sending and receiving commands is processed within 2 seconds. One of the advantages of this automated system is that users will get feedback status of household appliances via SMS on their smartphones. This system was implemented in hardware and achieved  $\geq 98\%$  accuracy. Due to the wide coverage of GSM network users can get access to appliances from anywhere in the world. It is concluded that the usage of GSM in the home automation system provides maximum security and reliability. Fig. 4 shows the functional block diagram of GSM based home automation system (HAS).

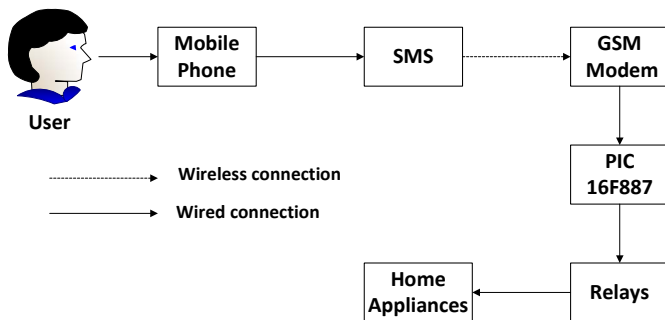


Fig. 4. Block diagram of GSM based HAS

Similarly, in [21], another GSM based home automation system designed by using the GSM SIM900 module, microcontroller LPC2148, LCD and a smartphone application for the user interface. This system enables the users to control home appliances by sending a message from android application to GSM SIM900 module. Moreover, this system displays the important notification on the LCD and it can be controlled anywhere in the world where mobile network is available.

#### E. Internet of things (IoT) based home automation system

Rajeev Piyare presented a home control and monitoring system based on the internet of things (IoT) technology [22]. It's designed and implemented by using embedded micro web server, controlling devices, smartphone and a software application. The architecture of system consists of three parts:

home environment, home gateway and remote environment. Fig. 5 illustrates the architecture of this system.

Remote environment allows the authorized users to remotely control and monitor the home appliances using a smartphone, which supports Wi-Fi, 3G or 4G and android application. Home environment contains the hardware interface module and home gateway. The function of home gateway is to provide the data translation service between internet, router and Arduino Ethernet server. The most important part of home gateway is a micro web server which is built by using an Arduino Ethernet shield. Hardware interface modules are interfaced with actuators and sensors via wires. This system has ability to control the energy management systems such as power plugs, lightings, security system such as gate and door locks and heating, ventilation and air conditioning (HVAC). For the monitoring system home environment supports sensors such as current, humanity and temperature sensors.

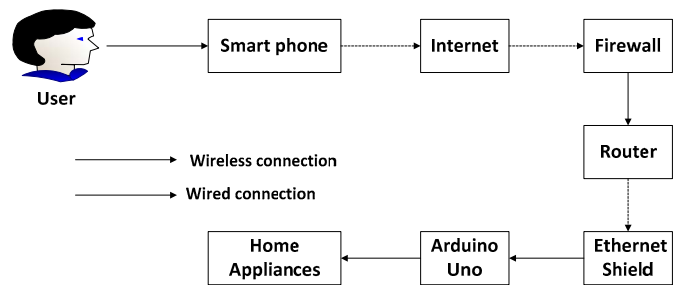


Fig. 5. Block diagram of IoT based HAS

Similarly, another system focuses on controlling the home appliances through World Wide Web [23]. This system allows the users to control and monitor the different home appliances using Wi-Fi and raspberry (server system). Home appliances such as fan, TV and light can be remotely controlled using the website. In addition, this system also provides protection to fire accidents and inform the user about fireplace via an alerting message.

#### F. EnOcean based home automation system

The EnOcean is newly developing energy harvesting technology used in transportation, building and home automation systems [24]. EnOcean's technology is productively in logistics as well as in the industry due to energy efficiency and easily installing device anywhere for users ease which significantly save the installation cost up to 40%. Moreover EnOcean's devices utilize 315 MHz band and it provides convenient ways for home automation system [25]. EnOcean based home automation system can be built up using internet, router, automation controller, duckbill 2 EnOcean and EnOcean devices. Duckbill 2 EnOcean is thumb drive used for home automation system and it has an EnOcean TCM310 transceiver and Ethernet. Moreover Duckbill 2 EnOcean run applications under Linux system [26]. It can work as a stand-alone automation controller inside building

automation systems [27]. An EnOcean based home automation system is depicted in Fig. 6.

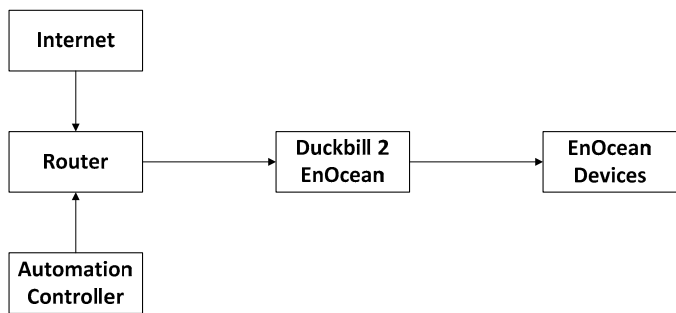


Fig. 6. Block diagram of EnOcean based automation system

### III. DISCUSSION

In this section comparison of all above discussed home automation systems has been done and their all common features, advantages and disadvantages are highlighted. All above discussed system have a main module that is connected with home appliances. Different types of communication techniques are used to transmit commands from the user interface to the main controller board. Comparison of cost, speed and real time application of above discussed systems is shown in Table 1.

Table 1. Comparison of Different HAS

| System                   | Cost | Speed | Real time |
|--------------------------|------|-------|-----------|
| <b>Bluetooth</b>         | Low  | High  | Yes       |
| <b>Voice Recognition</b> | Low  | High  | Yes       |
| <b>ZigBee</b>            | Low  | High  | Yes       |
| <b>GSM</b>               | High | Slow  | No        |
| <b>Internet, Wi-Fi</b>   | High | Slow  | Yes       |
| <b>EnOcean</b>           | Low  | High  | Yes       |

Bluetooth based home automation system gives complete control over home appliance as long as the user is in range of Bluetooth network. The Bluetooth system uses a PC or smartphone as receiver device. It has a high communication rate, great security and low cost, so it can be implemented as a real time system. Bluetooth network has limited range of 10 meters if the smartphone is out of range, then it will not be able to control the home appliances, this is one of the main disadvantages of Bluetooth based home automation system.

Voice recognition based home automation systems are most useful for handicapped and elderly persons, who wants to control home appliances by speaking voice commands. Voice of every human contains unique features so this such system has greater security. An operating system for Android smartphones has built-in voice recognition feature that can use for voice recognition tool for home automation system. The main drawback of this system is that communication between

user and voice recognition tool depends on signal to noise ratio (SNR), if voice signal is noisy then communication can highly effect and the system will fail to show accuracy. This system has a limited remote control range due to use of Bluetooth but it can be increased by using the internet but this solution will not be cost efficient.

ZigBee technology is almost same Bluetooth and its advantages and disadvantages are also similar to Bluetooth technology. It is one of the broadly used transceiver standard with low data rate and power. It has physical range is between 10 to 20 meters, which can increase up to 150 meters by using direct sequence spread spectrum (DSSS). It is ideal for developing prototypes and research related activities.

In GSM based home automation systems, communication between main module and appliances is done through text messages. GSM system allows the user to control and monitor the home appliances around the world and its cost depends upon the distance between user and home appliance. The main drawback of GSM based home automation system is that, there is no guarantee text message deliver to the system every time so it is not a reliable system. Thus, such home automation system cannot be implemented as a real time system.

Internet of things (IoT) based home automation systems is flexible and reliable. Communication between home appliances and user is done through internet. Any smartphone that can support 3G, 4G or Wi-Fi can be used for transmitting commands from user to server which is further connected with home appliances. One of prominent advantage of IoT based home automation system is that if Wi-Fi is not available, then user can switch to 3G or 4G services to control the system.

EnOcean is better than above discussed technologies in term of energy because it is self-power device. It is new technology and assure promising future for research activities to improve the system. Data rate of EnOcean is approximately 125 kbps, which is higher than above discussed technology, but the ZigBee data rate can increase up to 250 kbps using Quadrature Phase Shift Keying (QPSK).

### IV. CONCLUSION

In this paper different home automation systems surveyed and their pros and cons are discussed. Bluetooth based home automation system is a flexible and low cost, such system can only work in the short range of Bluetooth wireless network. Voice recognition based system are most suitable for elderly and handicapped people, they can control the appliances by just saying the name of appliances. Such systems are noise sensitive and their accuracy can be affected by signal to noise ratio (SNR). Another automation system used ZigBee RF modules for the implementation of wireless network, inside this wireless network user has full remote controlled access of home appliances. A GSM based home automation system is also studied, according to this system user can control and monitor the home appliances by sending a text message from the mobile phone. Internet of things based home automation

system can only work in the presence of internet. The rapid growth of IoT devices brings concerns and benefits. EnOcean based home automation system is more beneficial in term of energy usage. Their energy consumption is almost zero due to the energy harvesting fact.

The future of home automation system requires to make homes smarter and more convenient. For future work it is suggested to develop image processing based home automation system using the above discussed technologies. In such automation system home appliances will be controlled by different gestures which will be detected through the camera. Moreover, home automation system can be developed by interfacing biomedical signals such as Electromyography (EMG) signal with computer, it will provide opportunity to amputee to control appliances from different arm gestures. It can be useful in robotics area for controlling robot through gesture for different tasks.

In addition, future work would be implementation of above discussed home automation systems on a large scale, such as factories, industries and offices.

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