SMART HOME AUTOMATION USING A MOBILE DEVICE

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
MOHAMED ELAGELI M. GHET

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Computer Information Systems

NICOSIA, 2018

MOHAMED ELAAGELI M GHET
SMART HOME AUTOMATION USING A MOBILE DEVICE
NEU 2018

SMART HOME AUTOMATION USING A MOBILE DEVICE OME

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
MOHAMED ELAGELI M. GHET

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Computer Information Systems

NICOSIA, 2018

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: MOHAMED GHET

Signature:

Date

ACKNOWLEDGMENTS

I am extremely thankful to my supervisor Prof.Dr. Dogan Ibrahim, who has given me the support, advice and help from the beginning until the end the stages of the working and writing on my thesis.

My deepest gratitude goes to the chairperson of the Computer Information Systems Department, Prof.Dr. Nadire Cavus, who has given me many useful suggestions and comments for my thesis.

I express my very gratitude to my parents, wife, daughter, brother, sister and everybody in my family who supported and encouraged me throughout my years of study.
My thanks and heartfelt love would be dedicated to my late grandfather, late grandmother and late uncle for the immeasurable love and encouragement that were in my life.

Eventually, I would like to thank my friends from all of my heart for their help and support since my started study until now.

To my parents, wife, daughter, brothers and sister …

ABSTRACT

People use the technology to make their everyday lives easy. They may need to communicate with their homes from anywhere in the world and at any time of the day. The most popular way is using their smart mobile phones to communicate with their homes. The most important thing in smart homes is the protection from disasters such as fire and gas leaking. In this thesis a smart home automatic protection system has been developed that is controlled by an application running on a mobile device. The developed mobile application can control and monitor the smart home via the Internet and using the SMS to send commands. With the help of the developed mobile application, the user can open/close the doors, open/close the windows, open/close any pump in the house, open/close any fans, open/close lights in the home, and also open/close the air-conditioning system, for example before coming home. The user can monitor the ambient temperature, humidity and most importantly the gas level at home. The novelties of the developed system are that the system can automatically control the firefighting and gas leaking. Additionally, one of the most important novelties of the developed mobile application is that the user can get feedback from the control actions to ensure that the required control actions have been implemented successfully.

***Keywords*:** Mobile application; smart home; internet; SMS; home protection

ÖZET

İnsanlar günlük yaşamlarını kolaylaştırmak için teknolojiyi kullanmaktadırlar. Birçok durunlarda dünyanın neresinde olurlarsa olsunlar ve herhangibir zamanda evleri ile irtibata geçmek isteyebilirler. Bu iletişim de günümüzde en popüler ve en kolay olarak akıllı cep telefonları ile olmaktadır. Akıllı evlerde en önemli problemlerden biri evi yangın ve gaz kaçağı gibi felaketlerden korumaktır. Bu tezde, akıllı bir evi uzaktan korumak için cep telefonu destekli mobil bir sistem geliştirilmiştir. Geliştirilmiş olan sistem akıllı telefonlarda çalışan bir uygulama ve buna bağlı olan donanımdan meydana gelmektedir. Sistem, akıllı bir evi SMS ve Internet komutları sayesinde uzaktan izleyip control edebilmektedir. Geliştirilmiş olan mobil sistem sayesinde kullanıcı uzaktan kapıları ve pencereleri açıp kapatabilir, herhangibir pompayı veya serinliği uzaktan çalıştırabilir, evdeki ışıkları uzaktan yakıp söndürebilir, ve örneğin eve gelmezden önce klima istemini çalıştırabilir. Kullanıcı evdeki sıcaklık ve nem verilerini, ve en önemlisi evde olabilecek gaz kaçağı seviyesini anında uzaktan izleyebilir. Geliştirilmiş olan sistemin bir yeniliği yangına ve gaz kaçağına karşı otomatik olarak müdahele edebilmesidir. Buna ilave olarak sistemin diğer bir yeniliği ise verilmiş olan kontrol komutlarının yerine getirilip getirilmediğini anlayabilmek için kullanıcıya geri dönüş vermesidir. Bu geri dönüş sayesinde kullanıcı komutların başarı ile yapıldığından emin olabilmektedir.

Anahtar Kelimeler: Mobil uygulama; akilli ev; internet; ev koruması

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

IoT:	Internet of things
GSM:	Global System for Mobile communications
SMS:	Short Message Service.
LCD:	Liquid crystal display
GUI:	Graphic user interface
LED:	Light-emitting diode

CHAPTER 1

INTRODUCTION

This chapter provides the introduction, thesis problem, aims and significance of the study for IoTs, automation and control of a smart home.

The Internet of Things (IoT) is an area of technology that is in its peak of development which continuously improves people's living standards by digitalizing the physical world like homes, offices or vehicles, this digitalization is done by connecting different technologies and applications to the objects around (Li, 2011). IoT enables objects to be detected and controlled using various communication means, this makes physical world integration into computer world which provide proficiency and accuracy. (Bingol et al., 2014). In recent years, the mode of interaction with home appliances is fast changing, this is due to the development in IT and wide use of mobile devices and cloud-based services (Uhlemann, 2015).

Research in the IoT and smart homes resulted to several smart homes models, which includes setting a server that connect all the objects (Kumar, 2014).Other models included the connection of the objects with the cloud (Yang et al., 2010). There are several alternatives available for smart homes connections which includes Bluetooth, Wifi and sensors (Chew et al., 2016).

Home automation is becoming very popular due to its immense contribution in substituting human hand works, the connection is either remotely or by using local network (Jain et al., 2014). Automation minimizes human hardworks, save time and power efficiency, where everyone can manage and control different objects within minimal time. (Gandhi et al., 2016). Smart Home afford comfort, power performance and safety (Adriansyah and Dani, 2014). Also, smart homes interact with the smart power network to have sustainable electricity (Li et al., 2016).

The recent developments in IT gave birth to a small open source microcontroller called Arduino which serve as a mini computer used to build electronic projects. It has Bluetooth and Wi-Fi support features which enabled internet connectivity and data transfer from/to different objects (Aru, Ihekweaba and Opara, 2013). Nowadays,

Arduino is widely being used as a controller for different home appliances due to its high functionalities, inexpensive, easy to use as well as its GSM and Ethernet supports (Zeebaree and Yasin, 2014).

Nowadays, usage of mobile phones in accessing information and services is increasing rapidly due to its simplicity and portability. Mobile phone is an easy way to access web services which allows communication and interactions of applications with each other (Kumar, 2014).

This thesis makes a relationship between CIS and engineering by developing a mobile application that can communicate, respond and interact with hardware and devices. This is useful for the CIS students so that they become familiar with some other related fields.

1.1 Thesis Problem

There are different applications designed by various researchers for controlling smart homes, but one of the problems is that most of those applications needs an internet connection for it to work properly. Also most of these systems or applications have limited specifications or functions that it performs.

1.2 The Aim of the Study

The aim of this thesis is to develop a mobile application for controlling smart home using Short Message Service (SMS) and internet using Arduino to control the system.

1.3 Significance of the Study

This system will help people to manage their home devices from a far distance without visually present, it is also very useful because it does not require internet connection to work, it uses SMS to communicate with the devices. It will also serve as a guide for further researchers whom wish to pursue their studies on IoT and smart home. The developed system make use of sensors to capture data, and in some cases it automatically make a decision without human intervention, e.g. when it sense a smoke or fire accident, both windows and doors will automatically open, and water will be sprayed from the pump. Then the system return feedback to show the hardware situation.

1.4 Overview of the Study

This Thesis consists of six chapters which are Introduction, Related Research, Theoretical Framework, Systems Development, System Implantation, And Conclusions and Recommendations.

Chapter 1 give details about the general introduction of IoT, automation, the thesis problem, the aim of the study, the significance of the study and overview of this study.

Chapter 2 presents the related research work.

Chapter 3 introduces the theoretical framework.

Chapter 4 talks about the system development and architecture…etc.

Chapter 5 the system implantation was discussed in details.

Chapter 6 is about the conclusion of the study and recommendations of the thesis, suggestions, and for future studies.

CHAPTER 2

RELATED RESEARCH

This chapter presents the related work of IoTs, automation, smart home and controlling by many methods such as mobile application, Bluetooth, SMS and web based.

2.1 Controlling a Smart Home

Fitriyah et al. (2016) designed a remote control based on a button which is outfitted with LCD screen. The LCD screen reduced the quantity of buttons as choices might be displayed in it. In addition, The LCD screen would return visual feedback of observability for users.

Kumar and Pati (2016) proposed a low-priced and flexible solution to the smart home. Home devices can be controlled by different technologies like GUIs and the internet. The house owner can monitor his family and the home devices from anywhere and at any time he wants. It improves home safety where the owner became alerted in case of any emergency to take the necessary action at appropriate time. The system minimizes frequent supervision and management of home devices as well as proper handling of guests in case if the owner is not around. The system also helps in saving electrical energy by proper scheduling and monitoring of devices.

Gandhi et al. (2016) developed smart industrial system where by all machineries and electronic devices in a company or industry can be controlled via an android application, a message is sent when a sensor is active or inactive.

Li et al. (2016) developed smartphone applications for an energy-efficient to control smart phone applications. Two versions of the application was developed; the first is iSHome1 which can interact with power plugs, and the second version is iSHome2 which communicate with the home management server. Both 2 versions uses Bluetooth as means of communication.

Zhang et al. (2016) developed a smart home control system using speech signals, the system takes a voice command as an input, then translates speech signal to text

message. A robot will then use the text command and use it to perform a task. This system help old-aged people or people with disabilities in performing different tasks.

Khaled et al. (2016) designed a system for controlling and monitoring of submersible pumps using SMS with GSM modem. The system allows a user to control and monitor the pump remotely from anywhere, in which information about the state of the pump can be accessed or altered. This system works very fast and required minimal resources compared to other systems.

ROY and WILLIAMS. (2016) proposed a wireless control system for greenhouse which depends on Zigbee to minimize human hard work, the system was designed using Visual Basic then hosted to a Web server for easy communication with devices. A mobile phone was synchronized with the software using (TEAM VIEWER) to keep the devices in synchronization with the server, also a wireless camera was attached to monitor the real time activities. This system is mainly used for monitoring the three basic parameters for plant growth; humidity, temperature and light intensity. The results were truly consistent and accurate. The system successfully overcome several weaknesses of the current systems by decreasing the power loss, support and complexity, at the same time implementing a flexible and specific form of saving the environment.

Ransing and Rajput. (2015) developed a Wireless Sensor Network smart home system to help elderly people to work easier and faster. The Wireless Sensor Network (WSN) has many sensor nodes attached for sensing different environmental parameters, like temperature, LPG and gas leakage detector, it also have the capability to detect which door is opened/closed. In case of emergencies, a notification message will be sent via SMS, and also trigger an alarm system for quick notification.

Adriansyah and Dani. (2014) created a small smart home control web based system using by using Arduino which depends on WLAN connectivity. The system is able to control different home devices like turning on/off lights, temperature control and alarms and etc. The system is built up with HTML5 where the status of objects that are connected to the system can be monitored and controlled via a website. Lights switches can be turned on/off, sockets can be activated or deactivated.

Das et al. (2014) also developed a home appliances monitoring system using GSM phones, where one can easily send an SMS command to control and receive the operation status of each device.

Zeebaree and Yasin. (2014) implemented an electrical devices control system in which home used electronic are remotely being controlled and monitored using a microcontroller via a GSM network. A message command can be sent to the system via a mobile phone from anywhere without internet connection. This system is very flexible in which electronic devices can be added or removed to the system.

Kumar and Lee. (2014) developed a low-cost Smart Living System that can be controlled with android mobile application by using Bluetooth or internet connection. The system has an integrated home security and alert systems for switching of lights, sensing of temperatures and motion detection and alarms to prove its effectiveness and feasibility.

Kumar. (2014) designed a smart home monitoring system which is flexible and standalone. This system depends on the micro-web server hosted via Arduino microcontroller. This system make use of Google speech recognition to translate voice commands into text commands. It has many functionalities which includes light switching, temperature/humidity sensing, sirens alert in case of smoke/fire accidents.

Bingol et al. (2014) built a web-based system for smart home automation using C# programming and PLC device for information storage. The system can be controlled via PC and operator terminal called DOP-AS35THTD. This system detects and controls home security treats like; smoke, gas, movement, door opening/closing as well as lightening or climate change.

2.2 The Summary of the Related Research

The below table summarises the related research papers based on the authors, methodologies used which will directly show the missing gaps, and then based on the table I Chose my criteria.

Table 2.1: Summarises the related research

Method / Author	remote control using LCD	control speech signals	GUI interface	control by the internet	control by mobile application	control by SMS	control by Bluetooth	web-based	control by PC	Firefighting control	Gas control	Get feedback
Fitriyah et al. (2016)	*											
Zhang et al. (2016)		*										
Kumar and Pati (2016)			*	*								
Gandhi et al. (2016)					*							
Khaled et al. (2016)						*						
Li et al. (2016)					*		*					
Zeebaree and Yasin. (2014)						*						
Bingol et al. (2014)								*	*			
Kumar. (2014)					*			*	*			
Jain et al. (2014)								*				
Das et al. (2014)					*	*						
Kumar and Lee. (2014)				*	*		*					
Adriansyah and Dani. (2014)				*	*			*				
Ransing and Rajput. (2015)						*						
ROY and WILLIAMS. (2016)								*				
Smart home automation			*	*	*	*		*	*	*	*	*

CHAPTER 3

THEORITICAL FRAMEWORK

3.1 Internet of Things

In the literature, many researchers have defined Internet of Things as a system that is interconnected with sensors and actuators which are in devices and used to leverage data that is obtained through sensors (Arpita et al., 2015; Chase, 2015). Arpita et al. (2015) refers to the Internet of Things as the Internet of Objects implying the use of objects being connected to a wireless network and self-configuring system for example a household. Cisco Systems, Inc. describes the Internet of Things as:

"The Internet of Things (IoT) is a computing concept that describes a future where every day physical objects will be connected to the Internet and be able to identify themselves to other devices. The term is closely identified with RFID as the method of communication, although it also may include other sensor technologies, wireless technologies or QR codes."

The three main components of Internet of Things that enable ubiquitous computing between interconnected devices are explained below:

- ***Hardware:*** These include a group of embedded communication tools, sensors as well as actuators.
- ***Middleware:*** These refer to data analytical tools that are used and on demand storage services.
- ***Presentation:*** The output should be presented in an easy way that is easy to visualize, understand and interpret.

Arpita et al. (2015) explained that for Internet of Things (IoT) to function properly and achieve desired results, it is crucial to have the following technologies in place:

- ***Radio Frequency Identification (RFID):*** This technology is key for embedded communication as it allows the design of microchips which are used for wireless data communication. The same technology is also available in access control

applications as well as transportation facilities such as ticket replacement and registration tickets.

- ***Wireless Sensor Networks (WSN):*** This refers to a group of intelligent sensors which are responsible for collecting, processing and analysing vital information that has been obtained in different environments. The data obtained from the sensors are distributed among various nodes and sent for further analysis.
- ***Addressing Schemes:*** A system must be able to identify 'Things' for the success of IoT connecting elements for easier identification of location and other functionalities.
- ***Data analytics and storage:*** The creation of data is one of the outcomes that are recorded when using IoT it is therefore crucial for the data to be well analysed and stored. Artificial intelligent systems are often developed with algorithms to facilitate this process and data is either centralized or distributed as need arise.
- ***Visualization:*** This is a vital step in IoT as it facilitates the interaction between the user and the environment. Interfaces used for such devices should be attractive and easy to navigate for users.

3.1.1 History of internet of things

The origin of having networked devices began as early as 1982, with the first internet connected machine being a Coke machine at Carnegie Mellon University. The machine had the ability to detect whether loaded drinks were cold or not. In 1999, IoT started being well known through the Auto ID Centre at MIT as well as through market analysis publications. The convergence of multiple technologies in 2015 resulted in the vision of the Internet of Things being evolved starting from wireless communications to embedded systems (Arpita et al., 2015).

3.2 Introduction of a Smart Home

Smart homes have become popular with home equipment being controlled remotely such as refrigerators, washing machines, air conditioners and other gadgets using sensors which are controlled directly by the owner of the equipment (Arpita et al., 2015). Wi-Fi is used as the backbone to enable the transfer of higher bandwidth as well as higher sampling rates that eventually results in better home management as well as energy conservation. Furthermore, smart homes have the ability to provide enhanced security as well as ecological sustainability for example an air conditioner connected

on the Internet of Things can make more informed decisions using intelligent sensors and web technology rather than making simple manual and fixed decisions (Sumithra et al., 2016).

Smart air conditioning systems are able to predict house occupancy times based on the saved history and by so doing the air conditioner can automatically switch on to achieve the desired results the time the house occupants arrive (Arpita et al., 2015). Furthermore, the researchers explained that, enhanced comfort can be achieved through the use of smart homes assisting the elderly people with technology interconnected to do daily chores such as cleaning, cooking, shopping and laundry. In addition, reminders can be set to remind patients of their daily medicine dose through the use of intelligent home systems. These systems have the ability to monitor patients and send signals to the caregivers so that they can respond in a timely manner before extra costs such as hospitalization costs are incurred. It is crucial before implementing such systems to ensure that the smart home system is secure and trusted.

3.2.1 Automation of smart homes

Automation of Smart homes is an emerging technology that is designed to provide a more convenient, comfortable, energy saving and secure system to its occupants. Marius et al. (2016) described that by adding intelligent systems to house environments it has the ability of increasing the quality of life.

3.2.2 Applications and technologies

Marius et al. (2016) explained the various applications and technologies that are used in smart homes. Figure 3.1 below depicts the various technologies that work hand in hand in order to have the desired results. The components depicted are explained in detail below:

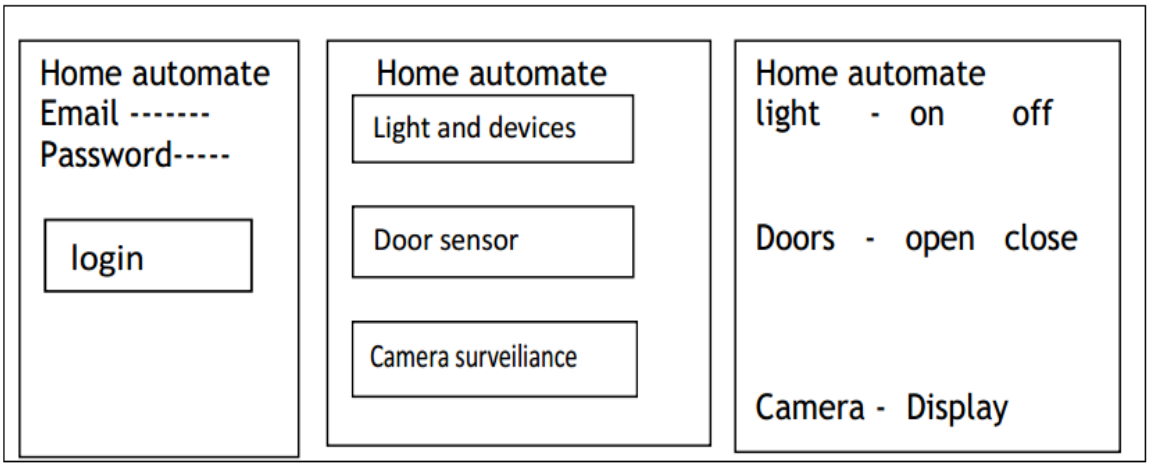

Figure 3.1: Applications of Internet of Things (Marius et al, 2016)

- ***Light and Devices:*** The status of the outside light can be checked remotely by the house occupant and switched off remotely without the occupant getting out of bed. Such devices are an advantage to the elderly and people with mobility problems allowing them to control devices and switches remotely without the need to move.
- ***Webcam Surveillance:*** This involves a video being streamed live through a webcam of what is currently happening in a certain environment. The camera captures the images in real time and the images are saved, viewed or even sent through the network as email attachments.
- ***Magnetic Door Sensors:*** These magnets have the ability to detect when a door is open or closed, the magnets are normally cased in a plastic shell to protect them from bad weather. When the magnet is less than 0.5 inches, the reed automatically closes.

3.2.3 Automation ways of smart homes

In order to fully understand how automation of smart homes work, Kodali et al. (2016) gave an example of a house owner expecting a visitor at his house, however the visitor arrives when the owner is not there. The moment the visitor arrives, the owner receives a video call and the owner now has the option of pressing different options besides 1, 3 will turn on lights, 4 will switch on the fan and 5 will turn on the air conditioner or the owner can disable the security system remotely. The same happens when a visitor

leaves the house in the absence of the owner, the owner can switch off the appliances and turn on the security system.

The camera that is connected to a microcontroller is helpful in assisting the owner to make well informed decisions based on whether the person is a guest or the person is an intruder. The system is solely dependent on the owner's discretion on the actions he/she chooses to take. The following actions can be done based on the user's discretion:

- The surveillance camera outside captures the image of the guest or intruder and emails it to the user.
- The user checks the received image to see if the face of the person is familiar or not.
- If the person is a visitor, the owner can disable the security system and welcome the guest into the house.
- If the face is not familiar and the owner suspects that the person outside is an intruder, he or she can remotely forward the captured image to the police station.
- The police investigating team can then make well informed decisions on how to get to the house and arrest the intruder.

The system can also be synchronised by integrating the system with a voice call feature that allows smart phone applications to control devices and appliances within the house by making use of voice and directing devices to do certain actions (Marius et al., 2016).

Figure 3.2 below, explains a flow chart with the various steps that the owner has to follow when a guest or an intruder visits. The diagram below explains the process in detail:

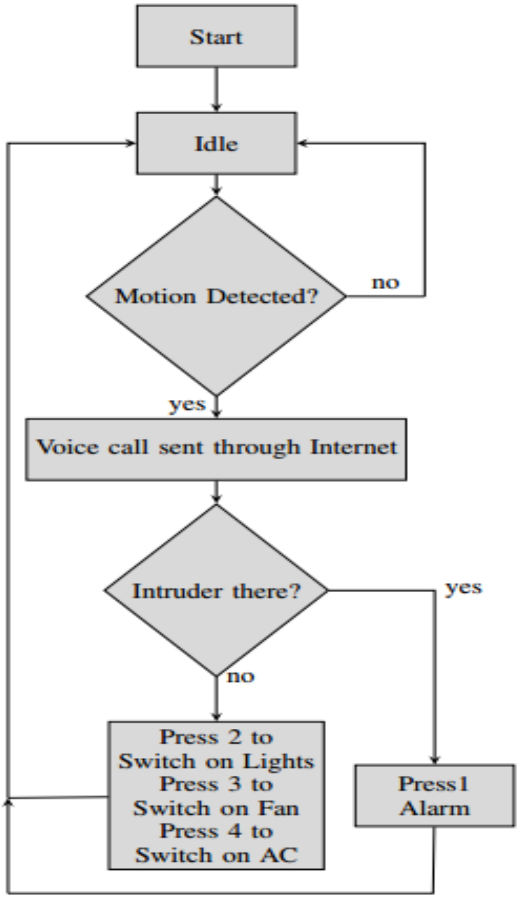

Figure 3.2: Steps taken in controlling a smart home (Kodali et al., 2016)

3.2.4 Protection of smart homes

In the literature, many researchers have explained the importance of protecting homes and the invasion of technology has resulted in even more secure residential homes than before. ElectronicDesign (2018) explained that house owners are investing in security schemes in order to fully protect their homes and the internet is controlling energy meters, lighting systems, thermostats, irrigation systems, pool management systems, video streaming boxes and many other devices and appliances through the use of web sites which are interconnected to smartphones enabling owners to control such devices remotely. Figure 3.3 below shows an Internet of Things enabled home that has been connected remotely and managed by the owner.

Figure 3.3: IoT smart home with connected devices and appliances (ElectronicDesign, 2018)

3.2.4.1 Firefighting

Smoke detectors in the house are linked to your smartphone sending push messages in the event that smoke is detected. Notifications sent range from false alarms, low voltage levels in batteries to genuine fires (Lin & Bergmann, 2016). In addition, smart smoke detectors are can be linked and monitored from the central office and in the event of fire, notifications are sent and the fire brigade can just appear. The air handling system can be shut remotely in order to stop the spread of fire or smoke allowing people to evacuate the house. Alternatively some systems will turn on lights and offer spoken directions with instructions on what to do.

Arpita et al. (2015) explained that the use of Internet of Things in firefighting may involve systems being integrated with cameras so that in the event of fire or smoke being detected, a footage is recorded and the origin of smoke or fire can be traced.

Motion sensing technology are normally integrated into the kitchen allowing the sensors to sense smoke or fire in the event of fires that arose as a result of cooking fires which often begin when the stove is left unattended (Kodali et al., 2016). Furthermore, in order to avoid the spread of fires that originate from the kitchen, the use of smart plugs is ideal as they automatically switch off appliances which can trigger fires or smoke when left unattended over a long time for example an iron or coffee machine.

3.2.4.2 Alarms

Kodali et al, (2016) explained the home security system of Internet of Things as being integrated with security systems such as alarms. As shown on Figure 3.4 below, any movement in the environment that is protected when sensed signals are sent and the owner of the premises is alerted over a voice call and an alarm sounds at the user's discretion. In the event of a serious security breach such as an invader in the premises the owner sends an alert to security personnel or police. On the other side when the owner can identify the person, he or she does not trigger the alarm, rather he or she welcomes the guest. The same system can be configured such that it can identify the owner and instead of alerting the security personnel, an alarm will not ring and arrangements can be put in place to welcome the owner and make the place comfortable such as automatically switching the television to his or her favourite channel as well as turning on the air conditioner to his or her desired room temperature.

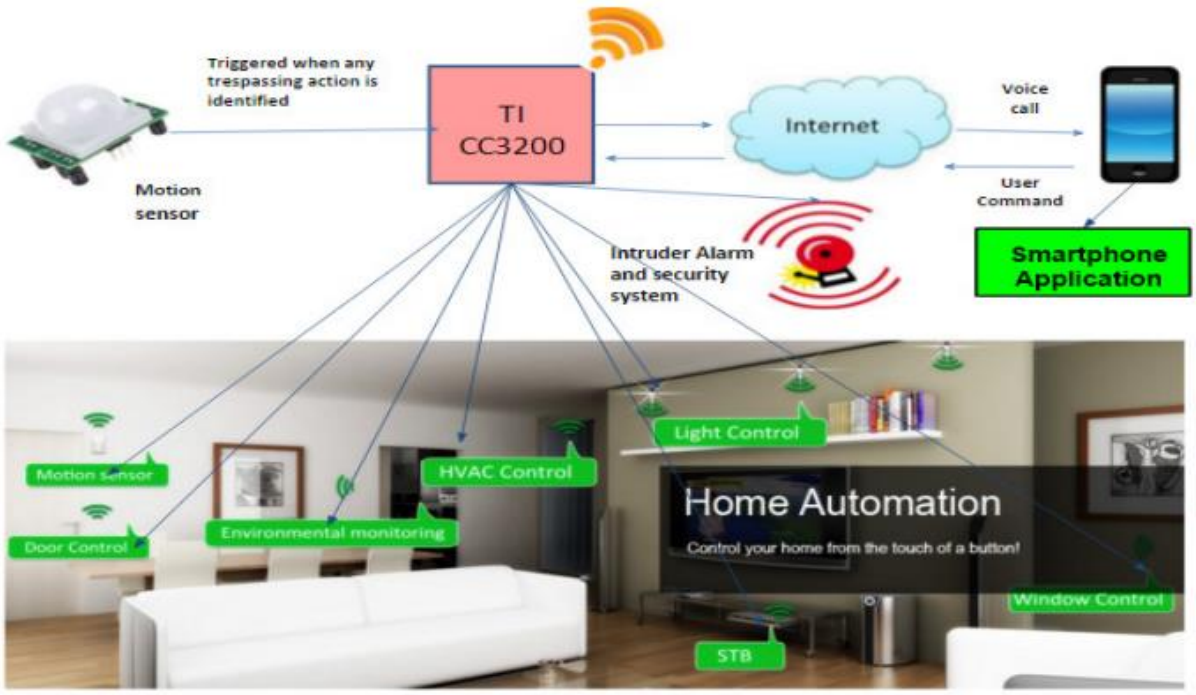

Figure 3.4: Security and home automation (Kodali et al., 2016)

3.2.5 Environmental monitoring

Environmental monitoring is a phrase used by researchers to refer to the different activities that are done in order to monitor the quality of life in a surrounding area. The different techniques and strategies which are used to monitor the environment are designed in such a way that they can monitor the current status of the environment and report any changes as well as establish environmental trends over a period of time (Sumithra et al., 2016).

Devices that have sensors in them are able to monitor the impact that certain activities have on the environment such as pollution, sewer disposal and garbage. The same devices have the ability to monitor woods, lakes, rivers and even oceans and report results (Arpita et al., 2015). IoT controlled systems that monitor the environment have sensors that monitor air, water, soil and atmospheric conditions including wildlife as well as their habitats to ensure that the ecosystem functions well. Hazardous environmental activities such as tsunamis and earthquakes can be reported early and pro-active measures can be taken into account before a disaster occurs hence saving lives. Figure 3.5 below shows the implications which may result if the environment is not properly monitored.

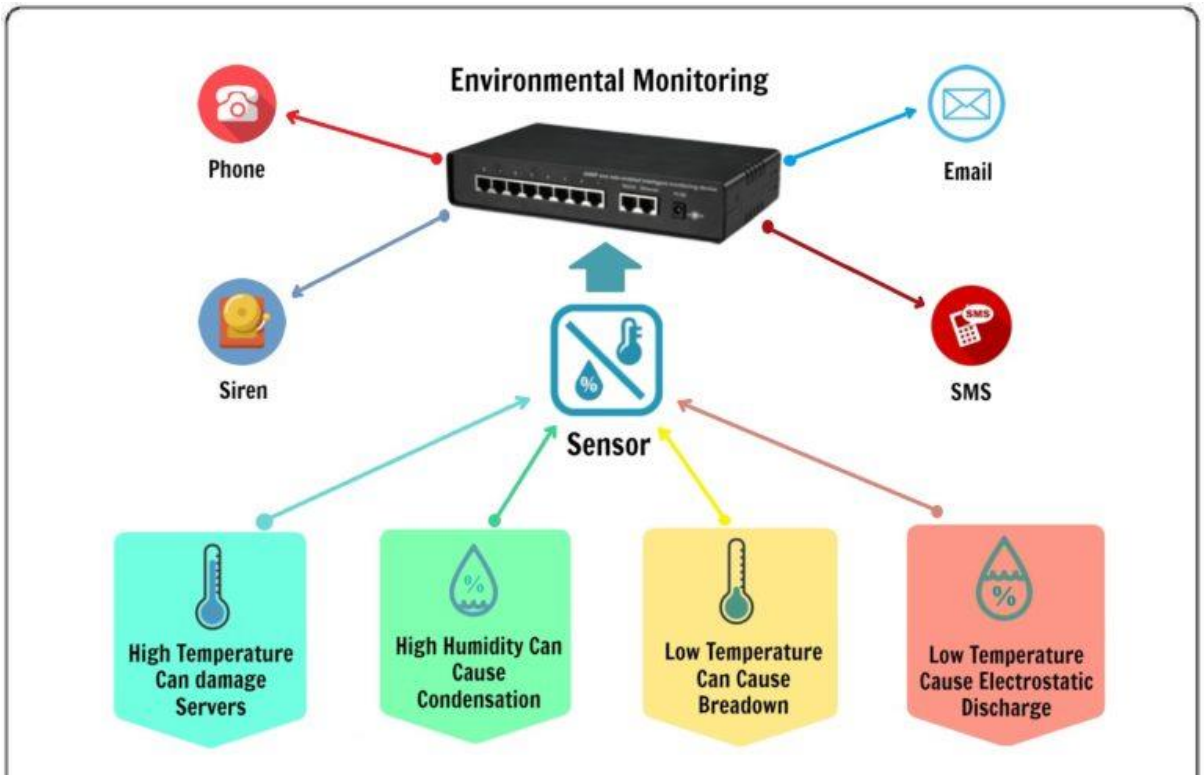

Figure 3.5: Implications which result due to poor environmental monitoring (Kodali et al., 2016)

3.2.5.1 Temperature

The Internet of Things has the ability to monitor temperature levels within an environment and alert the residents of that place when high or low temperatures are expected allowing them to be pro-active rather than being reactive. Sensors record the temperature and send push messages to the owner that vital changes have been recorded and the possible cause of such as smoke or fire within the house (Chase, 2015).

3.2.5.2 Humidity

IoT technologies are bringing massive changes in various industrial areas with agriculture being one of them. It is crucial to monitor the quality of soil remotely and the air to ensure that the desired level of humidity is achieved at all times to ensure a good harvest after analysing. The system is able to monitor the pH level of the soil and the humidity level. Records are saved and this helps farmers to know which time is ideal to plant their crops (Lin & Bregmann, 2016).

3.2.5.3 The Motion

Sumithra et al. (2016) explained how motion detection system works as depicted in Figure 3.6 below. A sensor chip is placed in an environment such as a yard and is responsible for monitoring all movements that are taking place in the surroundings and sending reports to the central system. The sensor illuminates an invisible infrared light that senses movement and cameras perceive objects and take recordings. If the sensor perceives the presence of an intruder information is sent to the system and the pro-active measures are taken such as notifying the user or reporting the case to the police.

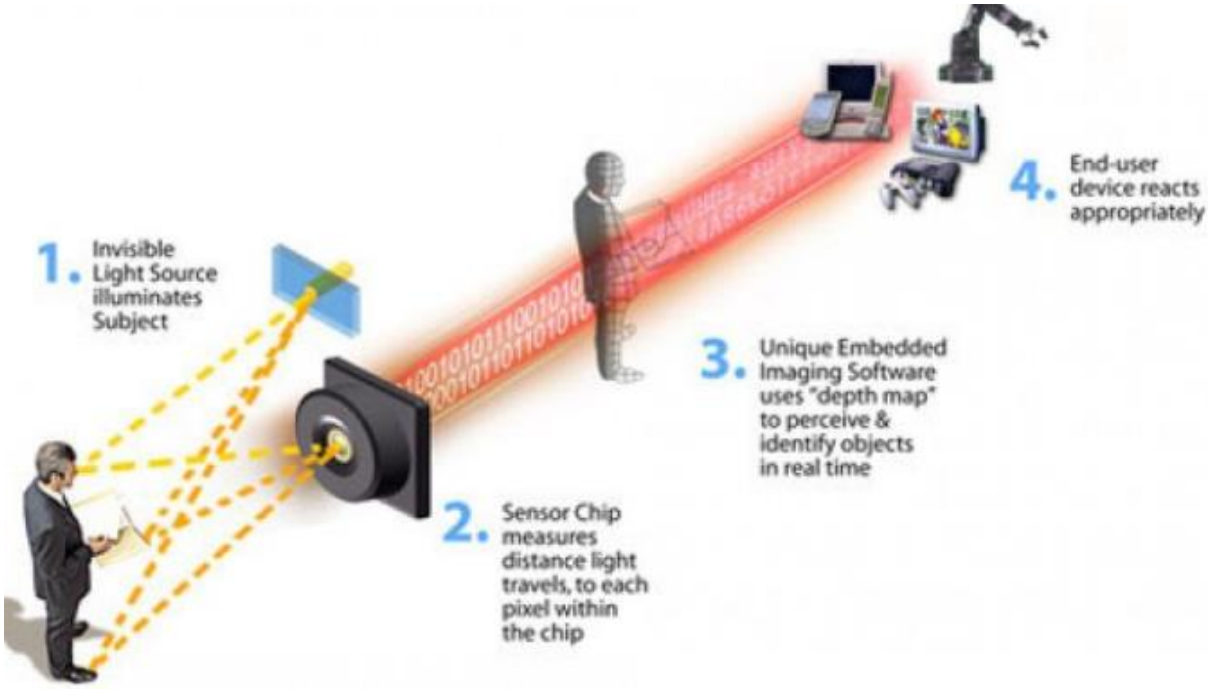

Figure 3.6: How an IoT based motion detection system works (Sumithra et al., 2016)

3.2.5.4 Gas Leakage

Gas is a major source of energy in many homes ranging from being used as a cooking fuel or a warming fuel when used in gas heaters. Gas leaks can be very hazardous and often result in fire, The Internet of Things can be used to monitor gas leaks through the use of smart sensors sending push messages to a mobile phone once the smell of a gas leak is sensed. Marius et al. (2016) developed an IoT gas monitoring system as depicted in Figure 3.7 below, the system detects any gas leaks within the house and has the ability of automatically closing the gas valve. In addition, if too much gas has leaked and the tank needs a refill, the system will automatically book a refill from the gas

station and they will send a person to come and fill the tank. Once a leakage is detected, sensors send a message to the internet and the directed message is forwarded to the owner in the form of a phone call or SMS. The sensors also monitor the gas stove and in the event that the gas valve is open but there is no pot on the stove, the gas is automatically switched off. The process is explained in detail below:

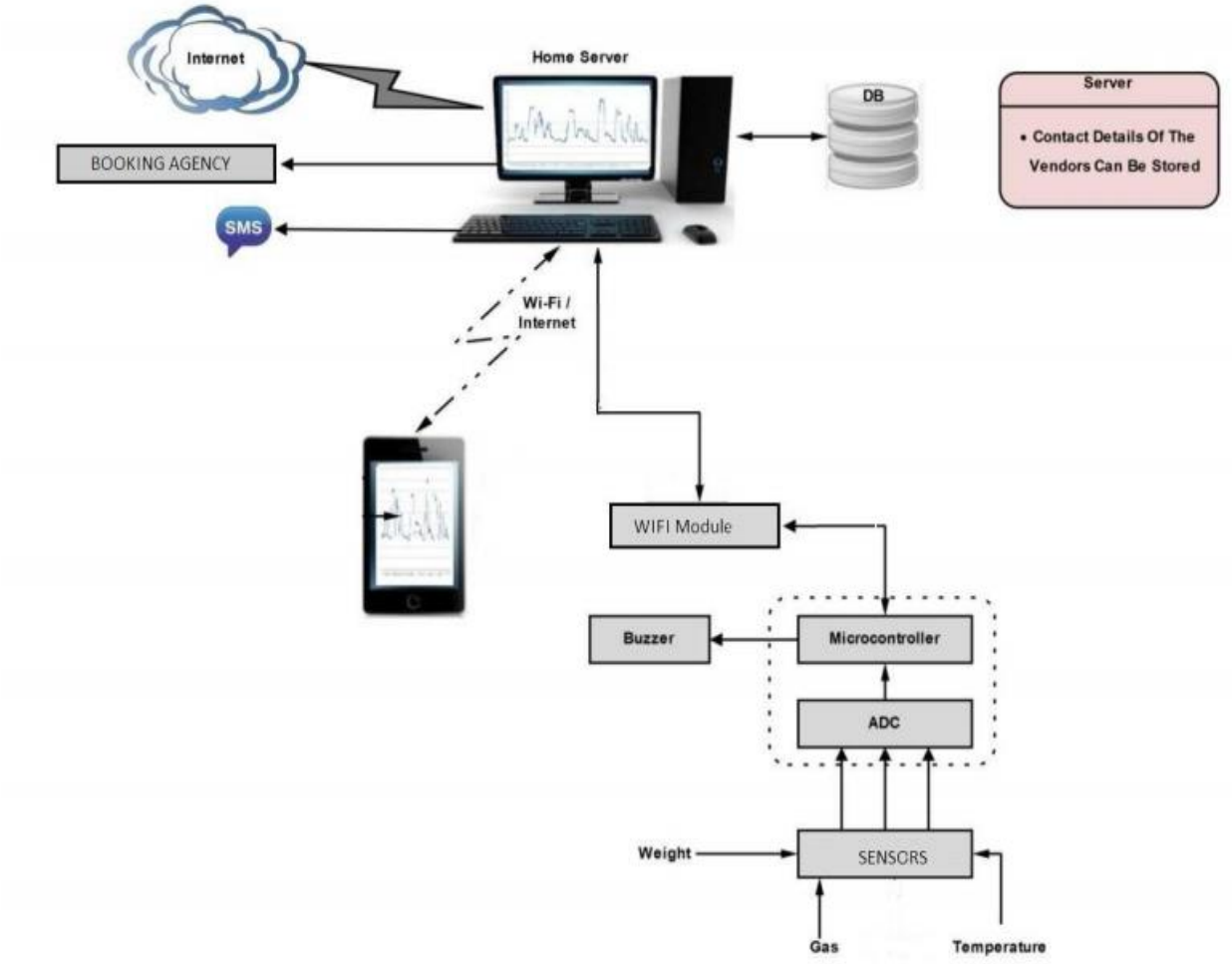

Figure 3.7: Gas leakage IoT controlled system (Marius et al., 2016)

CHAPTER 4

SYSTEM DEVELOPMENT

4.1 System Architecture

The proposed system has hardware and software parts. There are an online part and GSM-based part of the system. Therefore, the application needs the internet and mobile network to perform the tasks such as open/close door, window, light, air-condition and perform protection part such as open/close water pump, running alarm and fan. The system connects to the internet via LAN cable and mobile network via SIM card. The mobile application runs on a mobile device, which has an Android operating system.

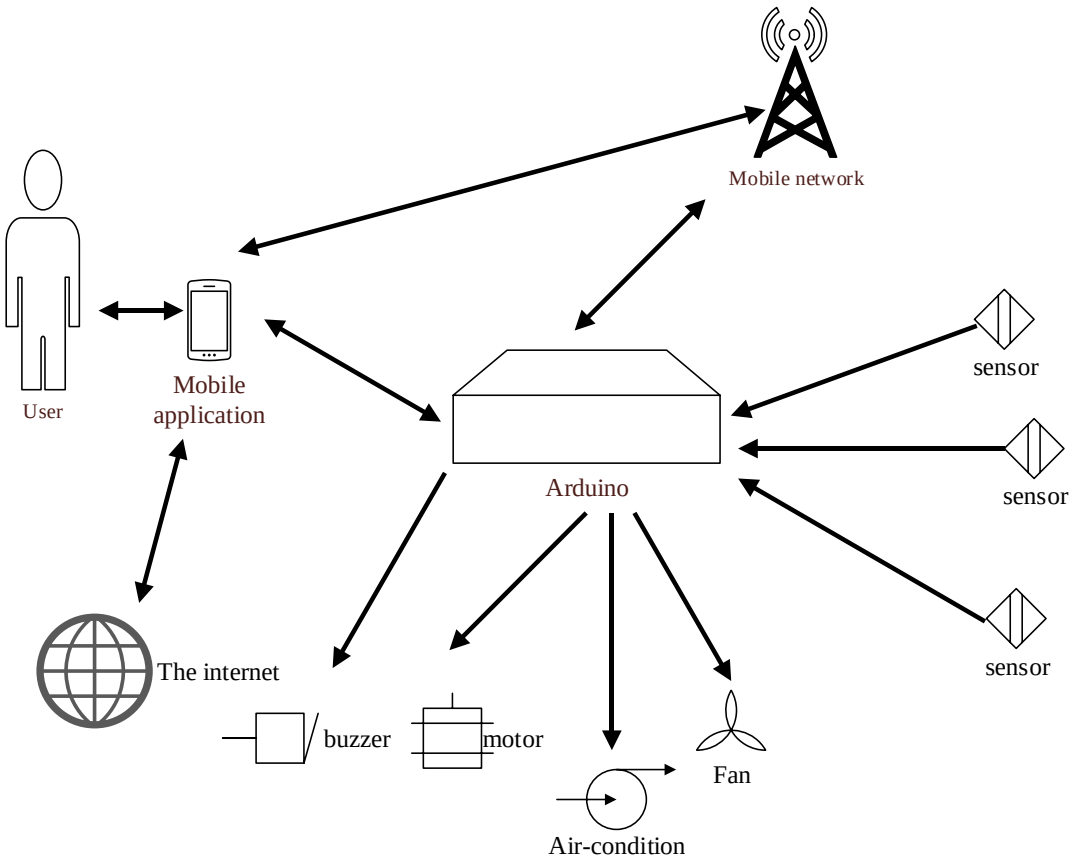

Figure 4.1: The system architecture

4.2 System Technology

In this project some technologies are used to offer many tasks to build the smart home application which control by a mobile application.

Mobile technology: The system based on a mobile device because the attributes as send and receive SMS and internet access are easy to use.

Arduino technology: Arduino is an open-source electronics platform designed at the Ivrea Interaction Design Institute in 2005 as a simple apparatus for quick prototyping, the design depends on simple hardware and software that can easily be understood by students (Abdullah et al., 2016). Arduino technology started from programs that reads inputs, light on a sensor, activating a motor, turning on an LED (Caldo et al., 2015). Instructions are sent to the microcontroller to determine the action to be taken. In the later years, Arduino board began changing to adjust to new challenges and difficulties, it offers from basic 8-bit board to IoT applications, 3D printing, and embedded environments (Fatehnia at al., 2016). It is been used in communition and controlling, and also became a backbone for many large number of complex projects.

4.3 Windows Operating System

Windows are sets of Operating systems created by Microsoft which started back in 1985 with Windows 1.0 as the first release. Several versions have been released in the later years (Sharma et al., 2017). Windows has been the most widely used operating system for PCs. They later releases CE versions used for handheld devices, and Windows mobile which is an OS for smartphones and Pocket PCs. In 2007, window mobile turned to be the most prominent smartphone software in the U.S. But later, this fame and popularity blurred and other software took over (Dinesh et al., 2015). In February 2010, when windows is in competition with its rivals i.e. iOS and android OS, they release a windows phone to succeed the windows mobile.

4.4 Android Operating System

Android is a mobile open source OS designed for smartphones and tablets using a modified Linux kernel. It was originally developed by Android Inc. and later sold to Google in the year 2005 (Shaw et al., 2016). Its first commercial version was released in 2008, and from that undergoes many version releases. The latest version 8.1 was released late 2017. For the past 7 years, Android is leading in the smartphone and tablets

OS markets. In the early 2017, they announced a report of almost two billion monthly active users (Wikipedia, 2018).

4.4.1 Android advantages

Some of the advantages of android OS are:

- It is an open source OS
- Very intuitive
- 2D, 3D graphics supports
- Multiple languages
- Different audio video support.
- Highly secured
- Supports different screen sizes and resolutions
- Qwerty keyboard

4.5 Programming Languages

A programming language is a formal language used by developers to feed in instructions to a computer in order to perform a particular task (Kulkarni et al., 2015). A programmer writes a program in a text format called source code, then the source code is then translated into machine understandable language called machine language or binary, this translation is referred to as compilation (Batty et al., 2015). Each programming language has its particular compiler which translates its source codes to machine codes.

There are many different programming languages developed and many more still being developed yearly. Many programming languages expect calculation to be indicated in a basic frame (i.e., as a succession of activities to perform) while some utilize different types of program specifications.

4.6 Java development kit (JDK)

The Java Development Kit (JDK) is a platform for the development of java applications and applets. It has a built in runtime environment named the Java Runtime Environment (JRE), the interpreter, and a compiler for the complete compilation and running of the written program. JKD can also be integrated in Integrated Development Environment (IDE) which speed up the application or program development by providing drag-and-

drop features for designing the application or applets. Different system platforms like Windows, Linux and Solaris supports a different JDKs and requirements (DiMarzio, 2015).

4.7 Android Studio

Android Studio is the official development environment (IDE) for design and development of Android operating system, it was released in 2003 with version 0.1, and several versions have been released subsequently ((DiMarzio, 2015). Now the latest version is 3.1 released in this year 2018.

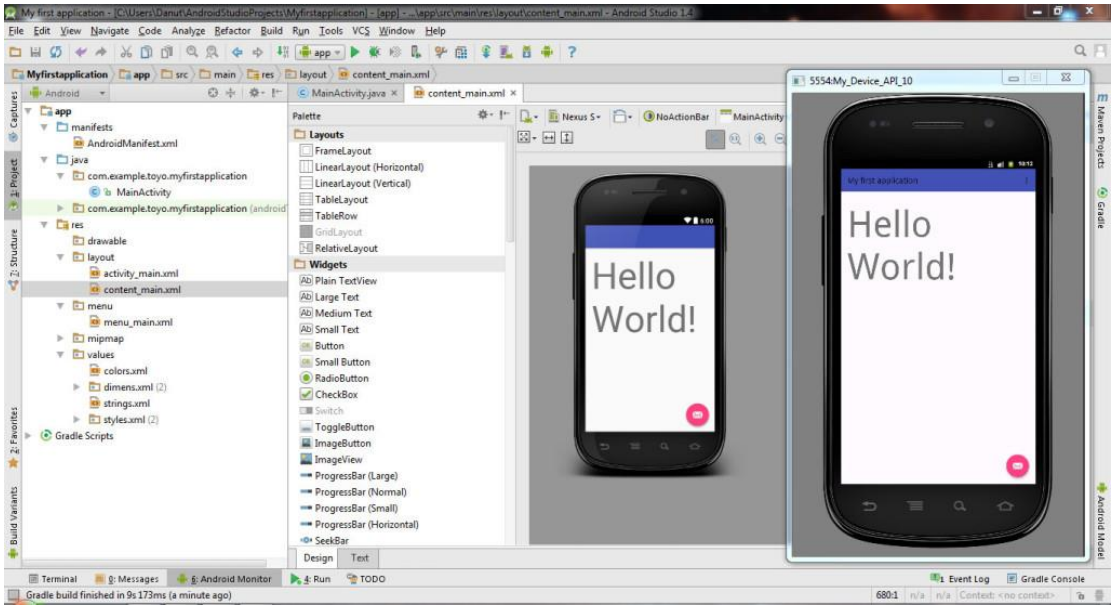

Figure 4.2: Android Studio

4.8 C Programming Language for Arduino

C is a procedural programming language developed in 1973 for writing operating systems and compiler designs. C language has a low level memory access and it has an easy set of keywords (Kanetkar, 2016). Most of the newer programming languages have copied the programming syntax from the C language. E.g. Java, PHP, JavaScript and many other languages is mainly based on C language. C language can be used on different platforms from PCs, microcontrollers and supercomputers. Arduino can be also be used for programming microcontrollers using C language.

4.9 Use-Case Diagrams

The use-case diagram explained the system designed. This it is a perfect method to understand the system behaviors. Also, it shows the user how uses the system. Furthermore, it displays the relationship between the user and system.

4.10 System user

The system has a user, which he can control and monitor the hardware part of the system.

The user of the mobile application role pointed out below:

Control: the system allows the user to control the hardware part as open/close door...Etc.

Monitor: the system allows the user to monitor the hardware part as the door is open or close and sensors as temperature, humidity and gas level.

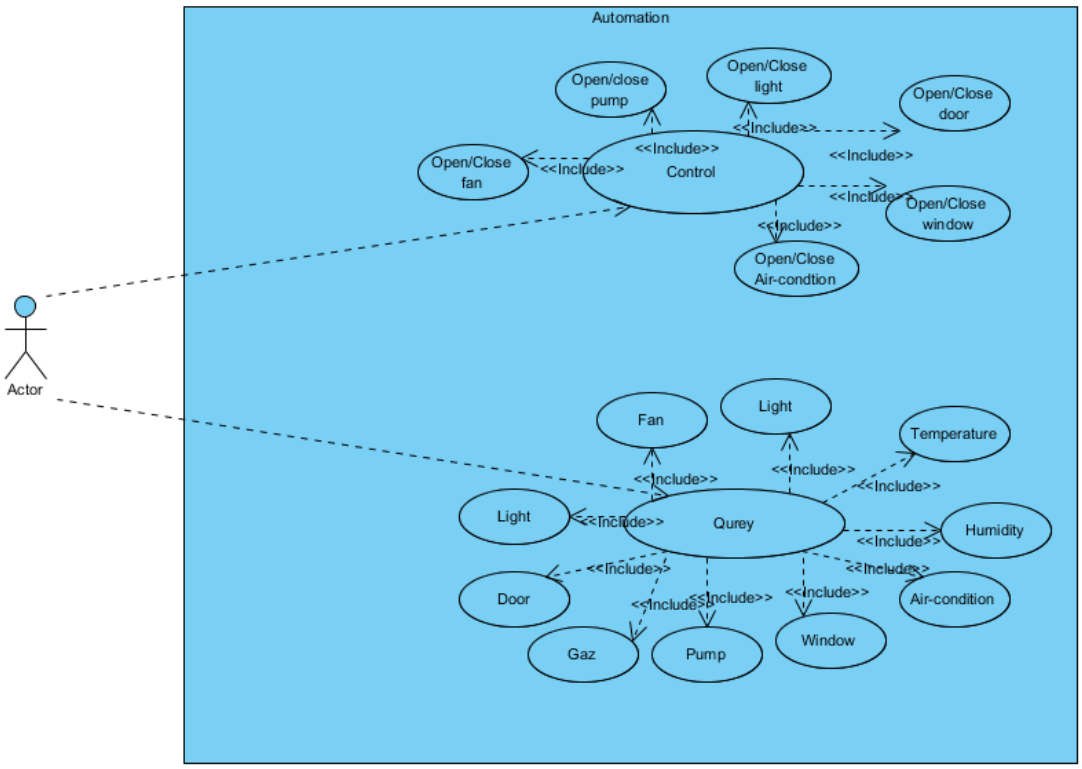

Figure 4.3: The use case block diagram

4.11 System Requirements

The system needs hardware and software tools as Arduino components, sensors mobile device and computer tools.

4.11.1 Computer tools

The tools that are utilized for developing the mobile application as follows:

1- Toshiba Satellite laptop based on Windows 7 (64-bit) operating system.
2- Arduino Software (IDE) version 1.8.5 for editing code and upload it to the Arduino board.
3- Android studio 3.1.2 for developing the mobile application includes tools of (emulator, debugger, libraries, etc.)

4.11.2 Android device

The application is acceptable for Samsung A9 Pro Duos (2016) with dual-SIM card slots devices, which have these features:
Android version: 6.0.1 (Marshmallow).
Size: 6.0 inches
Resolution: 1080 x 1920 pixels.
Dimensions: 161.7 x 80.9 x 7.9 mm.
SIM: Dual SIM
CPU: Octa-core 4x1.8 GHz Cortex-A72

4.12 Hardware Components

There are some components in the hardware part as shown below:.

4.12.1 The Arduino

Arduino refers to an open source computer hardware as well as software company and project with the ability to design and manufacture microcontrollers which are used for building digital devices that have the ability to interact with other objects and sense objects. The Arduino boards are available to users fully equipped with digital and analogue sets for pins and the boards have serial communication interfaces and the microcontrollers are programmed using C and C++ programming language (Sumithra et al., 2016).

4.12.2 History of Arduino

The origin of the Arduino project can be traced back to the Interaction Design Institute Ivrea in Italy. During that time students used basic stamp processors. In 2003 the project started with the aim of providing low cost devices that could interact with the environment and sense the surroundings using sensors and actuators (Lin & Bergmann, 2016). Examples at this stage included thermostats, motion detectors and robots.

The first wiring platform that was created consisted of printed circuit boards that used Atmega 168 microcontrollers. As time went by, the team added Atmega 8 microcontroller to the wiring and the wiring platform became lighter and less expensive and the team started distributing the source code in the open-source community until it became popular and its sensors have been widely used in many Internet of Things devices (Arpita et al., 2015). Figure 8 below shows the detailed history of Arduino from the beginning as well as the different sectors the technology is being deployed to in the modern era.

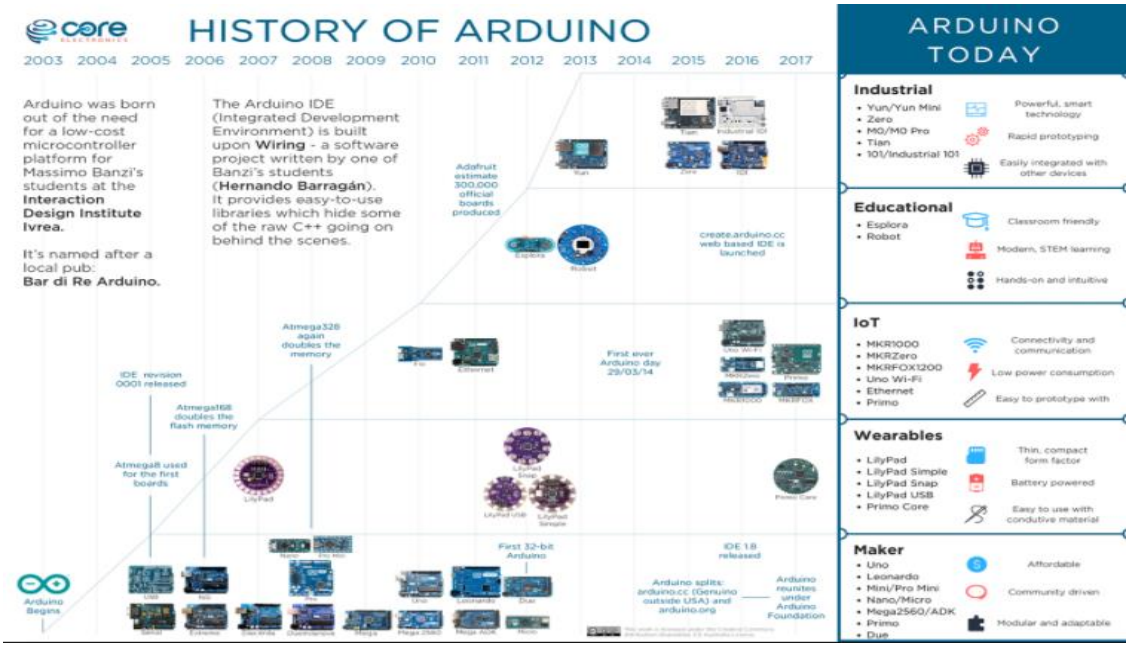

Figure 4.4: The history of Arduino (Arpita et al., 2015)

4.12.3 Arduino mega

Arduino mega refers to a microcontroller board that is based on a data sheet ATmega2560 with digital pins that sum up to 54 of which 14 of the pins are used as PWM output pins and 16 analog inputs (arduino.cc, 2018). In addition, the researchers

explained that the entire board consists of a 16 MHz resonator that is ceramic, USB connection ports, power jack, reset button and an ICSP header. The various functions on the board contain everything that is needed for maximum support of the microcontroller by just connecting the main computer with a USB to the power cable.

Figure 4.5 below shows the different components and pins contained in Arduino mega.

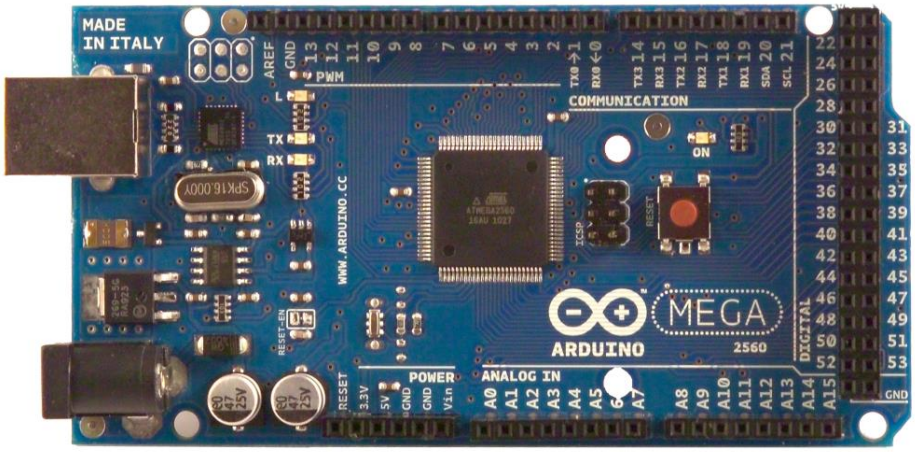

Figure 4.5: Arduino Mega

Table 4.1 below shows the different pin types that make up the Arduino board. The reset pin is responsible for resetting the entire system, 3v3 refers to pins with a maximum voltage of 3.3 the same applied to the 5 voltage pin type. Plugs with a voltage between 9 and 12 are plugged into the VIN pin. Furthermore there are Analog pins which can also be used as digital pins and the RX/TX pins contain serial communication that will receive and transmit information. PWM contain pins with output options of PWM and finally the AREF pins are responsible for external reference voltage which are used for Analog.

Table 4.1: Arduino mega pin type definitions (Arduino.cc, 2018)

Components	Specification
Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 Hz

4.12.4 Arduino IDE software

Meijer (2014) explains the Arduino IDE software as an open source project that allows programmers to take advantage of the Atmega chips which are contained within the software. The software allows programmers to write code and upload the code to the Atmega chip allowing the code to be executed on the chip. The user can upload the code using Arduino since it is compatible with most 3D-electronic printers and include megatronics, minitronics and RAMPS. Machine language is translated using the software known as “firmware” that can interpret machine instructions into actual movement. Some popular options mentioned in the literature include Marlin, Repetier and Sprinter.

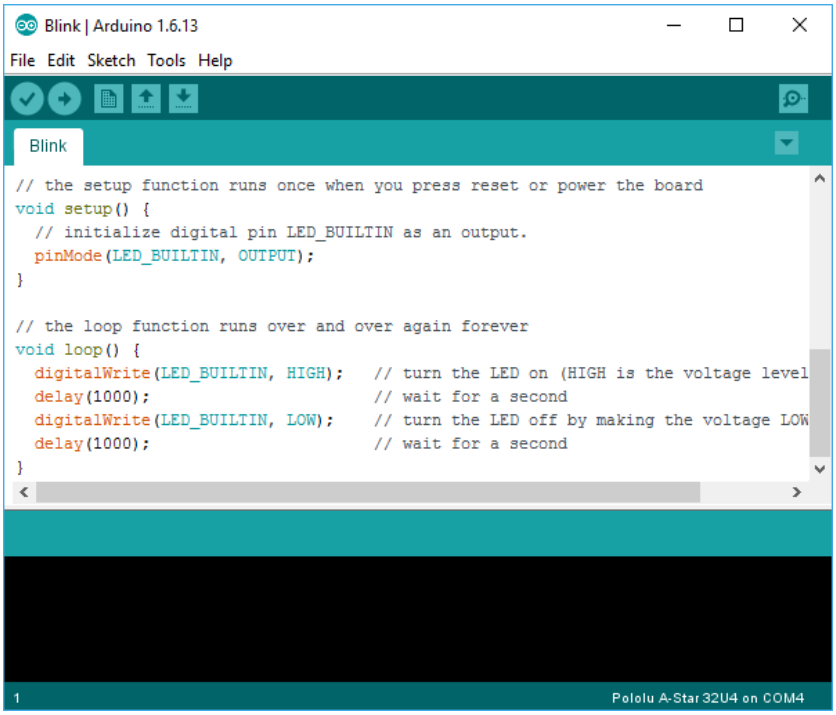

Figure 4.6: Arduino IDE software

4.13 Arduino Shields

Arduino shields are made up of modular circuit boards that are attached on the main Arduino board to add extra functionality (Chase, 2015). There are different types of Arduino shields that range from IO shields, motor shields, Ethernet shields, LCD & Keypad shields, input shields, XBee shields. The section below will address the Ethernet shield and SMS shield. Table 4.2 below shows the different Arduino shields and the control pins that are used for connection.

Table 4.2: Arduino shields and their connection pins (Afrobot, 2013)

Shield Name	Control Pin
IO Shield	None
Motor Shield	6,7,8(5),9(4)
Ethernet Shield	10,11,12,13
LCD&Keypad Shield	Digital Pin: 4,5,6,7,8,9,10 Analog Pin: 0
Input Shield	Digital Pin: 3,4,5 Analog Pin: 0,1
XBee Shield	0,1
Nano 1 IO Shield	None

4.14 Ethernet Shield

Arduino Ethernet shield allows the main Arduino board to connect to the internet. The shield bases its standard on the Wiznet W5100 Ethernet chip that provides a network stack that supports both the TCP and UDP socket connections (Radiospares, 2017). The Ethernet library is used solely for writing of sketches that are used to connect to the shield. The connection is made possible through the use of long wires with wrap headers that connect the shield to the board allowing the pins to stay intact (Meijer, 2014).

Arduino uses different digital pins to communicate with the Ethernet shield that range from pin number 10 to 13. A standard RJ45 Ethernet jack is provided which is capable of resetting both the W5100 and the main Arduino board (Radiospares, 2017). Figure 10 below shows the Ethernet shield and the informational LEDs contained on the shield are explained below:

- ***PWR:*** This LED indicates whether the board and shield is powered or not.
- ***LINK:*** It reflects the presence of network links which flash when the shield is transmitting data.
- ***FULLD:*** The short abbreviation that indicates that the connection is full duplex.
- ***100M:*** This reflects the presence of a 100Mb per second network connection which varies from the normal connection of 10Mb per second.
- ***RX:*** This pin flashes to indicate that data has been received.
- ***TX:*** This pin flashes to indicate to the user that the shield has sent data.

- ***COLL:*** A signal is given when a network collision is detected.

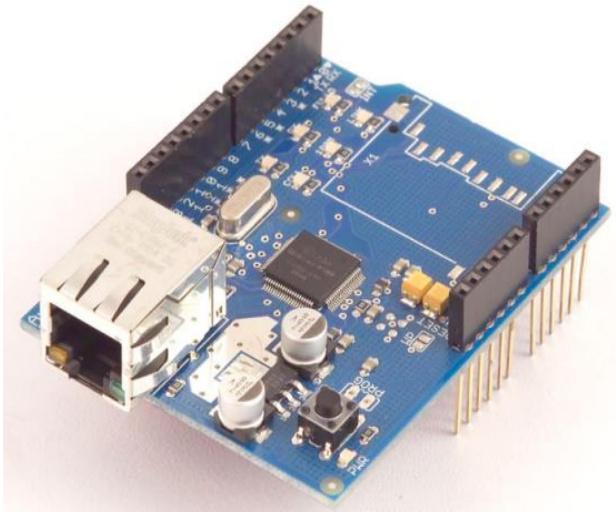

Figure 4.7: Ethernet Shield (Radiospares, 2017)

4.15 SMS Shield

The Arduino SMS shield allows the main Arduino board to be connected to the internet giving it many functions that range from making calls and sending SMS messages. AT commands are used for communication purposes between the board and the shield (Newart, 2018). A number of digital pins (2 and 3) are used by the shield for software serial communication with pin 2 being connected to the M10's TX and pin 3 to its RX pin.

To operate the shield, a user insert a sim card of any mobile network offering GPRS coverage and step by step instructions are given allowing the user to connect to the internet and start controlling his or her surroundings remotely. Figure 11 below shows the SMS shield for Arduino.

- ***Sim900***

This is an ultra small and secure wireless device which has a complete Dual-band GSM/GPRS that can be installed in a client applications. it also delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption (Dekate and Ramchaware, 2015). With a little

configuration it can fit in almost all the space requirements in user applications.

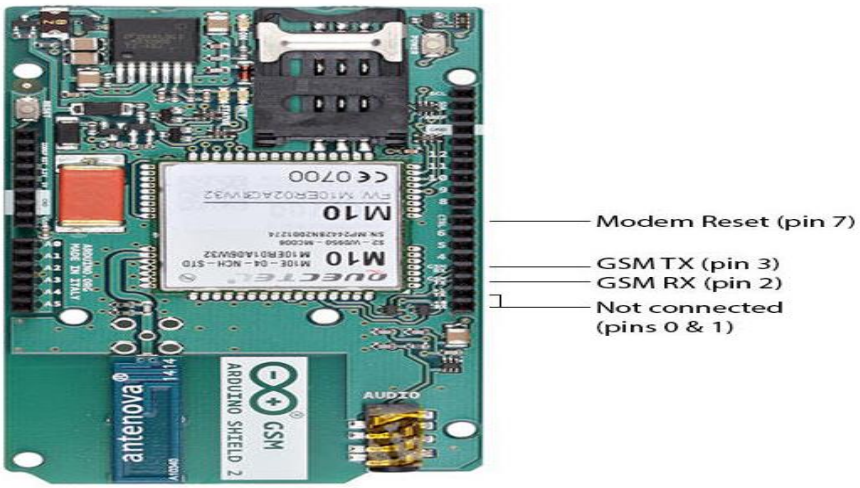

Figure 4.8: Arduino SMS shield (Newart, 2018)

4.16 Sensors

There are various types of sensors that are used in smart homes and other areas to detect and sense changes within the environment using the Internet of Things. In this section we will focus on four types of sensors that are used to sense temperature, humidity, gas and motion in the sections below:

4.16.1 LM35 Temperature Sensor

The LM35 temperature sensor is responsible for sensing the temperature and recording it. The sensor records an output voltage that is linearly proportional to the centigrade temperature and has an advantage over linear temperature sensors in that the user does not need to subtract the constant voltage in order to get the centigrade scaling (Peters, 2016). Figure 12 below shows the LM35 temperature sensor.

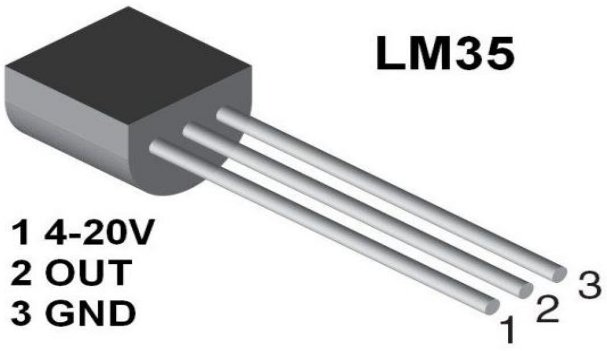

Figure 4.9: LM35 Temperature sensor (Peters, 2016)

4.16.2 DHT11 Temperature-Humidity Sensor

The DHT11 temperature-humidity sensor has the ability to measure both temperature and humidity using a calibrated digital signal output which ensures high reliability and long term stability (Meijer, 2014). The system has single wire interfaces that are integrated into the system making it easy to use. Figure 13 below shows the DHT11 temperature-humidity sensor.

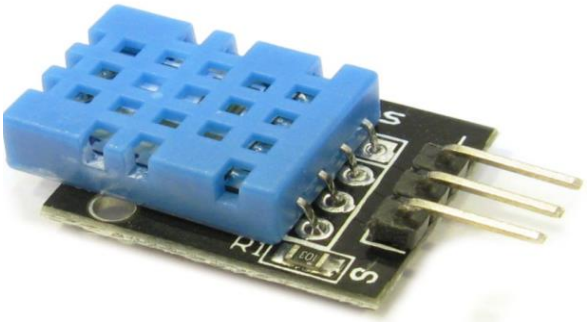

Figure 4.10: DHT11 temperature-humidity sensor (Meijer, 2014)

4.16.3 Gas Sensor (MQ2)

The Gas Sensor (MQ2) sensor is responsible for detecting and sensing any gas leaks in homes or industrial areas ranging from H2, LPG, CH4, CO, Alcohol, gas and Smoke (Afrobot, 2013). Figure 14 below shows the gas sensor.

Figure 4.11: Gas sensor MQ2 (Afrobot, 2013)

4.16.4 PIR Motion Sensor

PIR sensors have the ability to detect and sense movement within premises such as movement of a person within the monitored vicinity. They come in small sizes and are relatively inexpensive and are made up of pyroelectric sensors with crystals at the centre which emit infrared radiation (Ada, 2017). Figure 15 below shows the PIR motion sensor.

Figure 4.12: PIR motion sensor (Ada, 2017)

4.17 Servo Motor

A servomotor is very small and efficient actuator used for the control of rotating or linear movement from one position to another. It has of a proper motor attached to a sensor to receive or send a position. It is mostly been use in robotics applications and

IoTs. It can be used to control a remote-controlled or radio-controlled toys or robots (Huang and Hsu, 2015).

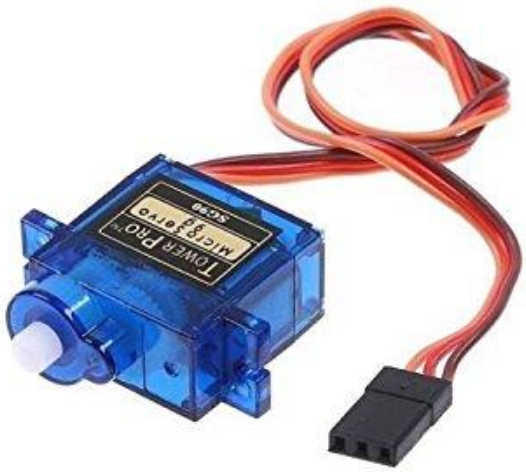

Figure 4.13: Showing a servo motor

4.18 Relays

Peters (2016) refer to electronic devices that are responsible for opening and closing electrical contacts, activating them as well as deactivating the operations of other devices within the same electrical circuit. There are two main types of relay technology which are:

- ***Mechanical state:*** This comprises of electromagnetic forces that have both an inductor and a switch and are responsible for changing the position of the switch.
- ***Solid state:*** It has the ability to accomplish the same function as the mechanical state however semi-conductor devices are capable of changing impedance as they activate or deactivate circuits by either opening them or closing them.

Table 4.3 below shows the different relay specifications and their descriptions.

Table 4.3: Relay specifications (Peters, 2016)

Specification	Description
MIL-R-5757	Relays for Electrical, for Electronic and Communication Type Equipment
MIL-R-6106	Electromagnetic Relays
MIL-R-28776	Relays for Electrical for Electronic and Communication type Equipment, Hybrid
MIL-R-39016	Relay, Electromagnetic, Established Reliability
MIL-R-28750	Solid State Relay
MIL-R-83726	Time Delay, Hybrid and Solid State Relays

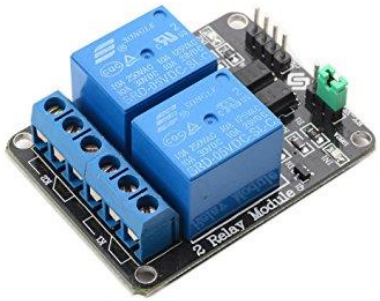

Figure 4.14 Relays

4.19 LEDs

An important tool that is used for electrical prototyping is the breadboard that contain various LEDs that stick electronics into the main board that is made up of plastics with holes in which wires are placed that connect the holes in order for electricity to flow smoothly (Meijer, 2014). Figure 17 below explains how the various LEDs are connected into the breadboard showing both parallel and series circuits.

The right side allows electricity to flow between different circuits and shows you the holes that are connected. Power supply connections have both positive and negative connections which run up and down through terminal strips which run from A to I, however the connection is broken down in the middle giving you two separate connections.

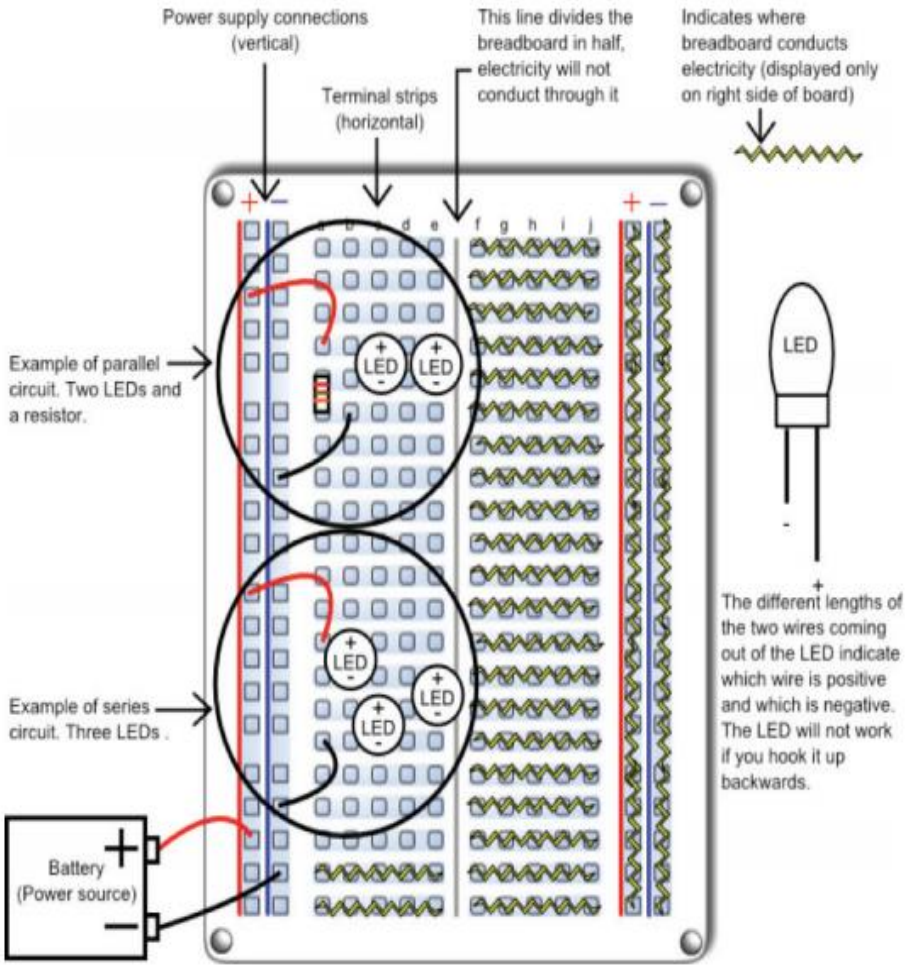

Figure 4.15: Showing how the different LEDs are interconnected into the breadboard (Sparkfun electronics, 2016)

CHAPTER 5

SYSTEM IMPLEMENTATION

A mobile device is used by people for interacting with technology. So, applications can help them to communicate with the environment to know the weather conditions and smart home situation. This application is a smart home system with automatic protection that controls via a mobile application and web based.
This application can control and monitor smart home through the internet and SMS. This chapter described all functions of the system.

5.1 Hardware Parts

The system has hardware part which is consists of Arduino, Ethernet shield, sim900 shield, two servo motor to control door and window, tow LEDs, four sensors (Temperature sensor, Gas sensor, Humidity sensor and motion sensor) and four relays to control outputs (water pump, fan, alarm and air-condition).

5.2 Software Parts

The system has two types of programing:

- ***The first:*** Arduino programming which uses C language to control input and output devices.
- ***The second:*** Android programming, which uses Java language to make a mobile application that, enables controlling hardware part.

System user: The system has one user who is controls and monitors the smart home system.
User: System user.
Features: Main screen, control by internet screen, control by SMS screen, setting screen and about screen.
Main screen this screen consists of a page that shows values as temperature, humidity and gas level.

Control by internet screen: This screen consists of buttons, which uses to control hardware via internet.

Control by SMS screen: This screen consists of buttons, which uses to control hardware via SMS.

Setting screen: This screen consists of two fields. The first one used to enter IP address and port number as a link. The second one used to enter the telephone number.

About screen: this screen consists of the information page.

5.3 The Diagram of The Circuit

The diagram below is shown the electronic circuit for smart home which has automatic protection:

5.3.1 Circuit details

The circuit has four sensors to sense temperature, humidity, gas and motion.

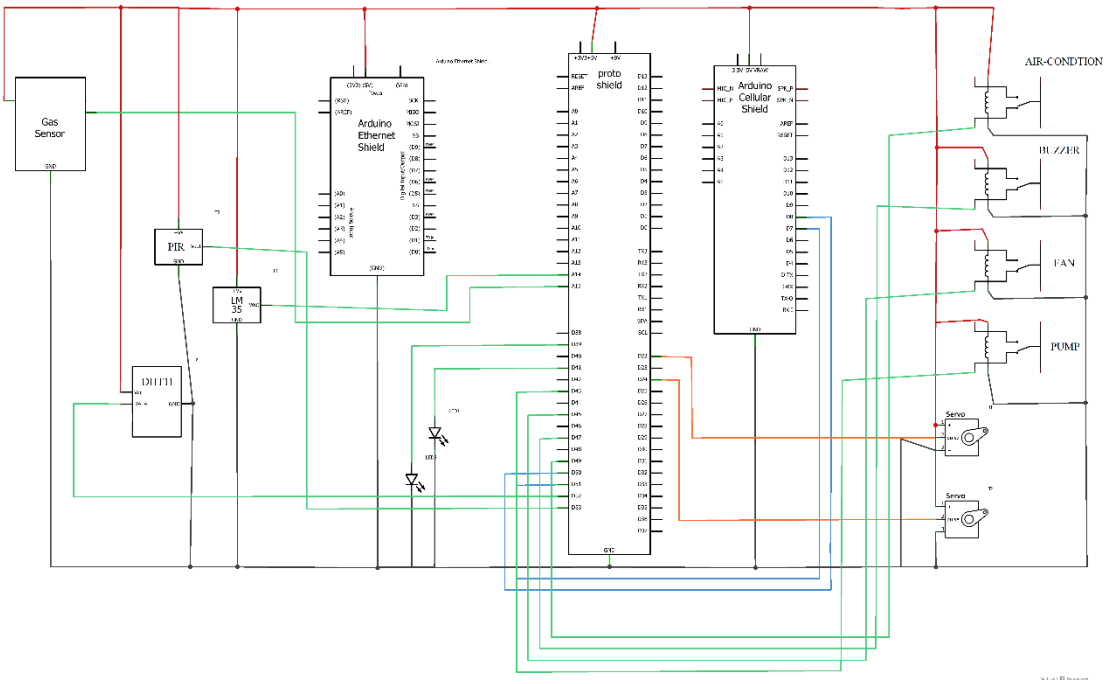

Figure 5.1: Circuit diagram

Figure 5.2: Anthropomorphic of smart house

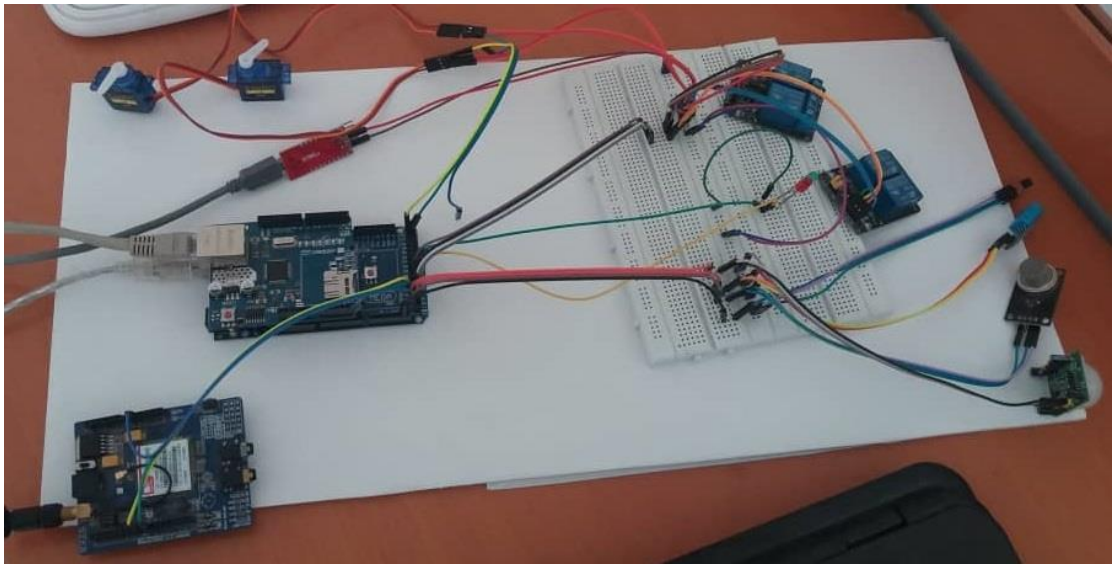

Figure 5.3: the hardware part of the system

5.3.2 The temperature

The LM35 sensor senses the temperature inside the home then send the temperature value through Arduino and Ethernet shield or SIM900. If the temperature increases, more than normal level then Arduino will send notification via Ethernet shield or SIM900. For example, there is a fire inside the home then Arduino will open the door, the window and water pump for firefighting. At the same time, Arduino will send the notification to the mobile.

Figure 5.4: Opening door and window

Figure 5.5: water pump

5.3.3 The humidity

The DH11 sensor senses the internal humidity. So, the humidity value will send by Arduino and Ethernet shield or SIM900.

5.3.4 The gas

The MQ2 sensor senses the gas leaking in the home then send the gas level value over Arduino and Ethernet shield or SIM900. When the gas level raises greater than natural level then Arduino will send notification via Ethernet shield or SIM900. For example, there is a gas leaking inside the home. Therefore, Arduino will open the fan and the window to expel the leaking gas. Simultaneously, Arduino will send the notification to the mobile.

Figure 5.6: Opening the window

Figure 5.7: Fan

5.3.5 Motion

The PIR sensor senses the external motion then motion value will send by Arduino after that Arduino will open LED.

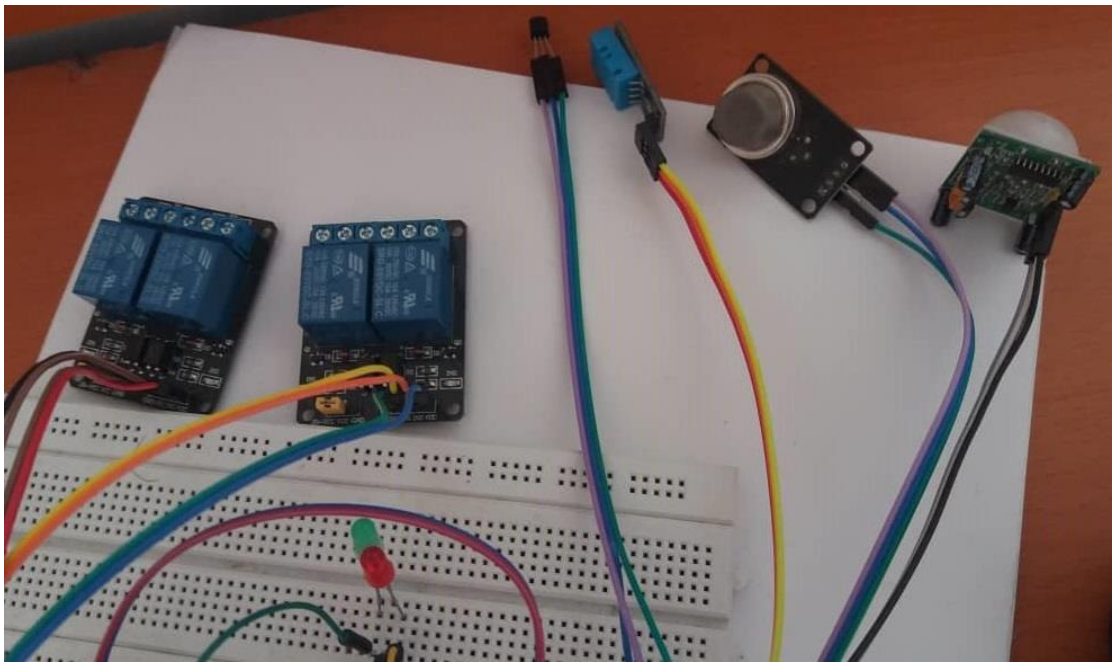

Figure 5.8: Input sensors and output relays

5.4 Running the Application

After the first installation, you meet setting screen. It has the two fields:

The first field used to enter IP address and port number as a link.

The second field used to enter the telephone number.

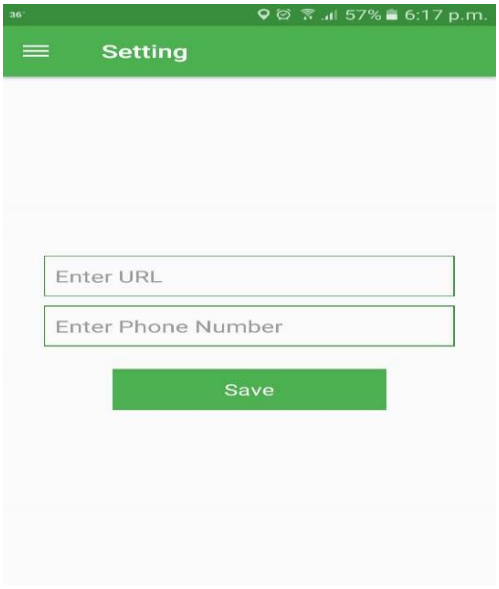

Figure 5.9: Snapshot of setting page

Then the user will fill these fields as shown.

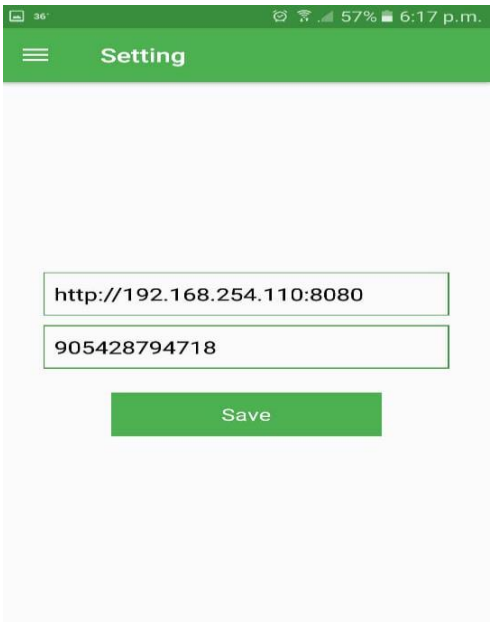

Figure 5.10: Snapshot of setting page after filling fields

5.4.1 Main screen

This is the next page you meet after entering needed information. This page used to show values which send from Arduino as a feedback to the user of the application.

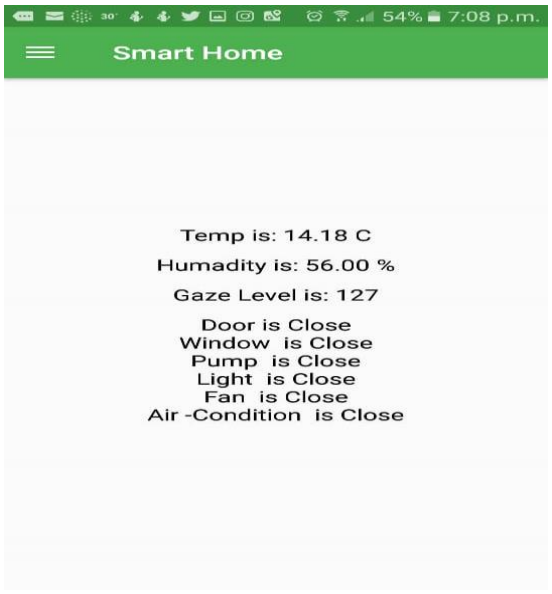

Figure 5.11: Snapshot of main screen and feedback

5.4.2 Side menu

The Side menu has four choices (Control by the internet, Control by SMS, query by SMS, about and setting).

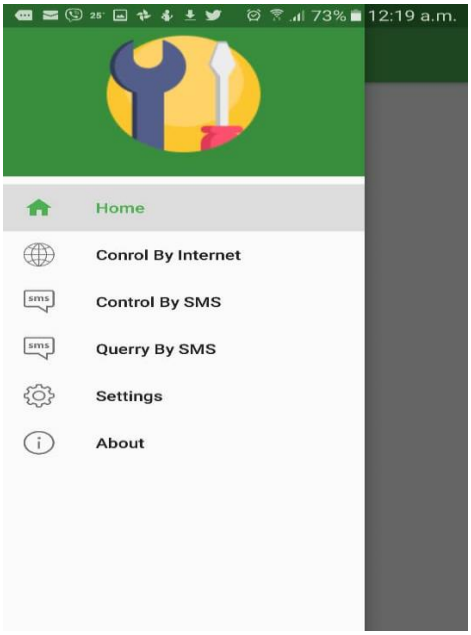

Figure 5.12: Snapshot of side menu

5.4.3 Control by internet screen

This page used to enter to the control page, which has buttons to control hardware.

5.4.3.1 Control buttons

Control buttons used to control hardware part via the internet. The buttons are (open door, close door, open window, close window, open pump, close pump, open light, close light, open fan, close fan, open air-condition and close air-condition).

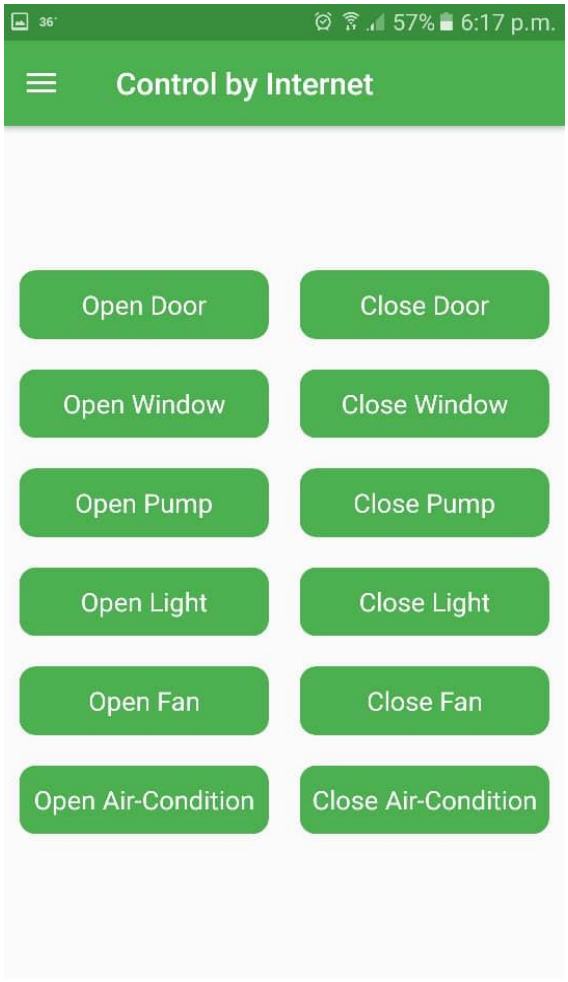

Figure 5.13: Snapshot of control by internet page

- ***Open door:*** When the user presses open door button then the application will send a request as a link (http://192.168.254.110:8080/?OPENDOOR) that communicates with Arduino. Then Arduino will execute open door commands.
- ***Close door:*** the user presses close door button so the application sends a request as a URL (http://192.168.254.110:8080/?CLOSECDOOR) which communicates with Arduino. Furthermore, Arduino executes close door commands.

- ***Open window:*** When the user presses open window button then the application will send a request as a link (http://192.168.254.110:8080/?OPENWINDOW) that communicates with Arduino. Then Arduino will execute open window commands.
- ***Close window:*** the user presses close window button so the application sends a request as a URL (http://192.168.254.110:8080/?CLOSECWINDOW) which communicates with Arduino. Furthermore, Arduino executes close window commands.
- ***Open pump:*** When the user presses open pump button then the application will send a request as a link (http://192.168.254.110:8080/?OPENPUMP) that communicates with Arduino. Then Arduino will execute open pump commands.
- ***Close pump:*** the user presses close pump button so the application sends a request as a URL (http://192.168.254.110:8080/?CLOSECPUMP) which communicates with Arduino. Furthermore, Arduino executes close pump commands.
- ***Open light:*** When the user presses open light button then the application will send a request as a link (http://192.168.254.110:8080/?OPENLIGHT) that communicates with Arduino. Then Arduino will execute open light commands.
- ***Close light:*** the user presses close light button so the application sends a request as a URL (http://192.168.254.110:8080/?CLOSECLIGHT) which communicates with Arduino. Furthermore, Arduino executes close light commands.
- ***Open fan:*** When the user presses open fan button then the application will send a request as a link (http://192.168.254.110:8080/?OPENFAN) that communicates with Arduino. Then Arduino will execute open fan commands.
- ***Close fan:*** the user presses close fan button so the application sends a request as a URL (http://192.168.254.110:8080/?CLOSECFAN) which communicates with Arduino. Furthermore, Arduino executes close fan commands.
- ***Open air-condition:*** When the user presses open air-condition button then the application will send a request as a link (http://192.168.254.110:8080/?OPENAIR) that communicates with Arduino. Then Arduino will execute open air-condition commands.

- ***Close air-condition:*** the user presses close air-condition button so the application sends a request as a URL (http://192.168.254.110:8080/?CLOSECAIR) which communicates with Arduino. Furthermore, Arduino executes close air-condition commands.

5.4.4 Control by SMS

This page used to enter to the control page which has control buttons to control hardware by SMS. The buttons are (open door, close door, open window, close window, open pump, close pump, open light, close light, open fan, close fan, open air-condition and close air-condition).

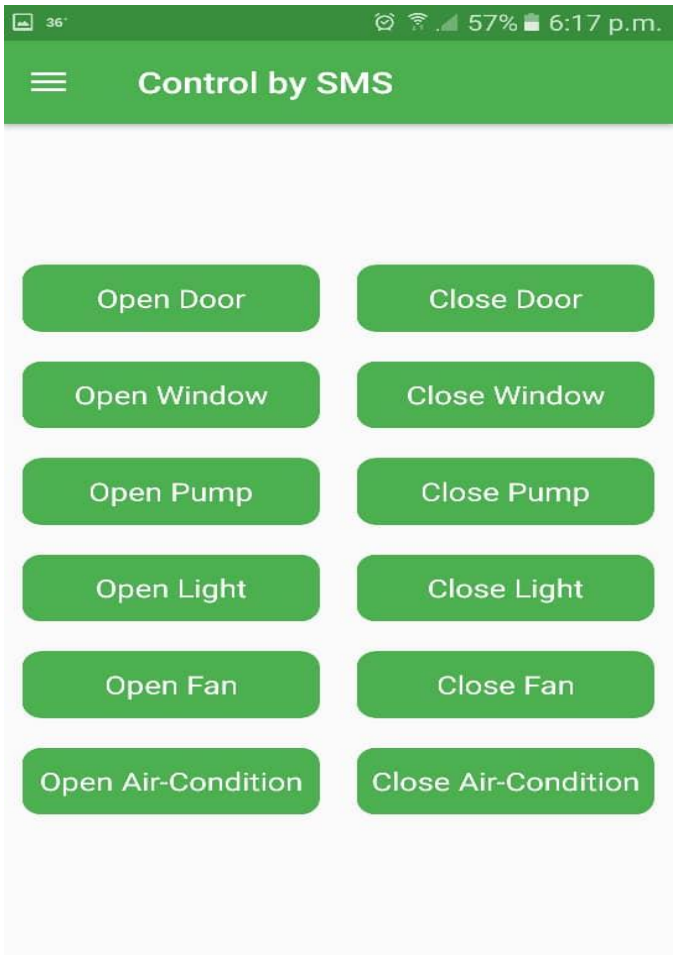

Figure 5.14: Control by SMS

- ***Open door:*** When the user presses open door button then the application will send SMS (OD) that communicates with Arduino. Then Arduino will execute open door commands.

- ***Close door:*** the user presses close door button so the application sends SMS (CD), which communicates with Arduino. Furthermore, Arduino executes close door commands.
- ***Open window:*** When the user presses open window button then the application will send SMS (OW) that communicates with Arduino. Then Arduino will execute open window commands.
- ***Close door:*** the user presses close window button so the application sends SMS (CW), which communicates with Arduino. Furthermore, Arduino executes close window commands.
- ***Open pump:*** When the user presses open pump button then the application will send SMS (OR1) that communicates with Arduino. Then Arduino will execute open pump commands.
- ***Close pump:*** the user presses close pump button so the application sends SMS (CR1), which communicates with Arduino. Furthermore, Arduino executes close pump commands.
- ***Open light:*** When the user presses open light button then the application will send SMS (OL) that communicates with Arduino. Then Arduino will execute open light commands.
- ***Close light:*** the user presses close light button so the application sends SMS (CL), which communicates with Arduino. Furthermore, Arduino executes close light commands.
- ***Open fan:*** When the user presses open fan button then the application will send SMS (OR2) that communicates with Arduino. Then Arduino will execute open fan commands.
- ***Close fan:*** the user presses close fan button so the application sends SMS (C R2), which communicates with Arduino. Furthermore, Arduino executes close fan commands.
- ***Open air-condition:*** When the user presses open air-condition button then the application will send SMS (OR4) that communicates with Arduino. Then Arduino will execute open air-condition commands.
- ***Close air-condition:*** the user presses close air-condition button so the application sends SMS (C R4), which communicates with Arduino. Furthermore, Arduino executes close air-condition commands.

5.4.5 Query by SMS

This choice used to enter to the query page, which has some buttons to display some data. The buttons are temperature, humidity, gas lave, light, door, window, pump, light, fan, and air-condition which used to show each situation individually.

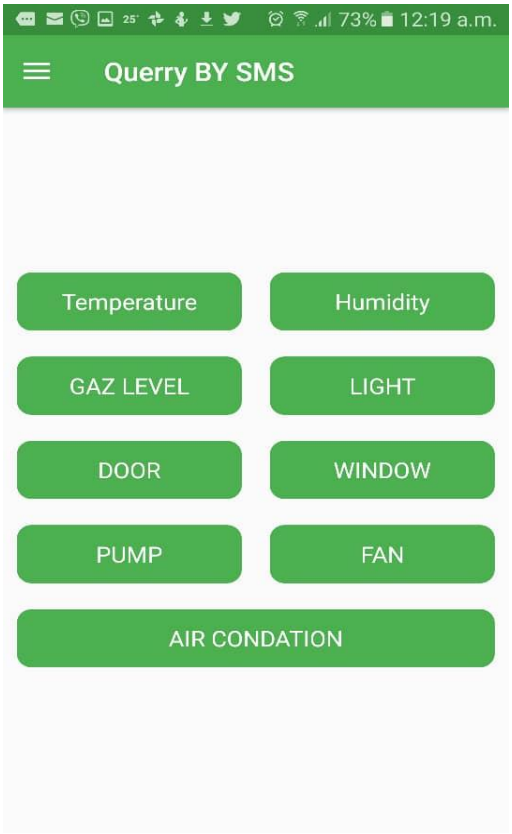

Figure 5.15: Snapshot of query page by SMS

5.4.5.1 Query buttons

- ***Temperature*:** when user press Temperature the application will send TEMP to the Arduino and Arduino will response the message the Temperature is 15*C.
- ***Humidity*:** When user press Humidity the application will send HUM the Arduino. Then Arduino will response the message the Humidity is 70 %.
- ***Gas level:*** when user press Gas level the application will send GAZ to the Arduino. Arduino will response the message the gas level is 190.
- ***Light:*** when user press Light the application will send LIGHT to the Arduino. Arduino will response the message the light level is on or off.
- ***Door:*** when user press door the application will send DOOR to the Arduino. Arduino will response the message the door is open or close.

- ***Window:*** when user press window the application will send WIN to the Arduino. Arduino will response the message the window is open or close.
- ***Pump:*** when user press pump the application will send PU to the Arduino. Arduino will response the message the pump is open or close.
- ***Fan:*** when user press fan the application will send FAN to the Arduino. Arduino will response the message the fan is open or close.
- ***Air-condition:*** when user press Air-condition the application will send AIR to the Arduino. Arduino will response the message the Air-condition is open or close.

5.4.6 About

This page used to show the name of the system and designer.

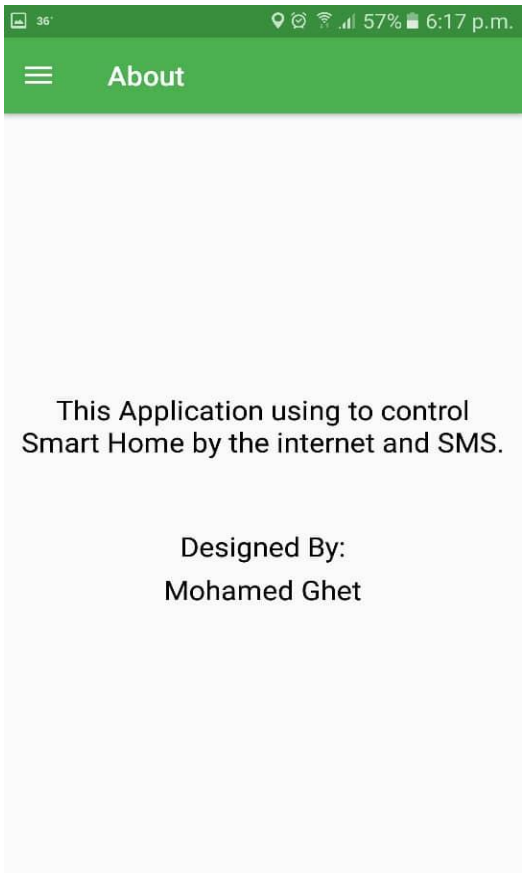

Figure 5.16: Snapshot of about page

5.5 Web Based Control

The designed system controls via the web page based that communicate with Arduino. The user needs to enter the IP and the port number using a web browser as a URL (http://192.168.254.110:8080) then Arduino will response to display the web page that used to control and monitor the system. The web page consists of three parts.

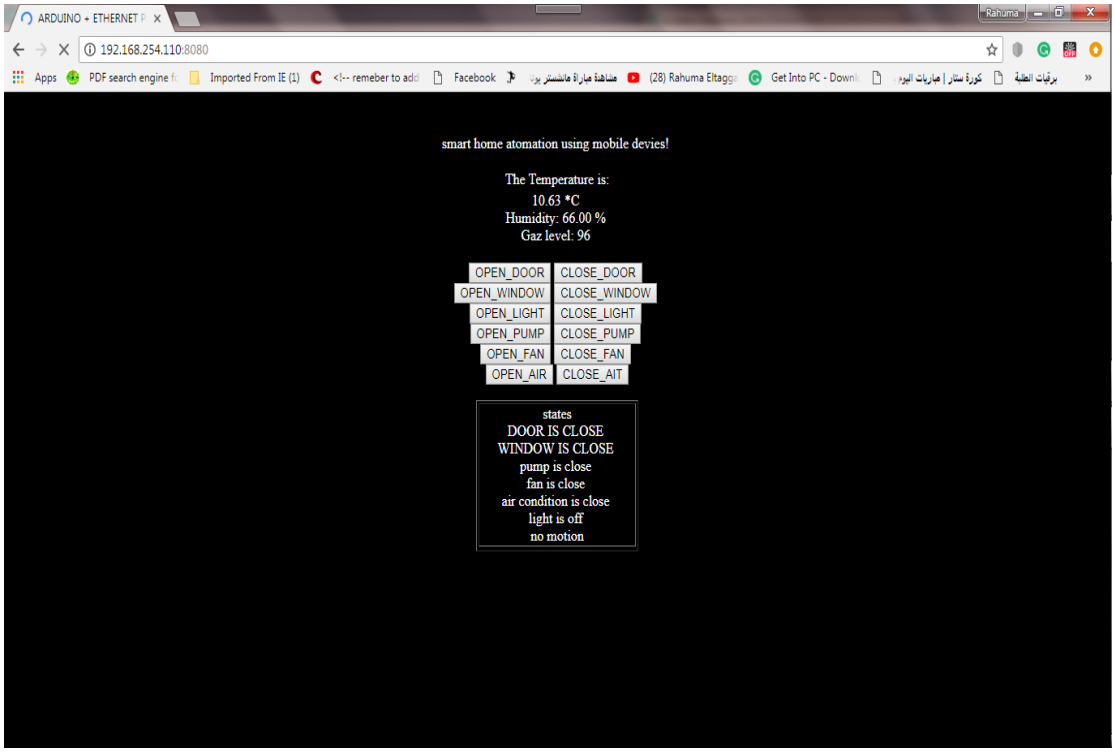

Figure 5.17: Snapshot of web page

The first part to display values which are coming from Arduino (temperature, humidity and gas level).

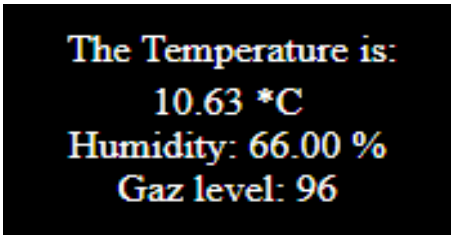

Figure 5.18: Snapshot of displayed values part

The second part uses to display situation of (door is open, door is close, window is open, window is close, pump is open, pump is close, fan is open, fan is close, air condition is open, air condition is close, light is on, light is off, no motion and There is motion).

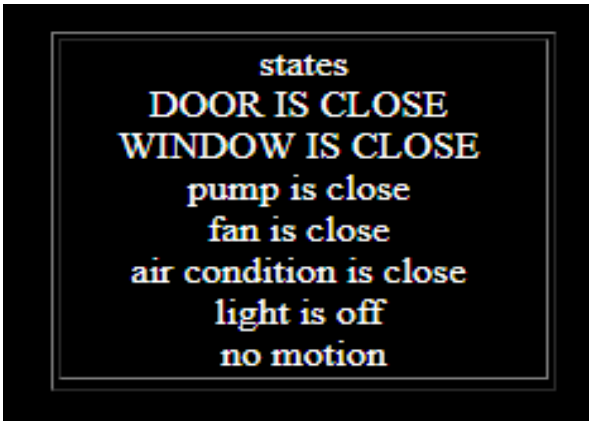

Figure 5.19: Snapshot of states part

The third part has the control buttons, which used to control hardware as following:

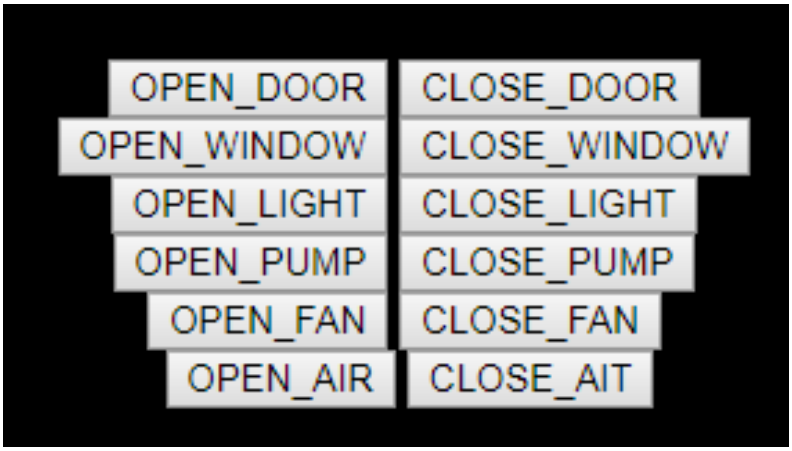

Figure 5.20: Snapshot of control buttons part

When the user clicks open door the system will respond the URL (http://192.168.254.110:8080/?OPENDOOR) and execute open door commands that allow servo motor opening the door.

If the user clicks close door the system will connect the URL (http://192.168.254.110:8080/?CLOSECDOOR) then implement close door commands, which allow servo motor closing the door.

After the user clicks open window the system will link the URL (http://192.168.254.110:8080/?OPENWINDOW) and execute open window commands that allow servo motor opening the door.

If the user clicks close window the system will connect the URL (http://192.168.254.110:8080/?CLOSECWINDOW) then implement close window commands which allow servo motor closing the window.

When the user clicks open pump the system will respond the URL (http://192.168.254.110:8080/?OPENPUMP) and execute open pump commands that allow the relay opening the pump.

If the user clicks close pump the system will connect the URL (http://192.168.254.110:8080/?CLOSECPUMP then implement close pump commands, which allow the relay closing the pump.

When the user clicks open fan the system will respond the URL (http://192.168.254.110:8080/?OPENFAN) and execute open fan commands that allow the relay opening the fan.

If the user clicks close fan the system will connect the URL (http://192.168.254.110:8080/?CLOSECFAN) then implement close fan commands, which allow the relay closing the fan.

When the user clicks open air-condition the system will respond the URL (http://192.168.254.110:8080/?OPENAIR) and execute open air-condition commands that allow the relay opening the air-condition.

If the user clicks close air-condition the system will connect the URL (http://192.168.254.110:8080/?CLOSECAIR) then implement close air-condition commands, which allow the relay closing the air-condition.

When the user clicks open light the system will respond the URL (http://192.168.254.110:8080/?OPENLIGHT) and execute open light commands that allow opening the light.

If the user clicks close light the system will connect the URL (http://192.168.254.110:8080/?CLOSECLIGHT) then implement close light commands, which allow closing the light.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In this thesis a smart home automatic protection application has been developed for the users so they have an ability to control a smart home by a mobile device. The system gets the commands through a mobile application and then executes these commands into Arduino that are used to control the hardware. With the developed system a user can control and monitor a smart home system. The user can open or close the doors, or the windows, or control a pump, activate or deactivate a fan, control the lights or start or stop the air-conditioning system. The user can monitor the ambient temperature, humidity and gas level. The user can know the door is open or close, the window is open or close, the pump is open or close, the fan is open or close, the light is open or close, the air-condition is open or close and there is motion or not.

The system can run the alarm, open door and window when there is a fire and then activate the water pump automatically for firefighting. The system can run the alarm, open fan and window when there is gas leaking. The user can control system by mobile application through the internet and SMS. The system gives feedback to show the situations via a mobile application and web-based page.

6.2 Recommendations

The application can be progressed from these aspects:

- Developing the same application for other operating systems such as iOS.
- Developing the application that can control by voice commands to help people with disabilities.
- Developing the hardware by increasing sensors and output devices.
- Developing web-based page to use database that can save all data.

REFERENCES

Abdullah, R., Rizman, Z. I., Dzulkefli, N. N. S. N., Ismail, S. I., Shafie, R., & Jusoh, M. H. (2016). Design an automatic temperature control system for smart tudungsaji using Arduino microcontroller. *ARPN Journal of Engineering and Applied Sciences*, *11*(16), 9578-9581.

Ada, L. (2017). PIR Motion Sensor. Retrieved, March 21, 2018 from: https://cdn-learn.adafruit.com/downloads/pdf/pir-passive-infrared-proximity-motion-sensor.pdf

Adriansyah, A., & Dani, A. W. (2014). Design of small smart home system based on Arduino. In Proceedings of the *Electrical Power, Electronics, Communications, Controls and Informatics Seminar*, (pp. 121-125). Lowokwaro, Indonesia.

Arduino.cc (2018) Arduino Mega 2560, retrieved 23th May 2018 via https://store.arduino.cc/usa/arduino-mega-2560-rev3

Arpita, R., Saxena, K., & Bhadra, A.A. (2015). Internet of Things. *International journal of Engineering Studies and Technical Approach, 1*(4), 1-36.

Aru O E ,Ihekweaba G, Opara F K, (2013). Design Exploration of a Microcontroller Based RF Remote Control 13amps Wall Socket, Journal of Computer Engineering, 11(1), 56-60,

Batty, M., Memarian, K., Nienhuis, K., Pichon-Pharabod, J., & Sewell, P. (2015). The problem of programming language concurrency semantics. In *Proceedings of the European Symposium on Programming Languages and Systems* (pp. 283-307). Berlin, Heidelberg.

Bingol, O., Tasdelen, K., Keskin, Z., & Kocaturk, Y. E. (2014). Web-based smart home automation: PLC-controlled implementation. *Acta Polytechnica Hungarica*, 11(3), 51-63.

Caldo, R. B., Seranilla, J. T., Castillo, D. J., Diocales, K. S., Gulle, W. D., Nuñez, B. L., & Parreño, C. T. (2015). Design and development of fuzzy logic controlled dimming lighting system using Arduino microcontroller. In *Proceedings of the Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management* (pp. 1-6). Cebu City, Philippines.

Chase, J. (2015). The Evolution of the Internet of Things. Retrieved March 20, 2018 from: http://www.ti.com/ww/en/connect_more/pdf/SWB001.pdf?DCMP=iot&HQS=iot-nsl-wp

Chew, I., Kalavally, V., Tan, C. P., & Parkkinen, J. (2016). A spectrally tunable smart led lighting system with closed-loop control. *Sensors Journal*, *16*(11), 4452-4459.

Das, S., Debabhuti, N., Das, R., Dutta, S., & Ghosh, A. (2014). Embedded system for home automation using SMS. In *Proceedings of the First International Conference on Automation, Control, Energy and Systems* pp. 1-6). Hooghly, West Bengal, India.

Dekate, A., & Ramchaware, P. (2015). Fault Acknowledgement System for UPS using GSM. *International Journal of Scientific and Research Publications. International Journal of Scientific Reasearch Publications. 5*(5) 360-363

Dfrobot. (2013). Arduino Shield Manual. Retrieved March 21, 2018 from: https://www.robotshop.com/media/files/pdf/dfrobot-arduino-shields-manual.pdf

DiMarzio, J. F. (2015). Setting Up Android Studio. In Android Studio Game Development. Apress, Berkeley, CA.

Dinesh, R., Pravin, S. A., Aravindhan, M., & Rajeswari, D. (2015). Library access system smartphone application using Android. *International Journal of Computer Science and Mobile Computing, 4*(3), 142-149.

ElectronicDesign (2018). A Smart Home Needs Smart Battery Management. Retrieved March 20, 2018 from: http://www.electronicdesign.com/power/smart-home-needs-smart-battery-management

Fatehnia, M., Paran, S., Kish, S., & Tawfiq, K. (2016). Automating double ring infiltrometer with an Arduino microcontroller. *Geoderma, 262*, 133-139.

Fitriyah, H., Widasari, E. R., Sagita, R. D., & Bagus, A. H. (2016). Design of remote control for smart home using interaction design method. In Proceedings of the *International Conference on Advanced Computer Science and Information Systems*, (pp. 91-96). Malang, Indonesia.

Gandhi, D., Kahar, N., Prajapati, P., Shah, J., & Patel, S. (2016). Anti-Theft Security System With Reporting and Safety Using Android Application Smart Industrial System using Android ADK. *International Research Journal of Engineering and Technology on* (pp. 631-634).

https://www.gsma.com/iot/wpcontent/uploads/2014/08/cl_iot_wp_07_14.pdf

Huang, W. S., & Hsu, P. L. (2015). Design the Adaptive Controller for Delta Robots with the Decoupling-Current Servo Motor. In *Proceedings of the International Conference on Intelligent Robotics and Applications* (pp. 197-208). Portsmouth, UK.

Jain, S., Vaibhav, A., & Goyal, L. (2014). Raspberry Pi based interactive home automation system through E-mail. In Proceedings of the *International Conference on Optimization, Reliabilty, and Information Technology,* (pp. 277-280). Faridabad, NCR, India

Kanetkar, Y. P. (2016). Let us C. BPB publications.

Khaled, M., Nouby, M. G., Nabhan, A., & GT, A. E. J. (2016). Design a Remote Control System for Submersible Pumps Based on GSM-SMS. *American Journal of Engineering and Technology Research*, *16*(2) 68-79.

Kodali, R.K., Jain, V., Bose, S., & Boppana, L. (2016). IoT Based Smart Security and Home Automation System. In *Proceedings of the International Conference on Computing, Communication and Automation,* (pp 1286-1289).

Kulkarni, T. D., Kohli, P., Tenenbaum, J. B., & Mansinghka, V. (2015). Picture: A probabilistic programming language for scene perception. In *Proceedings of the Conference on Computer Vision and Pattern Recognition* (pp. 4390-4399). Boston, Massachusetts.

Kumar, P., & Pati, U. C. (2016). IoT based monitoring and control of appliances for smart home. In *Proceedings of the International Conference on Recent Trends in Electronics, Information & Communication Technology,* (pp. 1145-1150). Bangalore, India.

Kumar, S. (2014). Ubiquitous smart home system using android application. *International Journal of Computer Networks & Communications. 6*(1) 33-34.

Kumar, S., & Lee, S. R. (2014). Android based smart home system with control via Bluetooth and internet connectivity. In *Proceedings of the 18th International Symposium on Consumer Electronics* (pp. 1-2). Berlin, Germany.

Li, C., Logenthiran, T., & Woo, W. L. (2016). Development of mobile application for smart home energy management: iSHome. In *Proceedings of the 6th International Conference on Power Systems* , (pp. 1-6). Delhi, India.

Li, X., Lu, R., Liang, X., Shen, X., Chen, J., & Lin, X. (2011). Smart community: an internet of things application. *Communications Magazine, 49*(11) 68-75.

Lin, H., & Bergmann, N.W. (2016). IoT Privacy and Security Challenges for Smart Home Environments. *Information, 7*(44), 1-15.

Marius, R., Remus, D., Monica, L., & Andreea, L. (2016). A Smart House in the Context of Internet of Things. *International Journal of Internet of Things and Web Services, 1*(2), 38-42.

Meijer, B. (2014). Arduino IDE user guide. Retrieved March 21, 2018 from: https://reprapworld.com/documentation/arduino_guide.pdf

Newart. (2018). Arduino SMS/ GMS shield. Retrieved March 21, 2018 from: http://www.farnell.com/datasheets/1696751.pdf

Peters. (2016). Relays. Retrieved March 21, 2018 from: http://www.navsea.navy.mil/Portals/103/Documents/NSWC_Crane/SD-18/PDFs/Products/Archive/Relays/Relays.pdf

Radiospares. (2017). Arduino Ethernet shield. Retrieved March 21, 2018 from: http://docs-asia.electrocomponents.com/webdocs/0db9/0900766b80db991d.pdf

Ransing, R. S., & Rajput, M. (2015). Smart home for elderly care, based on wireless sensor network. In *Proceedings of the International Conference on Nascent Technologies in the Engineering Field,* (pp. 1-5). Navi Mumbai, India.

Roy, C. K., & Williams, H. J. P. (2016). Green House Monitoring and Controlling using Android Mobile Application. *International Journal of Innovative Technologies. 4*(4) 720-724.

Sharma, A., Singh, G., Doshi, V., & Sharma, A. (2017). A Research Paper on the Comparison of Windows and Linux Operating Systems. *World Journal of Technology, Engineering and Research. 1*(1) 74-80.

Shaw, H., Ellis, D. A., Kendrick, L. R., Ziegler, F., & Wiseman, R. (2016). Predicting smartphone operating system from personality and individual differences. *Cyberpsychology, Behavior, and Social Networking*, *19*(12) 727-732.

Sparkfun electronics. (2016). Introduction to Arduino. *SK Technical Journal, 3*(1), 1-20.

Sumithra, P., Jane, D., Karthika, P., & Gavaskar, S. (2016). A smart environmental monitoring system using Internet of Things. *International Journal of Scientific Engineering and Applied Science*, *2*(3), 261-265.

Uhlemann, E. (2015). Introducing connected vehicles [connected vehicles]. *Vehicular Technology Magazine*, *10*(1), 23-31.

Wikepedia (2018) Android operating System. , retrieved 20th April 2018 via https://en.wikipedia.org/wiki/Android_operating_system.

Yang, M., Zhang, L., Yang, J., & Zhang, D. (2010). Metaface learning for sparse representation based face recognition. In *Proceedings of the 17th International Conference on Image Processing* (pp. 1601-1604). Hong Kong.

Zeebaree, S. R., & Yasin, H. M. (2014). Arduino Based Remote Controlling for Home: Power Saving, Security and Protection. *International Journal of Scientific & Engineering Research*, *5*(8), 266-272.

Zhang, W., An, Z., Luo, Z., Li, W., Zhang, Z., Rao, Y., & Duan, F. (2016). Development of a voice-control smart home environment. In *Proceedings of the International Conference on Robotics and Biomimetics,* (pp. 1697-1702). Qingdao, China.

APPENDICES

APPENDIX 1

USER MANUAL

Smart home automation is Arduino application has developed to enable the user to control and monitor smart home by a mobile device and web-based.

- ***System setup***

1. Connect the circuit as following:

Arduino pin	Equipment	Function
A14	LM35 sensor	Temperature input sensor
A15	MQ2 sensor	Gas input sensor
22	Servo motor	Control motor of door
24	Servo motor	Control motor of window
41	LED	Output of Motion
43	Relay	Control relay of air condition
45	Relay	Control relay of buzzer
47	Relay	Control relay of fan
48	PIR sensor	Motion input sensor
49	Relay	Control relay of pump
53	DHT11 sensor	Humidity input sensor
50, 51	SIM900	Receive and transmit

2. Supply the circuit using 5V, 2A adapter.
3. Upload the source code into the Arduino using a USB cable.
4. Install the application on the android phone.
5. Enter the IP address and phone number which using to communicate with the hardware.
6. Ren the application then start using the system.

APPENDIX 2

SOURCE CODES

The following the important source codes, which have written using the C language programming in the developed application.

```
//-------------------------------------------------------sms-----------------------------------------
  Serial.begin(19200);
  SIM900.begin(19200);
  delay(20000);
  Serial.print("SIM900 ready...");
  SIM900.print("AT+CMGF=1\r");
  delay(100);
  SIM900.print("AT+CNMI=2,2,0,0,0\r");
  delay(100);
  //-------------------------------------------------temperature-----------------------------------
  analogReference(INTERNAL);
    //-------------------------------------------------humidity-----------------------------------
  Serial.println("DHTxx test!");
  dht.begin();
  //-------------------------------------------------------Gaz-----------------------------------------
   pinMode(smokeA15, INPUT);
 //-------------------------------------------------------Motion-----------------------------------
  pinMode(51,INPUT);
  pinMode(41,OUTPUT);
  //-------------------------------------------------------Motor-----------------------------------
  myservo.attach(22);
  myservo2.attach(24);
   //-------------------------------------------------Realay-----------------------------------
     pinMode(43,OUTPUT);
     pinMode(45,OUTPUT);
```

```
    pinMode(47,OUTPUT);
    pinMode(49,OUTPUT);
    //-------------------------------------------------LIGHT---------------------------------------
  pinMode(41,OUTPUT);
   pinMode(39,OUTPUT);
   Ethernet.begin(mac, ip);
 }
//-------------------------------------------------------------------------------------------------------
float h = dht.readHumidity();
  float t = dht.readTemperature();
  float f = dht.readTemperature(true);
  if (isnan(h) || isnan(t) || isnan(f)) {   Serial.println("Failed to read from DHT sensor!");
    return;  }
  float hif = dht.computeHeatIndex(f, h);
  float hic = dht.computeHeatIndex(t, h, false);
 //-------------------------------------------------------------------------------------------------------
 reading = analogRead(tempPin);
tempC = reading / 9.31;
Serial.println(tempC);
//-------------------------------------------------------------------------------------------------------
int analogSensor = analogRead(smokeA15);
//-------------------------------------------------------------------------------------------------------
client.println("<FORM>");
client.println("<INPUT type=button value=OPEN_DOOR onClick=window.location=
'/?OPENDOOR\'>");
client.println("<INPUT type= buttonvalue=CLOSE_DOOR onClick=
window.location= '/?CLOSECDOOR\'>");
client.println("<INPUT type=button value=OPEN_WINDOW
onClick=window.location= '/?OPENWINDOW\'>");
client.println("<INPUT type=button value=CLOSE_WINDOW
onClick=window.location='/?CLOSECWINDOW\'>");
client.println("<INPUT type=button value=OPEN_LIGHT onClick=
window.location= '/?OPENLIGHT\'>");
```

```
client.println("<INPUT type=button value=CLOSE_LIGHT onClick=
window.location= '/?CLOSECLIGHT\'>");
client.println("<INPUT type=button value=OPEN_PUMP onClick=
window.location='/?OPENPUMP\'>");
client.println("<INPUT type=button value=CLOSE_PUMP onClick=
window.location='/?CLOSECPUMP\'>");
client.println("<INPUT type=button value=OPEN_FAN onClick=
window.location='/?OPENFAN\'>");
client.println("<INPUT type=button value=CLOSE_FAN onClick=window.location=
'/?CLOSECFAN\'>");
client.println("<INPUT type=buttonvalue=OPEN_AIR onClick= window.location=
'/?OPENAIR\'>");
client.println("<INPUT type=button value=CLOSE_AIT onClick= window.location=
'/?CLOSECAIR\'>");
client.println("</FORM>");
        if(readString.indexOf("?OPENDOOR") >0)          {          Motor1();       }
        if(readString.indexOf("?CLOSECDOOR") >0)       {          Motor2();       }
        if(readString.indexOf("?OPENWINDOW") >0)       {          Motor3();       }
        if(readString.indexOf("?CLOSECWINDOW") >0) {          Motor4();       }
        if(readString.indexOf("?OPENLIGHT") >0)
        { digitalWrite(39, HIGH);
          light_state="light is on";  }
        if(readString.indexOf("?CLOSECLIGHT") >0)
        { digitalWrite(39, LOW);
          light_state="light is off"; }
         if(readString.indexOf("?OPENPUMP") >0)    {       open_realay1();         }
        if(readString.indexOf("?CLOSECPUMP") >0) {       close_realay1();        }
         if(readString.indexOf("?OPENFAN") >0)       {       open_realay2();         }
        if(readString.indexOf("?CLOSECFAN") >0)    {       close_realay2();        }
       if(readString.indexOf("?OPENAIR") >0)         {       open_realay4();         }
        if(readString.indexOf("?CLOSECAIR") >0)     {          close_realay4();        }
```