Comparative Study of Methodologies for Home Automation System
A Survey

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Abstract— A home automation system involves controlling and monitoring entertainment systems, security systems, appliances, lights and more. The Home Automation industry is growing rapidly. This is because people prefer automatic systems over manual systems at home so that their daily chores can be reduced and they can concentrate more on their area of interest. This led to the development of different methodologies to implement a home automation system. There are many home automation methodologies available, each of which has its own implementation methods, advantages, and limitations. However, it is up to the end-users to select their own choice of methodology for automating their home. The specific parameters being considered by the end-users for opting a specific methodology is relatively low. Therefore, in this paper, a comparative study of home automation methodologies such as GSM, Voice recognition, Bluetooth and IoT is presented from the end-users view to fill the empty space regarding the choice of methodology to be taken. The readers can expect to choose a methodology that suits their best after the study of this paper.

Keywords— Home Automation System (HAS); Micro Controller; Arduino Uno; GSM; Bluetooth; Voice Recognition; Internet of Things (IoT); Wi-Fi;5G; Network Slicing;

I. INTRODUCTION

The idea of home automation has been prevalent for a long time. As the name implies, this technology mainly deals with controlling home appliances like light, fan, AC, etc. automatically [1]. Smart home can be classified as a home in which the devices are connected to one another and the controlling and monitoring of these devices is done automatically [2]. Automated devices must work evenly and should have the lowest error rate [3]. It helps in efficient use of money as well as the environment. More than serving as a cookie to people who are lazy it has indeed helped in simplifying the daily works of many disabled, old, handicapped people. As the age increases, people tend to forget things and in case of handicapped and disabled people it is difficult for them to operate systems every time they are in need [4]. The word Automation itself in day-to-day life is being used in hotels, offices etc. The end-user application is basically used to connect over to the network and to allow only the authorized users to adjust the settings of the system [5], [6], [7], [8]. After the widespread of Home automation, there was introduction of many methodologies in which it could be implemented. This includes Bluetooth, Voice Recognition, Internet of Things (IoT), Zigbee, Global System for Mobile Communication (GSM) etc. Before taking up the implementation of what one is interested in, it is very important to have a basic knowledge of the subject of interest

and its background and there is no better way of understanding it than doing a survey paper. Since the concept of Home Automation always fascinated me, I was very driven to know how it was implemented. The purpose of this study is to obtain a detailed insight regarding the implementation methodologies of Home Automation.

This paper consists of four sections. In Section II, the working of the methodologies is described. A comparative study of these methodologies is done in Section III listing out their advantages as well as limitations. The paper ends with Conclusion in Section IV.

II. METHODOLOGIES

A. GSM Based Home Automation System

Home Automation is done using Global System for Mobile communication [9]. The features of GSM are that it uses the network of the mobile and is battery powered. It consists of two important components which are GSM modem and the microcontroller. The GSM modem is the communication interface between the Home Automation System (HAS) and the end-user. The Microcontroller connects the GSM with both the actuators and sensors of the appliances at home. Here the users are identified by their mobile numbers and these are saved in the system, Electrically Erasable Programmable Read-Only Memory (EEPROM) during configuration. Short Message Service (SMS) sent from the

authorized user through the mobile phone is received by the GSM modem through the GSM network. The GSM modem is connected to the AT89C55 microcontroller which receives the instructions and decodes it. For serial communication between the GSM modem and the AT89C55 microcontroller, the Relay RS232 is used and these relays in turn are connected to the sensors and the actuators which control or monitor the device.
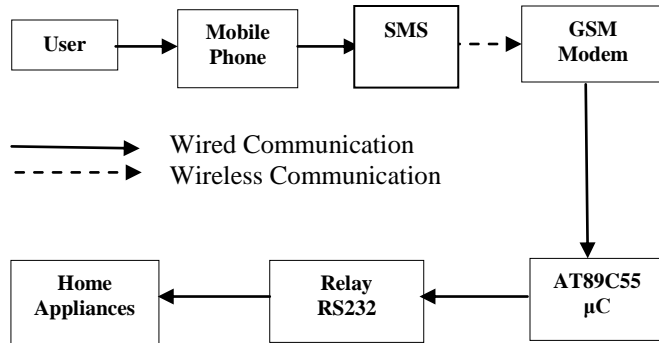
Figure 1. GSM based Home Automation System

B. Voice recognition-based Home Automation System
Speech Recognition is today being used in many applications such as iPhone's voice operated assistant Siri, Google Voice Search, Amazon's Alexa etc. [10].
In [10], the system is designed to enable centralize controlling over distant household appliances. Voice Control is provided by the Kinect V2 sensor which is used as a voice receiver. The system mainly consists of 2 components which is the Kinect sensor and the Arduino Uno based on ATmega32p.The voice signal is received by the microphone array of the Kinect sensor and the quality of the audio data is improved by pre-processing the audio to remove the background noise and removing echoes of the signal using automatic echo cancellation(AEC) algorithms. The sound coming from an appropriate beam is split into approximately 24 frames per second. The Central Controller then receives the audio and processes it. Speech module is constructed by Microsoft Kinect API. Speech Module uses the Microsoft Speech Recognition Engine and Microsoft Speech Recognition Grammar which contains one/more rules. Each and every rule defines a set of language constraints. Microsoft Speech Recognition Engine matches the input with words and phrases defined by the rules of the Microsoft Speech Recognition Grammar. Speech Recognition involves a confidence value which ranges between 0 and 1. The confidence threshold value is compared with the confidence value which specifies the validity of the selection. The command is only executed when the confidence value is equal or greater than 1. The Speech Module sends the recognized command to the Arduino as a message. Messages are mapped to predefined commands and the selected command is executed. When the commands are received by the Arduino, relevant pins will be high or low according to

the obtained command. Relays are used as electromagnetic switches. The proposed system accuracy is 95% when the distance between the user and the Kinect sensor is 4m and when the noise decibels are 53dB.
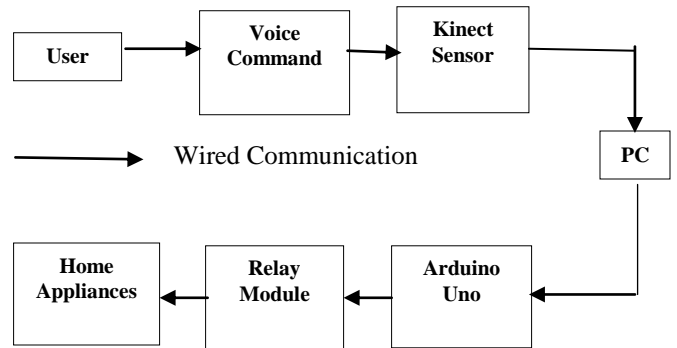
Figure 2. Voice Recognition based Home Automation System

C. Bluetooth based Home Automation System
Bluetooth is a technology standard which uses short range radio links [11].
Bluetooth based Home Automation system was studied [12]. The system mainly can be divided into two parts: Hardware and Software. Smartphone, Arduino Uno and Bluetooth module HC 06 comprise the Hardware part. Arduino Integrated Development environment (IDE) and Bluetooth terminal comprise the Software part. Bluetooth terminal is used as an app on the smartphone. Using this app, the end-user sends the command. Once the command is received, it connects onto the Bluetooth module HC 06. The Arduino Uno which is based on ATmega328P Processor then receives the user command in the form of numbers from the interface. These numbers are then designated to the home appliances and the appliances are toggled on or off on receiving the command.
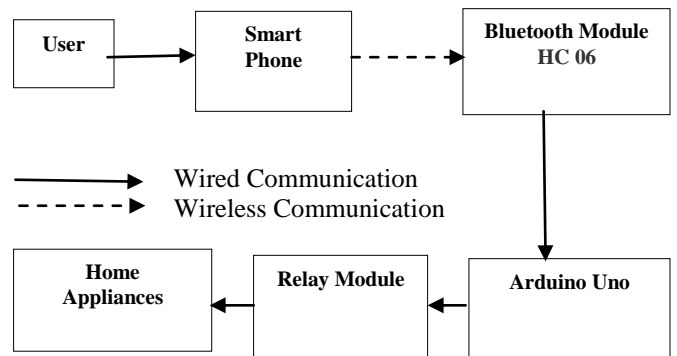
Figure 3. Bluetooth based Home Automation System

D. IoT based Home Automation System
Internet of Things comprises of a collection of sensors and actuators which gathers the data from the environment. The data gathered can be further processed to generate information [13].

This system allows the users to remotely control the appliances in their absentia at the home. IoT based Home Automation system was implemented [14]. The Main components of the system are Arduino Mega, Wi-Fi Module ESP8266, Relay Board. Many sensors and equipments are used to monitor or supervise the home appliances. Virtuino, an Android application is used to control the smart home. Arduino Mega microcontroller interacts with the Virtuino application. The Wi-Fi module, sensors are connected to the microcontroller. Once the relay board receives the input from the microcontroller, the action can be seen on the home appliances. It provides a more reliable security. However, security becomes a major concern for IoT due to the enormous amount of data that is passing through these systems [15].
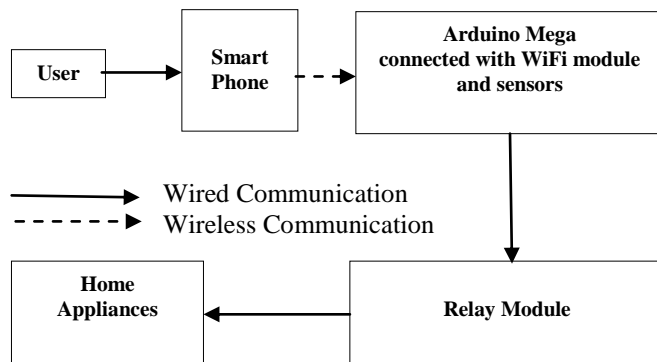

Figure 4. IoT based Home Automation System

Wi-Fi based wireless networks are becoming an integral part of our day-to-day life since Wi-Fi devices are being widely used in PDAs, laptops and other mobile computing machines [16].

In [17], WiFi technology is used as a network to monitor or supervise the appliances. The system consists of two main components; the web server which forms the system core that controls, and monitors end-user's home. Users can connect to Local Area Network or the internet and manage and control system code. A hardware interface module which is the second part provides appropriate coalition to sensors and actuators of home automation system. Server and the hardware interface module use secure Wi-Fi to communicate with one another. The same technology can be used by the end-users to login to the server. If the server is connected to the internet, users can access server web-based application through the internet using a web browser.

1) 5G for Home Automation System: Some of the important objectives that need to be considered in IoT are improved data rate, increased capacity, decreased latency and improved security of data while transmission [18]. The smart home area needs to implement services that are able to deal with daily activities. These systems must be able to interface with thousands of sensors [19]. AI-based systems are used to provide these services. These systems must be able to learn

the activities from users' behaviours and after learning the actions, they must be able to reproduce the learnt actions autonomously with high probability [20]. 5G cellular networks can play a major role in supporting the Internet of Things (IoT) due to their features which are Millimetre Waves, Full Duplex capability, Massive MIMO, Small Cells, Beamforming. Due to their frequency of about 28GHz and more, there is high data rate due to which there is low latency and it also provides the capability to connect multiple devices without compromising the wireless performance. Faster connections mean better communications between security devices. There is absolutely no need to fret regarding the number of devices connected to the network.

In [21], a description about how 5G Network Slicing can be used to implement Smart Home is given. Three Network Slices are proposed to meet varied and large number of devices with different Quality of Service requirements. For Security is of high importance in any matter, an end-to-end Network Slice is established for it. Further for Network segregation, it can have its own virtual network functions for access and core network. Enhanced Mobile Broadband(eMBB) Network can serve high data rate devices such as mobile phones, laptops etc.

Massive IoT Network Slice extends its support to low power devices such as motion sensors, washing machines etc.

Implementation basically involves establishing a 5G Network by acquiring and using network equipment from Telecom manufacturers. Here containerization of OpenAirInterface software stack of network functions is performed. Containers are then run on a single control host which in turn accesses the kernel. A configuration is which uses a separate container for the Network Slices is chosen at the Lab.
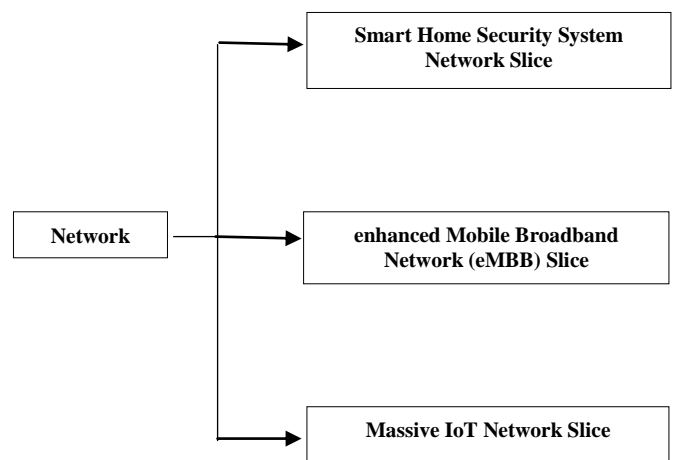

Figure 5. Network Slicing in a 5G Network

III. COMPARATIVE STUDY

The following table gives the comparison between the different Home Automation Systems with respect to its Speed, Cost and Availability.

TABLE 1   COMPARISION OF DIFFERENT HAS

System	Cost	Speed	Availability
GSM using microcontroller	High	Slow	High
Voice Recognition using Kinect Sensor	Low	Fast	Low
Bluetooth using Arduino	Low	Fast	Low
IoT	Low	Fast	High

In GSM based Home Automation system, communication between the user and the appliances is done through SMS. The advantages of GSM based Home Automation is it is easy to implement and is relatively at a lower cost. It is easily understandable as it is based on a simple concept of SMS. It is a global communication technology; therefore, it is accessible anywhere. The limitations are that it exhibits low performance in case of network congestion and limitations in coverage in terms of rural areas and the cost depends on the distance between the user and the home appliance.

In Voice Recognition based Home Automation system, communication between the user and the appliances can take place through voice sensors or Android applications. The advantages of Voice Recognition based Home Automation are that it is extremely helpful for people with physical constraints. The limitations are it is always better to use a slider for adjusting the volume rather than specifying the volume count. In case of Voice Recognition Home Automation system using an Android App, it is not completely free handed as we still need to press a button and then only give the command, if it becomes completely hands-free, then specific hardware has to be installed which might make the whole system expensive. In case of a noisy environment, it might not show adequate performance.

In Bluetooth based Home Automation System, communication between the user and the appliances occurs through the Bluetooth terminal. The advantages of Bluetooth based Home Automation are that it is suitable for a shorter range, user adaptable, ease of deployment, free ad-hoc networking and data transmission control. The limitations are it is comparatively slow, the data rate is low and it has a constraint of a short distance of up to 10 meters. Once the user is out of the range, no communication can take place between the user and the system.

In IoT based Home Automation system, communication between the user and the appliances take place through the Internet. The advantages are the end-users can remotely access the smart home. The limitations are the end-devices can reveal the user's identity, there is always carriage of data between the smart home and the user as long as the application is concerned; This can lead to intrusion as in many other cases such as social media etc. [22].

With 5G implementation, there is improved security and reliability. However, since 5G uses millimetre waves, it is prone to be affected by atmospheric parameters also there can be an occurrence of penetration loss leading to system inefficiency.

IV.   CONCLUSION

The paper discussed different methodologies used to implement a home automation system. GSM based home automation system is accessible anywhere. Voice Recognition home automation system is very helpful for handicapped, elderly people as they can give commands just by their voice. Integrating mobile phones to home automation methodologies such as GSM and voice recognition made it simpler for the end-users to monitor and control the home appliances as they no longer needed to carry special equipments for the same thereby also reducing the cost of investment to those special equipments. The home automation using IoT works satisfactorily and the appliances connected were controlled remotely through the internet and it also satisfies some of the major goals of home automation system such as cost-effectiveness, remotely controllable and improved security(5G). All these methodologies have their own advantages and limitations and it is up to the end-user to select the best methodology depending on their own individual requirements. In the future there can be 'plug and play' type where end-users can purchase devices from the store and use it without any support from professionals, Automated cooking assistant and more. Further the devices can communicate between themselves to maintain the overall health of the home and can be made to take measures other than sending an alarm.

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