ELECTRICAL HOME AUTOMATION USING IoT AND ARDUINO

By

Hussein M. A. Alshaer (170021151)

Abdullahi Ali Abdullahi Odowa (170021160)

Abdirahman Omar Hassan (170021161)

Soumaya Musse Omar (170021163)

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Declaration of Authorship

This thesis titled "ELECTRICAL HOME AUTOMATION USING IoT AND ARDUINO" submitted by HUSSEIN M. A. ALSHAER (170021151), ABDULLAHI ALI ABDULLAHI ODOWA (170021160), ABDIRAHMAN OMAR HASSAN (170021161), and SOUMAYA MUSSE OMAR (170021163) declare that this thesis is our work and has been accepted as satisfactory in partial fulfillment of the requirement for the Degree of Bachelor of Science in Electrical and Electronic Engineering.

Submitted by:

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Hussein M. A. Alshaer

170021151

_____

Abdullahi Ali Abdullahi Odowa

170021160

_____

Abdirahman Omar Hassan

170021161

_____

Soumaya Musse Omar

170021163

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Approved by:

Mr. Safayat Bin Hakim

Assistant Professor,

Department of Electrical and Electronic Engineering,

Islamic University of Technology (IUT)

Boardbazar, Gazipur-1704

Date: _____

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List of Acronyms

AC	Alternative Current.
CCS	Central Control System.
CPU	Central Processing Unit.
EEPROM	Electrically Erasable Programmable Read-Only Memory.
GUI	Graphical User Interface.
GSM	Global System for Mobile Communication.
GPRS	General Packet Radio Service.
HTML	Hyper Text Markup Language.
IaaS	Infrastructure as a Service.
IDE	Integrated Development Environment.
IoT	Internet of Things.
PoE	Power over Ethernet.
PaaS	Platform as a Service.
SaaS	Software as a Service
SMS	Short Message Service.

Acknowledgment

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Abstract

Internet of things (IoT) is a system which has several devices i.e. home appliances and any other gadgets which sensors and other various sensing devices are implanted with them to perform a task which is to interconnect and also transmit data in between neighboring devices and networks by using the internet. The inter-connected system of IoT provides and gives the possibility and the capability of controlling and monitoring devices automatically and remotely, each device is given a very unique IP address and they are recognized and communicated through those IP addresses. The IoT gadgets or devices are smart and intelligent and they take control from Web server that is installed in the cloud, the data that the gadgets gather from the environment is sent through an IoT gateway for analyzing and then perform the required task accordingly and sometimes those data are sent in to the cloud.

The home automation is referred as a way of managing and monitoring the home appliances/devices remotely by either manually or automatically. Home automation gives the owner of the house the capability of controlling his home devices.

Home Automation design refers to the ways of automating typical home appliance functions with not requiring for human input. Simultaneously, a home automation android application and an automated web page script have been built for deployment of the internet of things architecture. Home automation is effective because it helps users to utilize their home equipment smoothly and efficient.

The cutting edge technologies that has developed these days allows the technologies like Wi-Fi and Bluetooth to provide connection of several gadgets without the need of physical wired connection which reduces the cost.

One of the advantages of this system of automation is that it gives you the ability to control and monitor your home appliances from one centered place, which means you, can control your home appliances all at once and see their status.

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Chapter one

1 Introduction

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1.1 Background study

In this segment of this chapter serves a background study of some of the technologies that is been used in the home automation system, mainly here the focus is been given to Internet of things (IoT) which is the core and fundamental technology of the home automation, with the fascinating and easy to access features of IoT made the home automation become more famous in today's world and it made the home owners to invest in it more. In the coming segment a brief study of IoT is been described.

1.1.1 Internet of things

Internet of things (IoT) is a system which has several devices i.e. home appliances and any other gadgets which sensors and other various sensing devices are implanted with them to perform a task which is to interconnect and also transmit data in between neighboring devices and networks by using the internet [1].

The inter-connected system of IoT provides and gives the possibility and the capability of controlling and monitoring devices automatically and remotely, each device is given a very unique IP address and they are recognized and communicated through those IP addresses. The IoT gadgets or devices are smart and intelligent and they take control from Web server that is installed in the cloud, the data that the gadgets gather from the environment is sent through an IoT gateway for analyzing and then perform the required task accordingly and sometimes those data are sent in to the cloud [2].

The benefit of the IoT system is that they have the ability of transferring data from the local devices into the internet without the need of human interference. The internet of things made the living very easy and also comfortable in these days and people are giving a lot attention to it, there has been numerous of scientific researches in this field and even still going on to this day and many beliefs that in the future the world will shift in to making everything smart. Today the IoT is used in many sectors, it is used in medical department for monitoring patients also it is used in Agricultural sector for understanding about the climate change and checking the seeds, it is used in to control energy and waste management, it is also used in environment and industries and so many other sectors.

The smart home is also one of the area that IoT is used very extensively, the cutting edge technologies of IoT that is developing every single day made the life of living homes easier and comfortable, it made the manual controlling of devices into automatically controlled one instead of turning on and off every single device of your home appliances manually and it may be difficult to some people, the home automation and IoT ease those trouble so that you can control your appliances automatically and remotely from anywhere [3].

The significance of IoT is that it made living and working easier and smarter, it reduced the work or the need of human. In addition, IoT also helps management of business, it helped companies to make their processing automatically and fast, this minimized the cost that the company should have paid to employees. With that been said IoT is essential to everyday activities.

1.1.1.1. Features of IoT

IoT is most researched and famous topic in modern days, it attracted most of the people and investors by it's fascinating and smart characteristics and also the advantages they have on the daily lives, it made the life on earth simpler, smarter, and most importantly very secure one. In addition, IoT is one of the prime core and principles of the home

automation that we are using today, through using IoT you will have the ability to control your home appliance outside home or inside home. Furthermore, IoT enhances and gives good control of energy and waste management, by controlling the appliances those who are giving unnecessary energy without use energy will be managed and also the most importantly cost of the living will be less.

Some the promising features or characteristics of IoT are:

i.   IoT is able to integrating or coupling physical or hardware and software systems and make them act according the data they collect from their neighboring environment.

ii.   IoT has the ability of connecting several and different gadgets (i.e. sensors and actuators) and then is able to form a network which is interconnected.

iii.   IoT devices take the advantage of the environment and use it as control, they gather or collect the data and changes in the environment and then send it to the IOT system, and then the system will tell to act according to the changes in the environment.

iv.   IoT devices tell and inform the owner whether a certain device is ON sate or OFF state.

v.   Since IoT platform contains a lot of different devices, so it is diverse and also the platforms that we use for communication are unique to avoid overlapping.

vi.   One of the main features that almost all investors and research personnel made them to keep their eyes on IoT is that it has very secure system.

These characteristics and several more are the reasons that IoT is successful in these days   and also they are the reason of manufacturing several more devices those work on the principle of IoT.
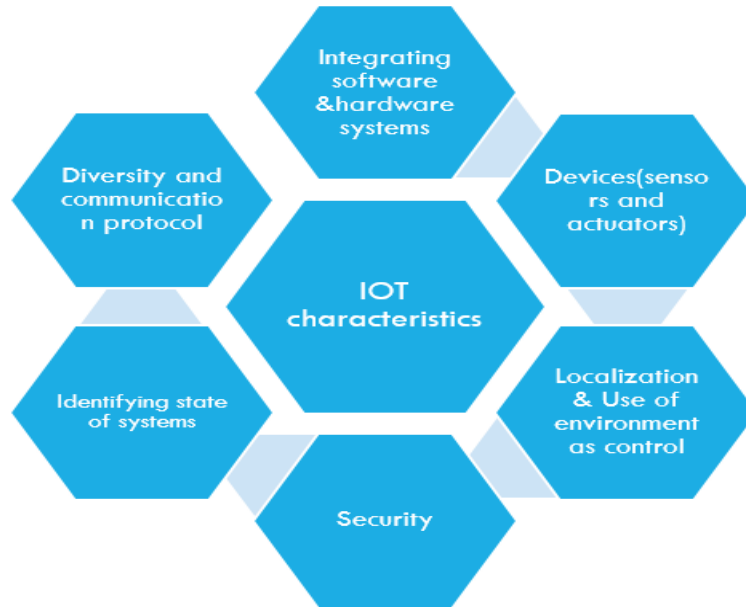
Figure 1. 1 IoT characteristics

1.1.1.2. Building blocks of IoT

The building architecture of IoT contains some interconnected structure and systems those work together as single system. The systems that IoT contains are the following:

1) **Devices/objects.**
2) **Network**
3) **Data**
4) **Information**
5) **End user**

At the starting of the process the objects i.e. sensors, actuators, lights, Ac etc gather the physical data from the environment and then translate it into form that internet can understand, the network operation starts from here it's operation is to take this data through different technologies like WI-FI, Bluetooth, ZigBee, and several more to link the physical devices into the edge gateway to transform the data from analogue domain to digital domain, then the network gateway gives distinct routing for the data that the

device collected and from here attach and store the data in the cloud. At last the data stored in cloud is used as communication between the cloud and IoT platform [4].

Figure 1. 2 IoT working process

- Devices(sensors , actuators, etc.)
- They collect raw data from the environment or the system

Device

- WI-FI, Bluetooth, ZigBee, etc.
- Transform the data from analogue to digital.

Network

- The gateway gives distinct routing to the data.
- Attach the data to the cloud.

Gateway

- This is where the data is stored and managed.

Cloud

- This is our whole system and it is connected to the cloud.

IOT system

- The user uses his mobile phone for controlling his system.
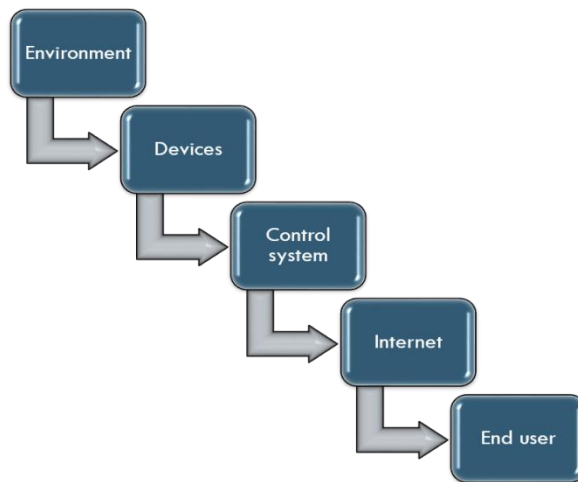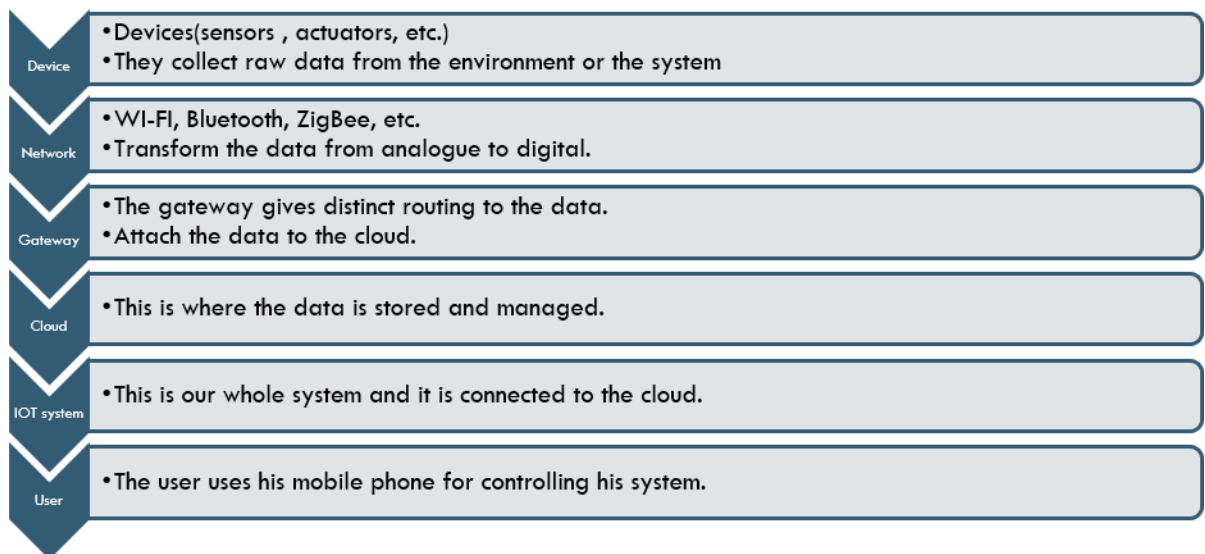
User

Figure 1. 3 IoT building blocks

1.1.1.3. IoT Applications

Nowadays, the IoT technology developed in every aspect and features of life and many more discoveries has been found in the ways IoT can be used in many departments and directions of living in this century. On top of that, thorough those applications the daily

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life became simpler, smarter, secure, and most importantly environmental friendly. In the early days, no one imagined that IoT devices would be this much helpful in the living on surface earth, people that time thought this system as a fiction.

Today, IoT is very popular and used in many areas of life and work, some of the very popular areas or departments that IoT is been used are [5]:

1.   Industrial department.
2.   Health department.
3.   Agricultural department.
4.   Environment and waste management.

In the industrial department, IoT helped a lot for building smart homes which you can control your house automatically from anywhere you are and it provides energy management, it also minimizes the power consumption. There are smart offices which you can monitor and control operations and work situations, this increases employee participation and understanding of his work. Smart parking is also one field that is used IoT; it helps manage the cars that are inside the parking slot.

In the health department, IoT also helps monitor patients and give their health status constantly to the nurse, like mostly for elder patients those who can't tell their problem. In the agricultural department, it is used for checking the seeds situations and for harvesting and also for checking climate change [6]. In environment, it helps reduce the unnecessary waste and manages the environment pollution and it provides green life in the environment [7].
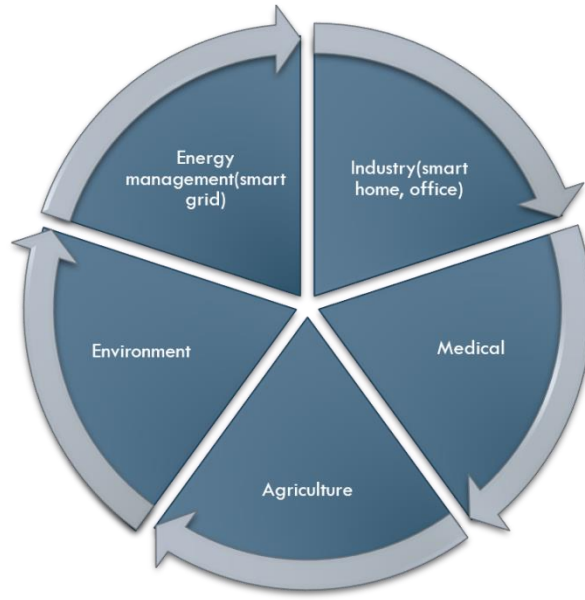
Figure 1. 4 IoT applications

1.2. History of Home Automation

Earlier days in 1920s the technology of "Home Automation" was seen as science fiction, however there are different opinions on the exact date of the starting this technology. Throughout the years as the technology evolved, the term home automation came to notice gradually step by step. In1940s with the development of digital computers made people realize the concept of this technology, hence in 1960s was the first the concept of home automation came up and it was for controlling temperature and appliances and that time it was called "wired homes".

In 1980s was really a revolutionary for this technology with the development of new technology like (motion sensors, programmable doors and security system), this led the way for first official name of "Home Automation" it is named by the American association of home builders.

In 1990s with the innovation of IoT, home automation got the attention of homeowners but in the meantime it was not very popular and growing.

About the years of 2000s the use and the productivity of home automation has been increasing swiftly, and nowadays with the increasing production and development of IoT devices and also the price of smart home system became affordable, due to these reasons it made the home owners to invest in this technology.

These days' home automation is more focused on living smarter and greener and most importantly improving the security system; with these attracting features this system of home automation became more popular in modern days.

1.2.1. Problems of not succeeding automation in earlier days

There are certain factors that caused this system to do not become very successful in earlier days and here are some of them:

i. Absence of incentives to produce more in domestic work.
ii. Very Little contribution of the users of the technology in design procedure.
iii. Product designers believed that household technologies are not compelling.
iv. The technologies that are used for this system were not developed very well at that time.

These factors that we mentioned above and several others caused that the home automation technology to not become very popular and developed in the earlier days. In contrast these days this technology is been used in several areas and it became very popular due to engineers are

giving this field a lot of intention and are trying to develop this technology every single day, also people in this era understood this technology very well and realized that this system is very trusted one and can make their lives easier.

1.3. Introduction to Home Automation

As everyone knows every home has some electronic gadgets such as lights, fans, air conditioners, refrigerators, television etc. The home automation is referred as a way of

managing and monitoring those home appliances remotely and locally by either manually or automatically.

Home automation gives the owner of the house the capability of controlling his home appliances remotely and automatically [8].

A home appliance is the electronic gadgets such as lights, AC, refrigerator, etc. those are used for household and intended to do specific job.

Automation means the procedure of making devices to work and control automatically by either remotely or close to the devices, this reduces the human interference but it will not eliminate the human interference completely [9].

The automation system not only provides the smart control of appliances but also it provides smart control of energy and power consumption, for instance the lights in a certain room are ON without the use of someone, so what the system will do is that it will turn OFF those lights, also let that in certain room there are 3 people and other room there are 6 people so the amount of cold that the air conditioner will releasing will not be same in those two rooms, the room with the 6 person will get more cold that means those two rooms are not using same energy and this reduces the total consumption of power and the money that you have to pay will be less, but if you don't have this smart system in your house those two rooms will not get any difference they will use same amount of energy and this causes to use more energy and subsequently you have to pay more money. In summary we can say that the use of home automation system will reduce the electricity bill that you have to pay, so the system is economical.

In modern days the use of home automation system became very popular and is been increasing rapidly day by day because the benefits that we mentioned above and many more, engineers and researchers are trying very hard to construct a well-organized and low cost home automation system which controls all the electronic appliances in anywhere such as homes, offices, stadiums, etc.

The home automation system made the life easier in a way that one can prepare his house while he is in his job location, for instance assume that the owner of the house finished his work and he is on the way to his house, while he is the road he can set his

house temperature if the weather is cold he can order the heater to be on to warm his room, and also he can set his television to his favorite channel, and whenever he reaches his house everything is set and ready and when the owner comes he finds his house is very convenient and enjoyable. That is how far this system can make the life easier.

The idea of controlling your house remotely by using the internet anywhere in the world became imaginable with the invention of IoT, the use of IoT promises that you can control your system anytime, anyplace using any available network. Meanwhile in today's world almost all of the people use mobile phones, accessing and the affordability of home automation system became easy for everyone by just simply using their mobile phones to control their home, in addition people can also use their PC and laptop as control to their system [10].

The devices (mobile phone, laptop) that we using as control has the ability of connecting all home appliances to it by using technologies like Wi-Fi and Bluetooth etc. We use android application to control the system from our mobile phone and to control it from laptop we use web applications, both ways of controlling you need to provide the build in user name and password before controlling the system, only the owner can access the system that means only if you provide the correct and matching user and password you can access the system.

The cutting edge technologies that has developed these days allows the technologies like Wi-Fi and Bluetooth to provide connection of several gadgets without the need of physical wired connection which reduces the cost [11].

The Wi-Fi based system the Arduino is communicating with internet by using Wi-Fi shield which is connected to internet router, this Wi-Fi shield is served the communication between the Arduino and the internet.

Since security is very important factor in life, this home automation system provides a secure and well trusted system, it gives security against intruders and other dangerous things (like fire) from your house, office, and other things. There are several sensors in the house like motion sensor, fire sensor which detect the changes in the house system

and if there is change in the system they give alarm to the owner so that he takes the appropriate actions to reduce the risks of that change of the system.
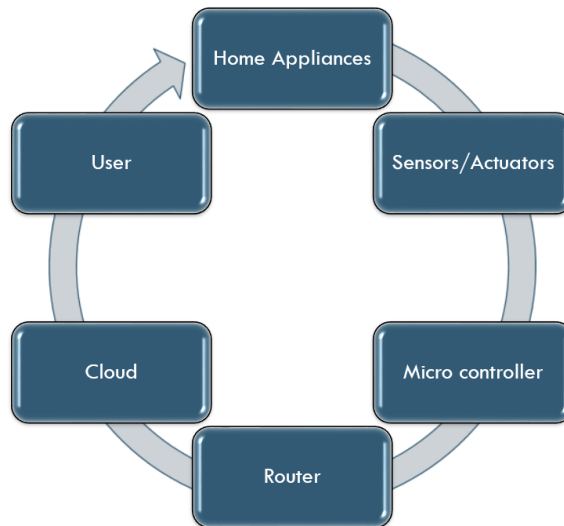

Figure 1. 5 Home automation parts

1.4. Advantages of home automation

The system of home automation has many advantages those made the system very popular in these modern eras [12].

To begin with, one of its advantages is this system of automation offers you the ability to control and monitor your home appliances from one centered place, which means you can control your home appliances all at once and see their status.

In addition, the home automation system makes you to not worry about your house while you are away, it gives you the ability to control your home appliances and monitor them remotely from anywhere, anytime, any network available.

Furthermore, this system can adapt and with stand with the changes and updates/ developments that is been done to the used appliances and technologies that means the system maintenance is not difficult.

The home automation system gives you the management of the power consumption of your house and minimizes the unnecessary use of energy which decreases the total power consumption, subsequently which reduces the price money that you would have to pay for the electricity bill. This system of automation gives increased security system.

In conclusion, home automation system provides a simple and improved way of living green life which minimizes the cost, energy, time that you would have given when you are not using this system.

1.5.   Summary

This chapter of this thesis paper is intended to give the reader a clear view of the related technologies of home automation especially the IoT technology, at the beginning of this chapter we have mentioned about how IoT works, then we talked about the features or characteristics that helped to develop the home automation system, also throughout the chapter we explained some of the building structures of IoT, also the applications and advantages of IoT is been discussed. Finally, in this chapter we have given a glimpse of how the home automation works and the advantages that it had brought to the live on earth. In the upcoming chapters we will discuss more about the home automation system.

Chapter 02

2. Brief Discussion of Home Automation system

2.1. Introduction

Nowadays, with the growth of internet technologies lifestyle has grown better and much more pleasant for us in this online era. The technology has opened many doors or ways of living for the people with unfathomable and extraordinary alternatives, such as that of the ultimate goal of developing automated smart systems. The principle of such an automated smart system arose first from expansion of the internet technologies; this system led into minimizing the risk and whatsoever the network could have and also it reduced the need of man interaction. Global developments and research studies are underway to determine how to adequately utilize the electricity of an electrical gadget such that the loss product of that device can sometimes be minimized which leads into green living in the environment. The effectiveness of such a smart energy control system can lead us all to the proper objective of an automated process that could be operated repeatedly and safely without man assistance.

In the coming parts we going to talk about the relation between IoT and the system of home automation, also we are will discuss about the energy management system, and the design consideration of the home automation system.

2.2. IoT and its relation with Home automation

The internet of thing concept helped to develop this system and it is the most researched area in the in the IoT. Human-to-human or human-to-computer interaction is not required for IoT gadgets data to be transmitted with one another. Those platforms are capable of reasoning and making judgments without the need for human intervention.

When done effectively, the Internet of Things can alleviate a vast variety of complex issues such as catastrophic events, contamination, and perhaps even remotely monitor devices in the home. Home Automation design refers to the ways of automating typical home appliance functions with not requiring for human input [13]. Simultaneously, a home automation android application and an automated web page script have been built for deployment of the internet of things architecture. Home automation is effective because it helps users to utilize their home equipment smoothly and efficient [14].

There are 3 major building blocks or components for home automation system and they are: Sensors (which detect the environmental changes and then command the system to act accordingly), Actuators (such as switches, motors they are activated by a an order from the controller), Controllers (such as smart phones, PC, which they work is send or get messages about the situation of the home) [15].

Wireless home automation management was implemented and designed using 2 techniques: WLAN technology and an RF wireless remote handheld to monitor chosen home equipment with an integrated secure and safety system. Every chamber has its own board which is attached to the computer via the microcontroller's serial port.

The software contains an assembly language for programming the microcontroller and a visual basic language for communicating between the PC and the two boards. It also includes a Graphical User Interface (GUI) that includes all of the devices that must be displayed on a home PC screen. With the growing number of gadgets to be handled, the method is fully and adaptable.

2.3. Design consideration of home automation

When establishing a system home automation, there seem to be various design issues and choices to be made, which are often decided through customer requirements. Beyond that, the engineer can select the proper CPU, preferred sensors, and suitable communication protocol for the system, maintaining the following features in consideration [16]:

- Configuration choice: The interface mechanism is the common communication mechanism and hardware pairing being used for transmitting and getting messages among gadgets and the consumer, and it is the most basic and vital necessity of a home automation system. Depending on the device, bandwidth, area of building, convenience of use, and other factors, engineers have a variety of alternatives for implementing network connection and communication between the user, and the entire system. If a consumer wishes to utilize the Internet to operate their home appliances, the engineer must include a Wi-Fi gateway that connects the system to the local network. The developer must include a Bluetooth device to interact with the devices if the customer wishes to operate the system over Bluetooth from a Smartphone.

- Sensor choice: The developer must identify the customer's sensory needs and select the appropriate sensor device to accomplish the work. Designer must similarly evaluate the sensor parameters available for specific demands and their effectiveness in various conditions. In general the sensors that we need in home automation are: temperature sensing devices, humidity sensing devices, gas sensing devices, light sensing devices, motion sensing devices. The CPU uses the data supplied by such sensors to make numerous wise choices about the devices, including when and what to turn on and off.

- Security Abilities: security is also considered one of the primary and important requirements of a home automation system. A secure system insures that no other person can get access to the home except the owner; this reduces the risk of intruders and dangerous people to get in the house. If the system is broken and someone gets access of the home, the system should be intelligent enough to recognize that intervention and send signal to the user personnel and also the closest station of the police. The system should be able to hide certain equipments from the control centre and also be able to prevent hackers from pairing into the system and using the same interface to access the home or its data.

- The method of connection and interaction: There are several types and ways of interaction between several units in the home, the most used one being a star type which uses a central control unit to interact with all other remote control units and then which takes the decision based on the information between them. The decision making process is as follows; first the remote control units send the data from the sensors to the central control unit then it assesses the data from the sensors after that it takes decision based on the input and gives orders to the remote control units to do certain action. The mesh topology is also considered a way of interacting between units of the home, in this method there is no central control unit each unit has same equal capability of controlling and taking action independently. Each unit shares its information into other parts of the network then each network makes action based on the information. The factor that tells the engineer which topology is suitable for a particular home system is the communication method that he used like; WI-FI, Bluetooth, ZigBee, etc.

- Cost: Its one of the vital factors to consider when building an automation system since we need to get a system which has large range of automation, and if the system installation becomes expensive the customer will not want to purchase it.

The system cost is related to the amount of components and interface used, also the depth of automation and complexity of design.

There should be tradeoff between the amount of components used and the suitable hardware and software design; we should minimize the amount of components that we need to use while we should have a high quality system in order to minimize the cost and also the size of the system.
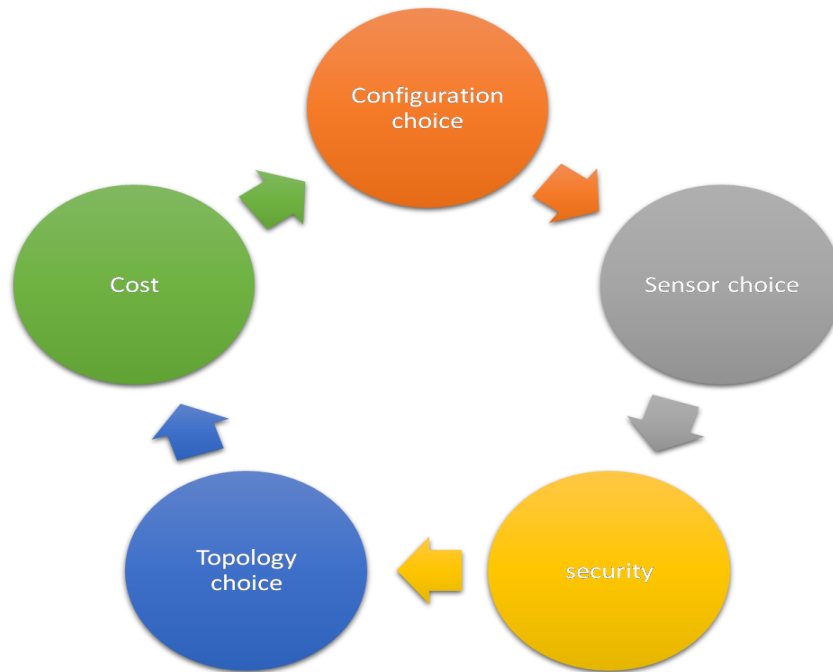
Figure 2. 1 factors to consider

2.4. Summary

This chapter of the book is mean to give the reader some more discussions about the home automation system; we have seen that with the growth of internet technologies lifestyle has grown better and much more pleasant for us in this online era. The technology has opened many doors or ways of living for the people with unfathomable and extraordinary alternatives, such as that of the ultimate goal of developing automated smart systems. This chapter also discussed the relation between the system of home automation and internet of things. The IoT concept helped to develop the home automation system and it is the most researched area in the IoT.

The factors that we need to consider when designing such system is also discussed in this chapter.

The following chapter there is a discussion on the different communication protocols used in the home automation system.

CHAPTER 03

3. Literature review

3.1. Introduction

Before we talk about the literature review of home automation we will give some introduction about the system.

Home Automation can be defined as a system which contains devices such as light, Ac, refrigerator and all other forms of electronic gadgets those can be integrated together and be monitored from distance using network and cloud technology [17]. This system main priority and objective is to achieve a home that can be controlled and monitored remotely and also centrally. In otherworld, this system is to integrate all home appliances to a CCS (central control system) which governs those appliances with respect to customer inputs. The appliances/electrical gadgets are coupled with a microcontroller to enhance the ability of the system to work automatically.

The theory of Internet of Things made it easy to connect all gadgets to the internet and gave them the capability of them to work without the need of customer interference. The IOT helped the home to be smart and environment friendly. This smart home could be smoothly governed and monitored across the internet by operating your mobile phone, laptop or personal computer.

Nowadays Bluetooth, WI-FI, ZigBee and many more other communication techniques are of the communication topologies that are utilized in home automation [18].

Realizing that these days the IPv6 which has very wide addressing range and also the rise of the concept of Big-data and Cloud, these recent internet technologies took part a major role in expanding the concept of smart home.

In the future with the advance of the internet technologies this system will take over the normal home that we live in these days, they can have the ability to track day to day working i.e. water use, power consumption, fire detection, and security.

The home automation system ambition is to scale up the luxury level with also minimizing the amount if cost that we pay [19].

3.2. Communication technologies

In this part of the chapter there is a discussion on the technologies that are used in the home automation system, there is a comparison between several communication techniques that are used in this system. The communication techniques that we will describe in this section are: Bluetooth, WI-FI, GSM, and Cloud based system.

3.2.1. Bluetooth build system

A home automation that its system is working based on Bluetooth is achieved by connecting the user's Smartphone Bluetooth to the microcontroller and this connection is achieved through wireless communication [20].

Firstly, the electronic devices of the home are attached to the microcontroller (Arduino) board by the use of relay. The Bluetooth receiver inside our system takes up the messages received out from mobile [21], which are then processed in the microcontroller with the device state instructions.

Various household devices are linked to the microcontroller board's output terminals through relay switches to give adequate current and voltage stability.

The microcontroller board is programmed using programming language, there is a feedback line in the system which is intended to get the feedback from the device and it tells the state of a certain device that you need. The feedback line detects monitors the operation and produces an output signal so that the user recognizes that the particular action is being executed successfully, if the output signal is not generated then it can be

recognized that the certain operation is not carried out successfully. To protect the system from other people to get access, there is password that you have to enter so that only the owner gets the access of the system.
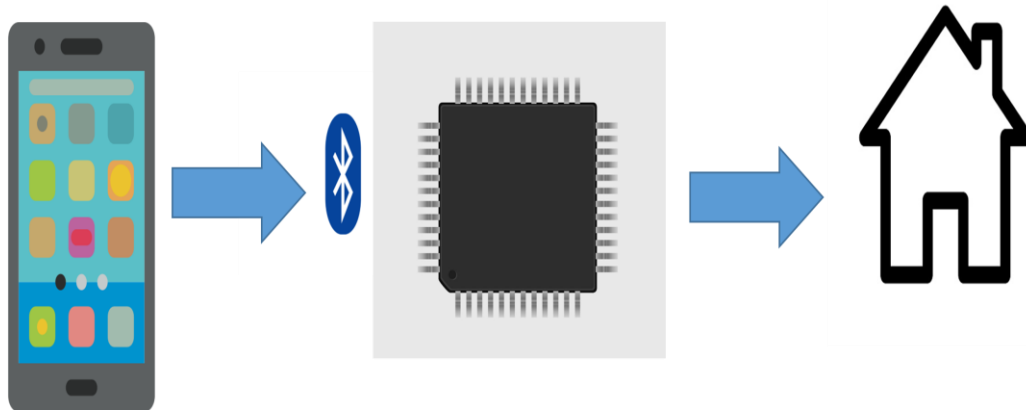

Figure 3. 1 Bluetooth system

3.2.2. WI-FI build home automation system

The network architecture which links the server and hardware devices is chosen to be Wi-Fi technology. Wi-Fi was selected to boost network security as well as accessibility and manageability. This type of connection has three main parts which are; a server which is connected to the internet and to access the server data we use web applications through the internet which makes easy for the user to access his home remotely through any internet, second part is hardware interface which contains all the hardware devices of the system, third part is software module which is divided in to two parts one part is for programming the microcontroller using C programming language, the microcontroller software is able to collect and observe the incidents of the attached sensors, after the collection of the data from neighboring sensors it gives order to the actuators to do the required action, and also it has the duty of reviewing and recording the history in to the server, and the other part is for programming the server application software, this software can be retrieved from inside network or using the internet but this

one server has to have real IP on the internet. Server application system has the ability of keeping the whole system of the smart home setup and layout[22]

The server's primary purposes are to administer, regulate, and oversee aspects of the system, allowing hardware devices to complete their designated tasks and notifying activated actions towards the domain controller (server). Straightforward wire interconnections are used to interconnect hardware interface devices to sensors and actuators. The ability to monitor energy performance system is provided by hardware interface components.
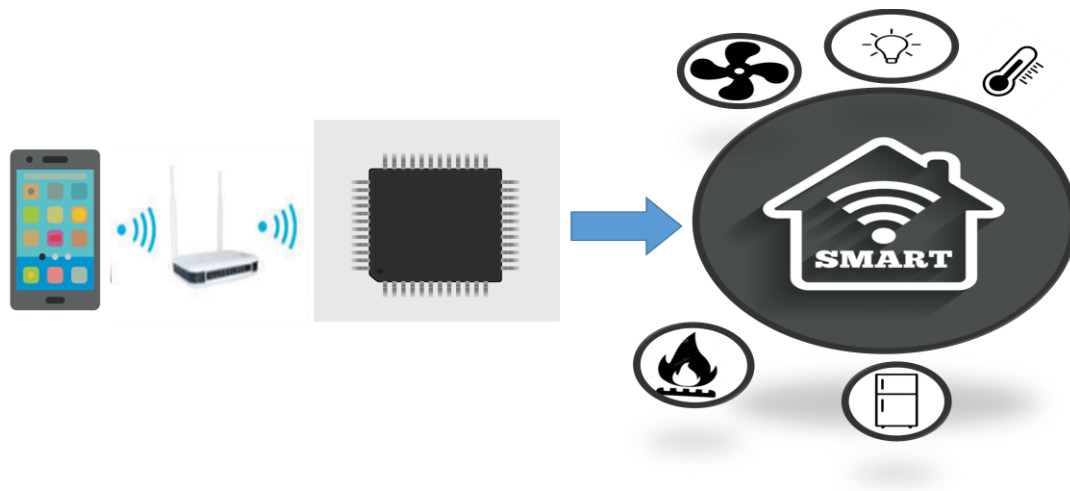

Figure 3. 2 WI-FI systems

3.2.3 GSM build home automation system

GSM (Global system for mobile communication) is a cellular technology that is flexible and digitized and is used for mobile communication. GSM-based home automation has captivated researchers' interest due to accessibility of mobile phones to everyone and the attractive features of GSM technology. Some of the GSM communications that have been thought in the smart home are SMS, GPRS, etc. The microcontroller that we use is coupled with the GSM module to govern and monitor the electronic appliances of the house, the microcontroller (Arduino) transmits data with the GSM module using consecutive number of communication protocol, then the microcontroller will decrypt and scan the arrived SMS with respect to three parameters (pin number, device number,

and action to be performed) if the PIN in the SMS match with the one in the system then the operation will be successful, if the PIN didn't match the microcontroller will disregard that SMS.

The App on the mobile phone of the owner gives the SMS messages with respect to his order and desire and gives this order to the GSM module that is coupled with the microcontroller to Manage and run the home appliances based on the owner command and orders. When the operation is been done by the certain actuators and the operation is successful the GSM module will send the owner a confirmation text message to the user mobile phone i.e. if the user is a way from home, so that the user can know if the operation is been done [23].
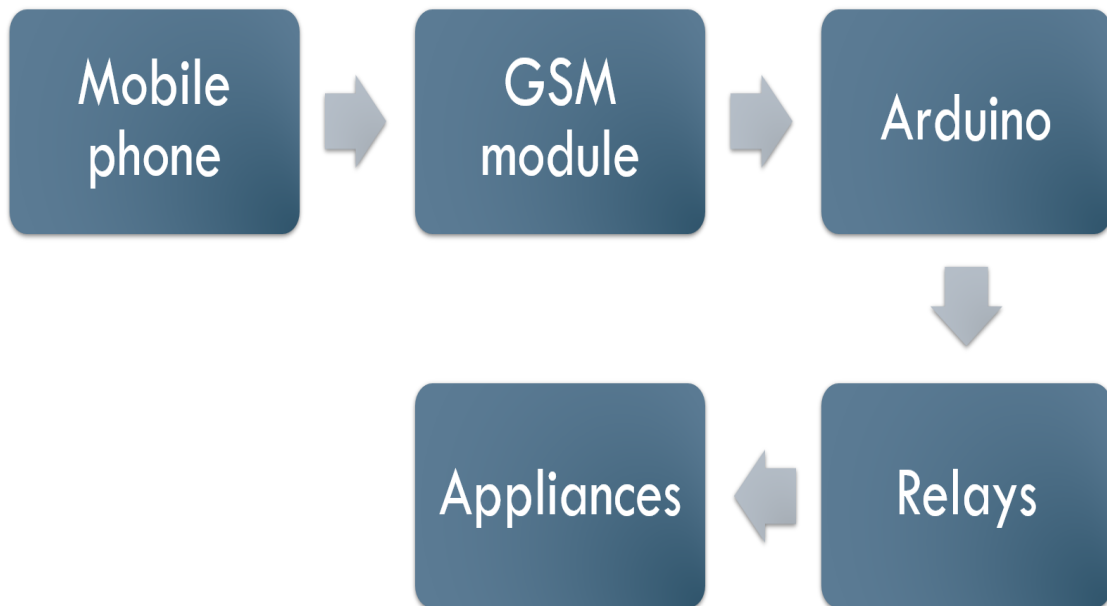

Figure 3. 3 typical GSM based system architecture

This system can be implemented in a way that the electronic devices can automatically restore power after unpredicted or unwanted power disconnection happens, it has the ability to remember which devices were functioning before the power outage and it can put them back to work after power is been restored. This restoration of power is achieved by making the use of EEPROM that is available in the microcontroller (Arduino).

This system of the SMS has some disadvantages in terms of the cost of the equipment that is related to it and also system reliability performance isn't good enough, also this system is only supports Bluetooth system you can't customize your desired medium.

Typical building blocks of GSM based home automation system sequence of instructions is been demonstrated in figure 3.1.

3.2.4 Cloud Build home automation system

This section discusses the procedure and implementation of a home automation system that utilizes cloud system infrastructure.

A cloud based home automation keeps its attention on the designing and establishing of a path gateway to gather data from home electronic sensors and subsequently send those data to the cloud server in order the data to be stored there [24].

There are three main building blocks in this cloud based system; to begin with there is cloud server which is the main component of this system it regulates server and customer data information as well as it controls hardware device conditions, in addition there is home server which serves in building the physical gadgets and grants and offers interface for the customer, furthermore there is physical interface part which builds and gives the attachment to the desired actuators and sensors.

The control of this system is achieved by using mobile phone application, the home system that looks out the home devices and sensors which also communicates to the cloud server that governs the information and gives the user update on the system by data which are to and from the mobile phone through the user orders, that means the home automation system can transfer information to the cloud server, which then will be analyzed to meet the demands of the customer [25].

Since cloud system is far more convenient than regional Web servers or control rooms, it appears likely that it would become the leading platform in the home automation space.

This cloud based system is Cost-effective, dependable, and pleasant, with a safe home automation system throughout the whole household. The fundamental advantage of cloud system is that it is flexible and can adapt to changing conditions such as the amount of queries, client locations in the entire world.

There are some drawbacks of using the cloud as your media in building home automation system; those disadvantages are related to amount of work needed in building such system also the amount of money needed is more in this system, also there are drawbacks related to the system privacy and security reliability.
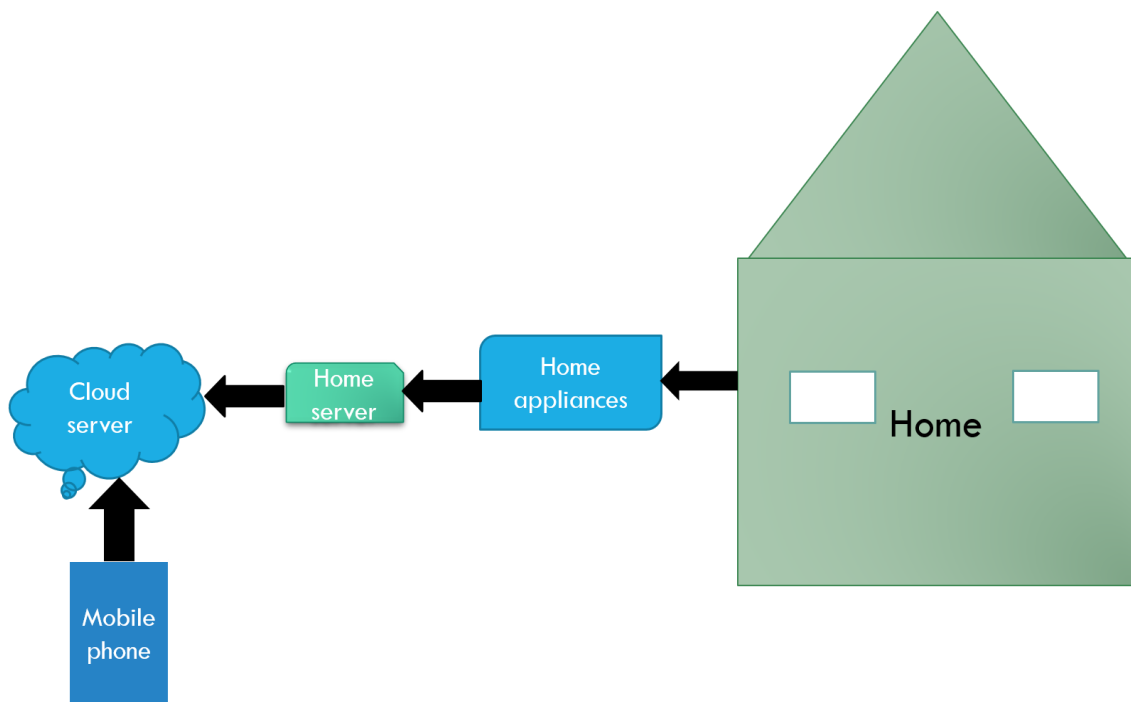
Figure 3. 4 typical cloud based system

3.3. Summary

Internet of things has been clarified as on the brightest future and amazingly convincing in building home automation system it offers the customer the ability to monitor and manage his home appliances remotely by using any internet network available to him.

The IOT gives the advantage of storing the status of appliances and offers the customer to see those data and analyze his home appliance conditions and offers the customer the ability to control his home from anywhere, anytime.

This chapter also discussed some of the communication media that we use in the home automation system, there is comparison between those different technologies and their advantages and disadvantages are been discussed.

The system technologies that have been discussed here are: Bluetooth based system, WI-FI based technology, GSM based technology and Cloud based technology.

Throughout this chapter there is brief discussion on each system and how to implement those systems in the smart home.

Chapter 04

4 Design and Architecture of Home Automation

4.1 Introduction

The designing of the system of home automation basically compromises of two main blocks which are software and hardware, the software part function is to program the microcontroller and the main control system and the hardware part work is to arrange the connection of the main controller and sensor networks to form a smart home, together a well planned and developed software and hardware parts make up a perfect home automation.

The architecture of the system is very important in home automation and to choose the optimal one is very crucial it can lead into either average system or outstanding system architecture. To choose the perfect system architecture the designer will ask himself some questions; how would devices and gadgets interact with a browser application, accept instructions, and report actual condition? Is this a server-client interface that establishes a link between the gadgets and the customer's application? How a real link would be created in the internet? Whether the user and the server exchange information by using a path way which the messages be transmitted on before arriving the server or the user end?

Based on these questions and several more are to be considered when choosing the system architecture of a particular system, the designer or the engineer will choose the architecture to the answer that he found those questions and based on the customer

specification, in addition to these consideration the engineer will also add another factor into priority and that factor been the way to minimize the cost of the system.

To interconnect several sensors and gadgets collectively as well as to the internet, Arduino was described as the primary micro controller. The Arduino is a little microprocessor that is programmable; and it was picked for its ease of use and features that it has among other microcontrollers [26].

In the next sections of this chapter there is description about the software design and also the hardware design and also the equipments used in designing such system.

4.2 Software implementation

In the software implementation there discussion on the way the microcontroller is programmed to make the actuators execute the desired function, the structure and formation of the program, web server and cloud storage used, and also the applications used to control and monitor the appliances.

4.2.1 Microcontroller

The microcontroller used is Arduino Ide, it can be programmed easily, it is designed by Atmel and the Arduino program can be developed using any available programming language that has processors that can generate binary codes for the intended machine processor.

The Arduino microcontroller's integrated development environment (IDE) is a merged platform that is developed in a java Programming language that is provided by the Arduino organization.

The platform has a editor which code editor which has attributes like cutting and pasting texts and also changing and replacing text, right indenting, gives easy one-click procedures for compiling and uploading programs to an Arduino board, as well as syntax highlighting, a comment box, a message terminal, a taskbar with regular action keys, and a structure of function menus are also included.

The Arduino's integrated environment has program coding formatting structure and rules and allows the programming languages such as C programming and C++ programming methods. The linking project is library that is contains with the Arduino IDE and put forward multiple conventional incoming and outgoing operations.

The program that is developed by the designer needs to do two principal responsibilities one that is beginning the sketch of the program and main program loop and processed and merged together with program main.

The Arduino IDE makes use of the program and changes the codes into a file which contains hexadecimal of encoding which are stacked into the Arduino board.

The structure of the Arduino programming can vary from one developer to another one due to feature that Arduino has which is that can develop a program using any supporting software available [27].

The Arduino program at least has two functions which are:

- Setup function: while the sketch begins to run following giving power the setup function is called one time, it is also the place that the sketch's parameters, inlet and outlet port configurations and as well as other libraries are set up.

- Loop function: the loop is called frequently inside the program main code once setup function is called. It where the system board is governed till it is turned off or get reset.

4.2.2 The web design

The web page design consists of the design of the front end which is by developing the way to reach the web and also the storage that will use to store the data and the sequence of instructions.

The front end design is about how the web page is reached by using HTML (hyper text markup language), it is a way which informs the computer the way to show a certain web page. The document papers are simple text writing folders which contains particular codes in which the internet browser interprets and the displays on the computer of the

user. The markup codes/tags inform the browser the way to discover and show the required page.

In terms of storing the data the use of cloud computing is necessary due to the availability of using distant servers in the net to regulate, store and operate data rather than utilizing one's own computer [28].

There are three departments in the cloud computing which are:

• Infrastructure as s Service (IaaS): this one obeys the standard utility approach, by delivering required computing and storage resources and charging the customer appropriately.

• Platform as a Service (PaaS): this service permits the design of the applications inside the frame of the supplier.

• Software as a Service (SaaS): the one here gives the user to operate a certain app on request by using a web browser.
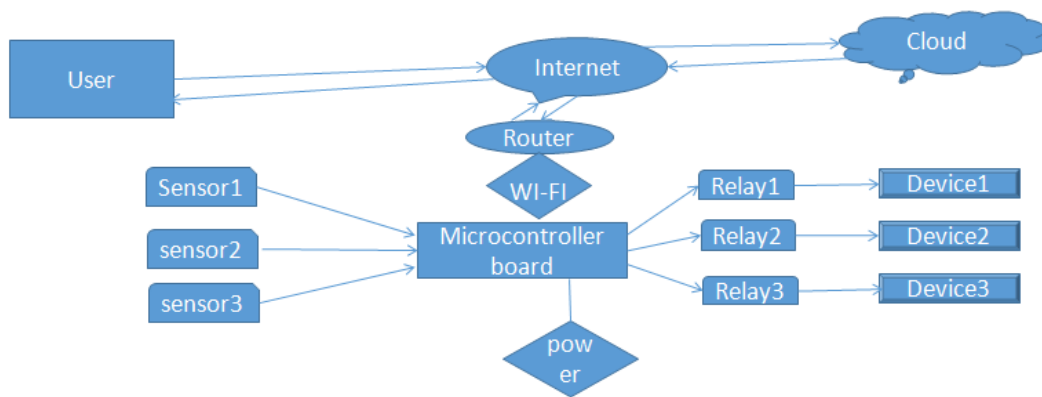

Figure 4. 1 Cloud storage (User to server)

For implementing the design of the automation system from when the connection of created to the moment the desired work is executed there are a number of staged that are will be described below. As described in figure 4.2 when the connection is achieved the variables of the sensors will be read by the system, there is a predefined threshold or

gateway levels for each of the sensors, then the data of the sensor are forwarded in to the server of the web system and then kept in the cloud to be examined at any moment. Whenever the sensor variables exceed the predefined threshold value then the corresponding buzzer will be alarmed and the desired work is been done by required appliance.

The sensing devices like temperature sensor, gas sensor and motion sensor data is stored and analyzed in the cloud, for instance if the temperature of the environment raises above the normal predefined threshold then the Air condition will turn on automatically to cool down the room and it will turn of when the room temperature goes back to the normal value [29]. The user/client has also the ability to control his home appliances through the web using any internet available to him.
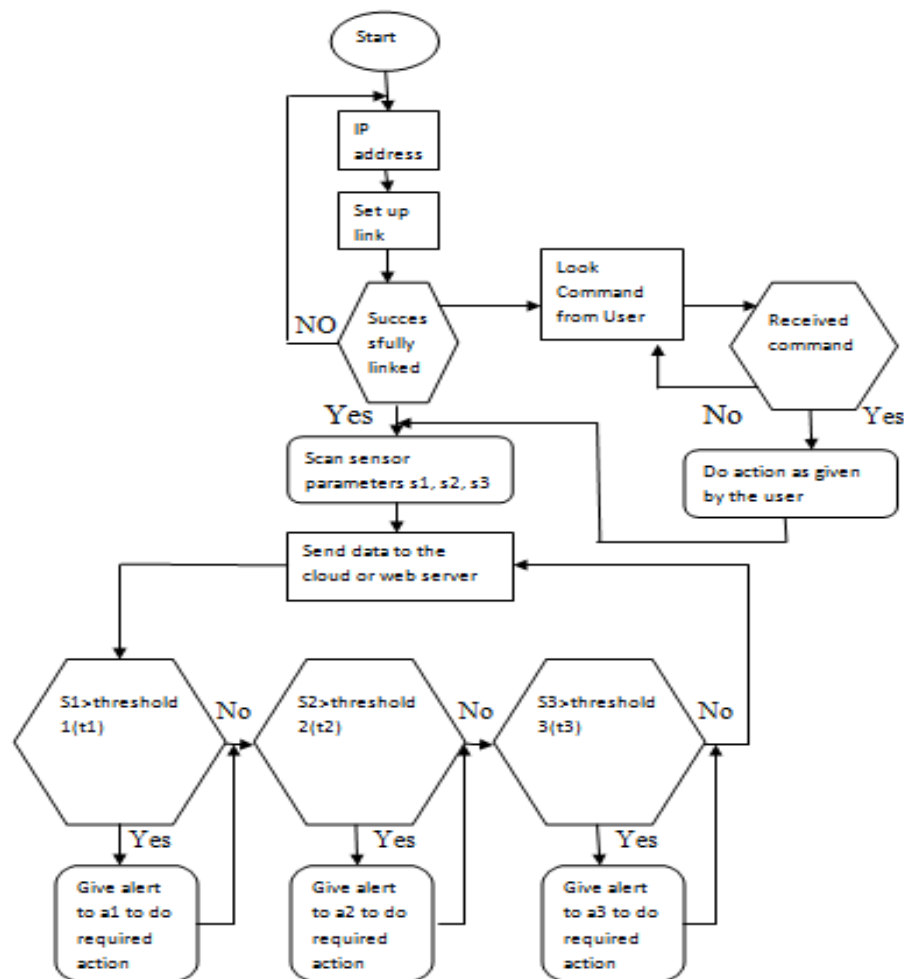
Figure 4. 2 typical implementation set up

4.2.3 Applications used in home automation

The smart phones with the operating platform system like Android which is having software stack, the Android platform gives the mechanism needed to start advancing apps on the Android platform by utilizing programming language like java.

The Android platform gives the designers the capability to create applications which exceptionally rich and inventive by offering an open platform for innovation. Designers have the complete access to the exact similar platform that is used by the applications.

There are several Android applications that are available for controlling and monitoring the home appliance and a discussion on of them is given below.

4.2.3.1 Blynk application

This application was developed for the use of IOT; it has the ability to monitor and do action on the devices remotely and has the feature to show and store the sensor status.

The application consists of three structures which are: the App, server, libraries.

The Blynk app gives you the ability to create extraordinary platforms for the required design, the Blynk server has the duty to allow all the communications in between the mobile phone and the hardware system by using either Blynk cloud or develop your own local Blynk server [30].

The Blynk libraries allow communication to your server and operate all the inlet and outlet instructions.

The Blynk has several characteristics which made it is use very easy; some of the characteristics are:

- Straight pin management that does not need coding

- Virtual pins make it simple to incorporate new operations and add on new features.

- New functions can be added frequently.

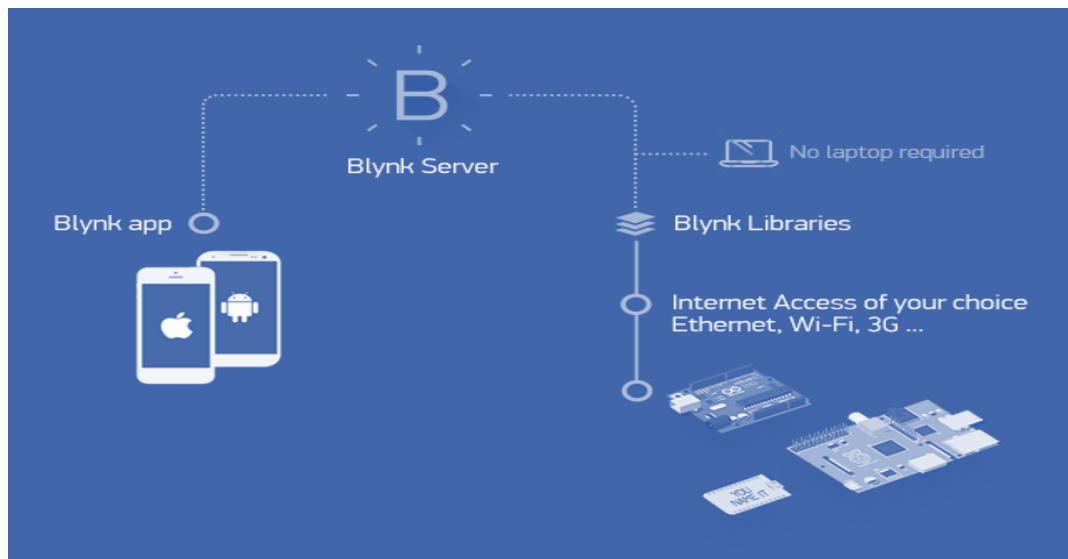- It has history data control and supervision.

Figure 4. 3 server communication of Blynk [31]

4.2.3.2 The Cayenne app and Web

Cayenne is mobile phone application that works based on the internet of things which is used for operating in the home automation also it can be used through web browsing, it makes use of an appealing user interface and prober good communication system protocol to enable the user to operate his/her project by using a microcontroller like Raspberry pi or Arduino.

Cayenne platform didn't require the knowledge of programming or coding skills it is an easy to use app or online platform which allows you to create any IOT project, this platform is free platform and developer didn't made a service which you have to pay if you want to use and developers intend to make this platform into more reliable service.

This application has some cool features which are:

- It gives the user the ability to add on new devices and control the devices remotely.

- It has instrument board which can be personalized with a simple drag and drop function if we need to link devices.

- It has the feature to arrange single and multiple time appliance activities for the purpose of making automation simple.

- It can be setup fast and easily.

4.3 Summary

In this chapter of thesis book there is a discussion on design and implementation of home automation, we have seen that to design such system there is two parts that need to design with good care and thinking which are software and hardware.

This chapter discussed the software part and it's important for integrating and efficiently designing the home automation system.

The software part contains the design and programming of the microcontroller used which is very crucial in the designing of the system, also there is discussion on the ways that the system communicates with the cloud server and web browser. In addition to this there is a brief discussion on how the sequence of action happens during controlling such system. Furthermore, there is a discussion on the applications that are used in controlling and managing the home appliances.

In the following chapter of this thesis book there is discussion on the second design part which is the hardware part and equipments needed for designing home automation system.

CHAPTER 05
5. HARDWARE INTERFACE

5.1 INTRODUSCTION

The hardware interface design is very important in designing a smart home; it is the core and fundamental part of the total design of the system. The main idea of this chapter is to give a brief discussion on the components and hardware used in the most home automation design.

5.2 Hardware Components

5.2.1 The microcontroller

Figure 5. 1 AT mega arduino [32]

The microcontroller used is Arduino Ide, it can be programmed easily, it is designed by Atmel and the Arduino program can be developed using any available programming language that has processors that can generate binary codes for the intended machine processor. The microcontroller is the core and brain of the system and its design needs to be as precise as possible. The Arduino ATmega 2560 microcontroller is the most used in this project [32].

There are fifty four input and output ports, it comes with just about anything the designer will want to start working with the microcontroller by solely plugging it into the computer by using a USB wire.The Arduino microcontroller could be charged by in two ways one way is to use USB cable and the other way is by delivering power from other sources.

The outside source of energy can be supplied from a battery or from a connecter which converts AC to DC; a 2.1mm wire which is positive in the middle could be plugged further in the power jack of the board for purpose of attaching the adapter. In the case of using battery as power source we inject in the ground terminal (Gnd) and input voltage terminal (Vin) port heads of the power coupler.

The Arduino board can tolerate from an external power of (6-20 V), and if one gives a voltage which is lesser than 7v but nevertheless the port which is 5V port might give voltage which is lesser than 5V and if this happens it will lead the board to get damage, on the other hand if user gives a voltage which is more than 12V this will lead to the board to get damage due to the overheat, so the user has to give power which is in the range of (7-12 V) to operate saver. It has a memory of 256 KB which consists of 8 KB memory for loading boot, 8 KB designated for SRAM, and 4 KB memory is for EEPROM.

The Arduino has certain specifications that are defined by the manufacturer and the user has to use it based on those specifications. The Arduino operating voltage potential is been specified by the manufacturer which is 5V the can use inlet voltage which is in

between 7-12v, it also has (54 input-output ports) in which 14 of them give an output which is PWM, there are also 16 ports which are Analog inputs. The DC current that each port uses is specified and it is 40 mA also the DC current for a given 3.3V port is limited to 50 mA.

The Arduino also has a flash memory which its size is 256 KB among (8 KB is utilized as boot loader), there is a memory which is SRAM and the size of it is 8 KB, in addition there is also an EEPROM memory which has the size of 4 KB, furthermore the speed of the clock of the Arduino is 16 MHz.

Additionally for the internet shield of the Arduino gives the operator the ability to connect it into the internet, it allows connection for maximum number of 4 sockets, the libraries of Ethernet allows laying down sketches that link up in to the internet [33].
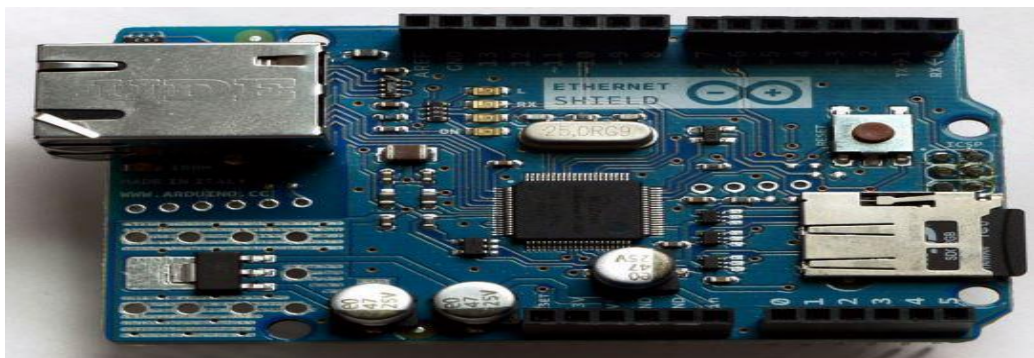

Figure 5. 2 Ethernet shield [33]

The Ethernet socket attaches with the microcontroller Arduino board via headers those lengthen above the shield which holds the structure of the pin intact.

The latest versions of the Arduino board there is pin out that is used for connecting the internet wire which is Rj-45 that is used for connection between the internet router and the Arduino board.

The ATmega also has micro-SD port and it is accessed in pin 4 and it meant for storing files and sending them into the internet, in addition the board also has a reset bottom to make sure that the Ethernet interface is possibly restarted when power is given unlike

the version before which was not having automatic reset and it needs to be reset manually.

This board also has PoE which means power over the Ethernet which is a new feature in it this feature is developed to take power from a cable which is twisted pair (5).

The shield specifications of the Ethernet board are:

- It has lower ripple and noise at the output in the range of 100m Vpp.

- The scale of the input voltage is in between 36V to 57V.

- The shield has protection against short circuit and overload currents.

- It has a good efficient DC converter.

To give power to the Ethernet module we will need another accessory it is not necessarily mean that it can powered from the Arduino, the ports (11, 12 and 13) are used for W5100 and ports like (50, 51 and 52) are used for SD card purpose and to select which one that we will work on we use port 10 to choose W5100 and we choose for the SD card by selecting port 4. The ports that mentioned above can't be utilized for purpose of general input and output, also the port 53 can't be utilized as general input and output purposes it is left as an output pin otherwise the SPI module will not operate normal. At a time only either the W5100 or the SD card can operate because both of them use the same SPI bus. Nevertheless, if you are utilizing the two circumferential of the program then it must be given into real care by the respective libraries, on the other hand if you are not utilizing in the program by one of the peripherals that time the developer might want to individually deselect it. In the SD card to be done this operation the developer needs to make port 4 as output and give high command to it, and in case of W5100 the developer has to give port 10 a high command. The Ethernet shield has a resetting pin which is used to reset the W5100 and also the Arduino shield.

5.2.2 Relays

Relay is also primary equipment in building any home automation project or any electrical related work. In simple words, relay is a electrical gadget that works on the principle of electro-magnetic and it is work is to separate and dynamically connect two channels.

Normally they are utilized for the purpose of been a media of transmission in between an electronic gadget that whom operates a lower voltage potential and electrical channel that operates at higher voltage potential. The relays can be build to in a way that a battery which is having DC voltage of 5V to turn on a main controller which is having 220V by coupling it to the MCU which means a very tiny relay device can make a electronic gadgets those operate on a high power ratings like bulbs, fans, and also very big ones like AC or Fridge operate.

The relay switch board could be segmented into 2 segments (one part in the inlet and other part at the output), the part of the input there is a coil that produce magnetic field in the moment a little potential coming out-of electronic channel and is coupled with it, where as the outlet part contains of contactors that attach or detach effectively.

Figure 5. 3 relay

There exist double pairs of contacts one that is normally closed (NC) and other which is normally open (NO), at the moment of the coil does not get energy the NO contact is not operating the NC contact is operating at this moment. If an additional voltage is given to the coil there will be current passing through it that will produce the effect of electromagnetic generation.

During the energizing the armature resists the force of the spring and it is brought close to the core in which results the closing the armature contact and also the NO contact. In contrast, when the coil gets de-energized the electromagnetic force that was appearing before disappears and armature contact goes back to its starting position and breaking the moving contact and the contact of the normally closed, these actions of closing and breaking the contacts gives the on and off actions of the appliances.

At the input of the relay there are terminals like VCC which is attached to the positive end of supply voltage, GND terminal which connected into the negative end of the voltage and the terminals of the relay these relay terminals depend on the number channels relay is having.

At the output of the relay there is a normally close, a normally open, a common ports, the number of each one depends on the number of channel relay we are using if we are using a four channel relay there will be 4NO, 4NC and 4COM ports, similarly in case of using 8channel relay there will 8 normally open, normally close and COM ports.
The relay has number of features with it and here we will mention some of the specifications and characteristics of relay:

- Relay has the ability to manage line that is producing signals having 10A and 30V DC also 10A and 250V AC.

- For the 8 channel relay they have trigger which is lower level and having displays that tells the status of the operation.

- The use of materials which are plastic for the purpose of dealing with high temperature and chemical solutions.

5.2.3 Motion sensor

The motion sensor that is frequently used is Passive Infrared Receiver (PIR) sensor or referred as Passive Infrared or Pyroelectric or IR motion which is a sensor that gives the user to sense and detects motion of the person in a range that the sensor can sense the

motion. The PIR features made them very popular in use in the home automation, they are tiny, affordable, need lesser power, and they are user friendly.

Passive infrared receivers are normally created from pyroelectric sensor which of round metal container mentioned above it has the ability to sense the levels of infrared radiation, as every object gives some radiation which means the hotter it is the radiation emitted increases.

The motion sensor normally is divided into two parts because the sensor is looking to sense and detect the change in the motion in the house but not the average of Infrared radiation levels [34].
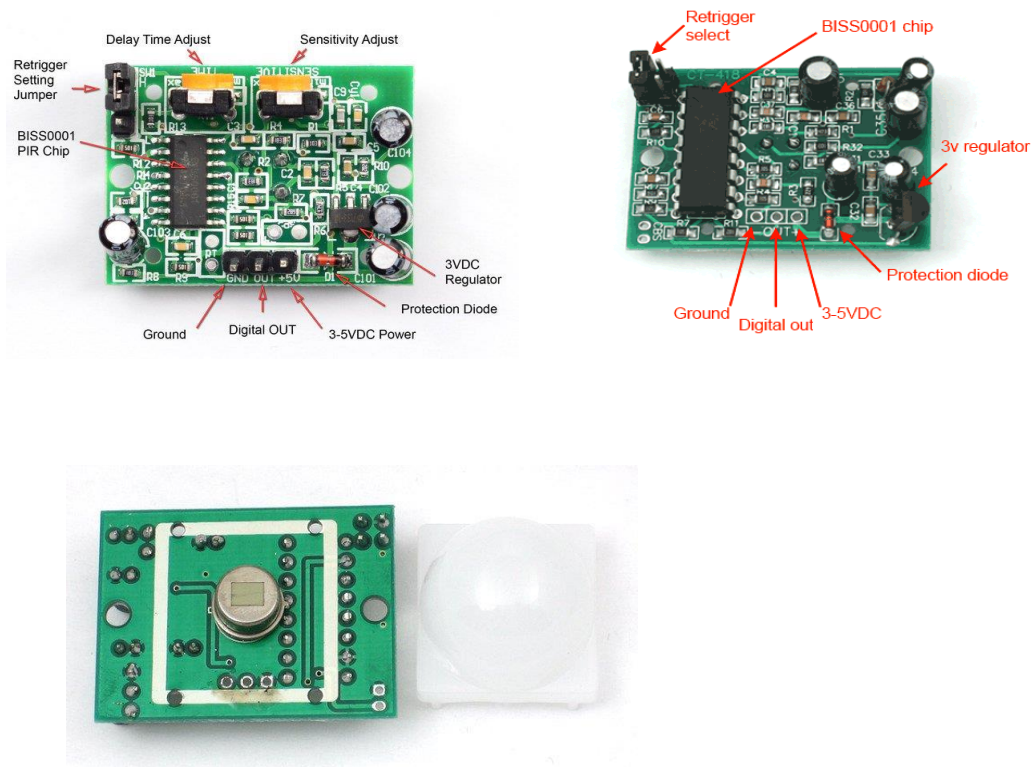

Figure 5. 4 PIR sensor [34]

The pairs of levels are wired up in essence that the two halves cancel one another, and if certain cases one half gets IR radiation increase or decrease than the other then there will be high or low change in the output.

In addition, there are also some other electronic devices that help the PIR sensor such as resistors and capacitors and there is also BISS0001 IC which is takes the outlet of the sensor and gives a small operation on it for the purpose of emitting a digitalized outlet pulses from the analog sensor.

PIR sensors are useful for several fundamental activities or goods which require to simply detecting whenever an individual has gone or invaded the place, or has neared, because the modern PIRs have so much more changeable configurations and a header inserted in the ground/out/power lines.

These sensors need lesser power and their prices are affordable somewhat durable, do have make it extremely spectrum, and are simple to use. The sensor can't determine the amount of individuals in the home or the distance they are to the sensor their lens is attached into given distance.

5.2.4 Temperature and humidity sensors

There are several sensors that are used as temperature sensor one of them is DHT11 and other is LM35 these sensors are frequently used in the projects of home automation.

DHT11 is one of the temperatures and also humidity sensing devices coupled to a regulated digital signal output are included. It offers high assurance and magnificence durable stability by engaging a new fresh digital-signal purchase methodology also temperature and humidity detecting mechanics [35].

The sensing device has the ability to link to an increased 8-bit microcontroller and also combines a resistive kind humidity computation device and also an NTC temperature measuring device, providing great resolution, prompt reply, non-intervention capability, and lesser price.
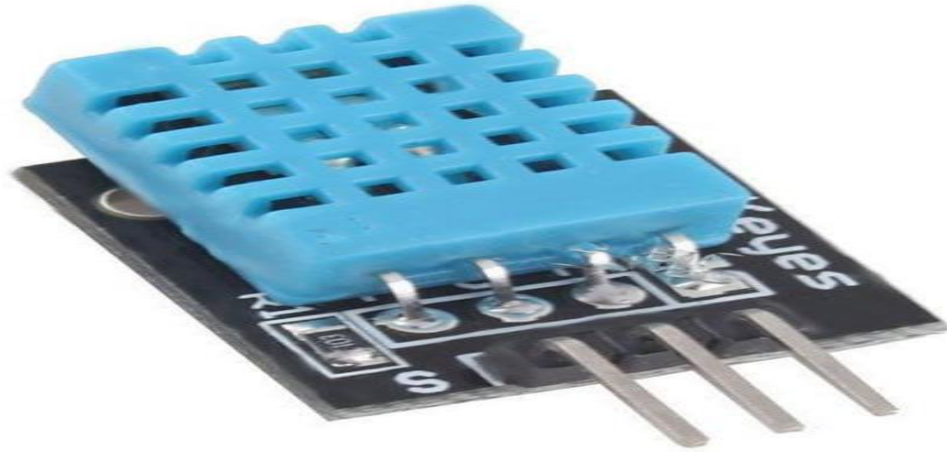
Figure 5. 5 DHT11 sensor [36]

The sensor can be given a supply voltage of in between 3V and 5.5V DC, and the signal is send to the sensor after 1 second of the moment the power is given to the sensor due to the need the sensor condition to go from the unstable condition, sometimes there could be some distortion to remove those distortions a capacitor of 100nF is been given for filtering power in between VDD terminal and ground (GND) terminal.

For any DHT11 component that is used in the sensor is thoroughly measured in laboratories to ensure the highest level of humidity accuracy. The use of only single-wire serial interface simplifies network implementation. Its tiny width, little energy use, and signal available bandwidth of approximately 20 meters make it the finest alternative for a multitude of scenarios, involving some of the most challenging ones.

Including a reliability of 1°C and 1 percent, the system can sense temperature between (0°C to 50°C) and also humidity in between (20% to 90%).

This sensor is well used in measuring the temperature and humidity change in an area, the weather stations also use this sensor as measuring device, also the sensor is used as automatic control of the weather and measuring and overseeing environment conditions.

LM35 is also another sensor that is used in developing the home automation temperature sensing, the interface of this sensor and Precision synchronized circuit temperature sensors with a voltage level precisely proportional to the Degrees c temperature make up

the framework. This sensor give in little impedance, direct produce, and precise inherent adjustability allow connection to display or command hardware unambiguously.

Generally, the sensors that detect temperature need the presence of thermocouples to compute the temperature of a signal; the thermocouple produces voltage due to involvement with respect to the temperature change.
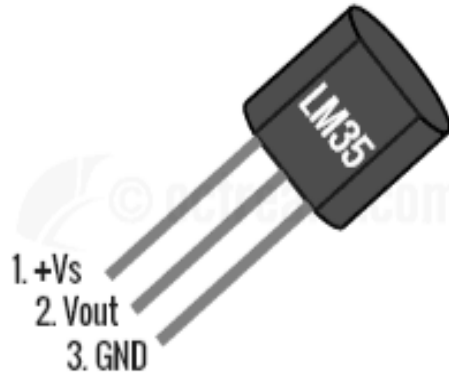

Figure 5. 6 LM35 sensor [37]

The LM35 Sensor is a detector that produces a relative analog response to the current temperature. The voltage outlet can be simply translated into Degrees c values.

The temperature device's judgment is all about the heat or cold of an object. The volt which passed through the diode serves as just the sensing devices' operational basis. If the voltage is increased, then temperature goes up, and there is a voltage drop seen in between the transistor endpoints of base and emitter, then the sensors registers it. When the voltage difference is increased, the device produces a plainly signal that is proportional to the temperature directly.

5.3 Summary

This chapter was intended to give a brief discussion on some of the hardware interfaces used in this automated system, choosing the optimal one on each hardware device is the job of the designer.

These hardware devices are available in the market in different categories and each have certain specifications so the designer chooses the one that suites his design and also can meet the customer demand.

Some of the devices that have been described in this chapter are the microcontroller Arduino, Relay, the temperature sensor, motion sensor, but however there are also a lot other devices that exist in this system.

Chapter 6

6. Conclusion

IOT is most researched and famous topic in modern days, it attracted most of the people and investors by it's fascinating and smart characteristics and also the advantages they have on the daily lives, it made the life on earth simpler, smarter, and most importantly very secure one. In addition, IOT is one of the prime core and principles of the home automation that we are using today, through using IOT you will have the ability to control your home appliance outside home or inside home.

The home automation is referred as a way of controlling and monitoring those home appliances remotely and automatically. Home automation gives the owner of the house the capability of controlling his home appliances remotely and automatically.

A home appliance is the electronic gadgets such as lights, AC, refrigerator, etc. those are used for household and intended to do specific job. Automation means the procedure of making devices to work and control automatically by either remotely or close to the devices, this reduces the human interference but it will not eliminate the human interference completely. The home automation system gives you the management of the power consumption of your house and minimizes the unnecessary use of energy which decreases the total power consumption, subsequently which reduces the price money that you would have to pay for the electricity bill The home automation system gives you the management of the power consumption of your house and minimizes the unnecessary use of energy which decreases the total power consumption, subsequently which reduces the price money that you would have to pay for the electricity bill.

In the future this home automation system will grow and it will become really famous as predicted by many researchers, with the advance of the internet technologies this system will take over the normal home that we live in these days, they can have the ability to track day to day working i.e. water use, power consumption, fire detection, and security.

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