SMS Based Home Appliances Controlling and Monitoring System Using Arduino PCB

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2018

SMS Based Home Appliances Controlling and Monitoring System Using Arduino PCB

A dissertation submitted for the Degree of Master of Information Technology

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University of Colombo School of Computing
2018

UCSC

Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

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This is to certify that this thesis is based on the work of

Mr./~~Ms~~. K.D.N.C. Perera

under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by:

Supervisor Name: Dr. K.L. Jayaratne

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Signature: Date: 06/07/2018

Abstract

While people are dealing with new technology they expect the way of their life become more comfort, convenience and more secure through this technology. The remote controlling and monitoring of electronic devices is one of the developing areas in current technology. Today, there are so many applications have been developed by using different technologies to make our life easier.

The main objective of this project is to design and develop a cost effective and user friendly system that allows for a user to easily and effectively control and monitor various home appliances from a remote location by using a smart mobile phone. The bi-directional communication between the mobile phone and the home appliance is based on Short Message Service (SMS) in Global System for Mobile (GSM) Communication.

To control an appliance, the user sends a message in the form of SMS from his/her mobile phone to a computer which is connected to the home appliance. Once the message is received, the computer will send the command to a microcontroller for controlling the appliance accordingly. The feedback mechanism of the system will verify the success of switch ON/OFF operations. Also, the user can check the switch ON/OFF status of any appliances. Moreover, this system provides security by means of alarming the user, when there is intrusion detection. At the same time activate the webcam, which is attached to the computer and capture the images of the scene in front of it. Apart from that, system allows the provision of security such that system took no action against the instructions receive from unauthorized mobile numbers.

The feedback from the user evaluation of the system provides how users satisfied with the system outcomes and system characteristics as well as suggestions to improve product with different perspectives. According to the user's response further proof that this system facilitates to manage electrical power consumption, assistance for elderly and disable persons at home alone, provides home security against intrusions, makes better safety against any current leakage, easier control of the system will improve people's lifestyle and helpful for people who are unaware of typing SMS and mistakes occur when typing SMS.

Acknowledgement

I would like to acknowledge, and thank all those who assisted me out for completing this project. Otherwise this project would not have been possible to complete without the valuable assistance of many people.

First and foremost, I would like to express my sincere appreciation to my supervisor Dr. K.L. Jayaratne. His guidance, support and continuous encouragement throughout the project was the reason behind accomplishing this work successfully. I also thank him for his insightful comments and suggestions which continually enthused me to successful completion of this project.

I also would like to take a moment to thank the senior lecture Mr. A.M.C.P. Atapattu who is working at Faculty of Management and Finance, University of Colombo, for providing me with the necessary electronic apparatus and share his knowledge of electronics to simply carry out some tasks of the project.

I am also grateful to the invariably friendly and helpful administrative staff of the UCSC's postgraduate unit and especially the library staff who efficiently attend to the student's need and requirements making their journey at UCSC a pleasant one.

Last but not least, I would also want to express my sincere gratitude to my wife, parents and family members who has always helped me and believed that I could do it.

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List of Abbreviations

1G   First Generation

2G   Second Generation

3G   Third Generation

API   Application Programming Interface

CLR   Common Language Runtime

CO   Carbon Monoxide

EEPROM   Electrically Erasable Programmable Read Only Memory

GSM   Global System for Mobile communication

GPRS   General Packet Radio Service

IDE   Integrated Development Environment

IEEE   Institute of Electrical and Electronics Engineers

ISDN   Integrated Services Digital Network

IR   Infra-Red

IP   Internet Protocol

MMS   Multimedia Messaging Service

MEDIUMBLOB   Medium Binary Large Object

MSISDN   Mobile Station International Subscriber Directory Number

NDK   Android Native Development Kit

OHA   Open Handset Alliance

PCB   Programmable Circuit Board

PC   Personal Computer

PIR   Passive Infrared Sensor

PDA   Personal Digital Assistant

PSTN	Public Switched Telephone Network
PDU	Protocol Data Unit
RFID	Radio-Frequency Identification
RF	Radio Frequency
RX	Transmit
RDBMS	Relational Database Management System
SMS	Short Message Service
SIM	Subscriber Identity Module
SRS	Software Requirement Specification
SRAM	Static Random Access Memory
SQL	Structured Query Language
TDMA	Time Division Multiple Access
TTL	Transistor-Transistor Logic
TX	Receive
UMTS	Universal Mobile Telecommunications Service
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
WiMax	Worldwide Interoperability for Microwave Access
XML	Extensible Markup Language

CHAPTER 01: INTRODUCTION

1.1 Introduction

In the present day, people's lifestyle moves with rapid changes because of the advancement of the information and communication technology. The society based on the information technology, highly influenced human being's way of life as well as challenging the traditional residence. When people deal with the technology they expect the way of their life become more comfort, convenience and more secure through this technology. As a continuous effort of researchers, lifestyle practitioners and the consumers, the concept of smart home has become a reality. Thus, significant efforts have been made development of remote control systems for home automation.

Today we are living in the 21st century, where automation plays gradually more important role in human life. Home automation is one of the essential parts of the concept of automation. Home automation allows us to control and monitor household appliances and also provides home security. The term "Smart Home", "Digital Home", "e-Home" and "Intelligent Home" are similar to home automation and although each of these means a high living condition with many smart devices.

The concept has been around for a long time and products have been on the market for decades. It began with a student connecting two electric wires to the hands of an alarm clock in order to close a circuit of a battery and light bulb. Later, companies developed automated systems of their own to control alarms, sensors, actuators and video cameras and, in so doing, created the first automated buildings which followed the term "Intelligent Home"[1].

Home automation system can be divided into two mediums which are wireless or wired connected. The difference between wireless and wired system is depends on how home appliances are linked to a host or central controller. Wireless systems had been introduced in order to dispose of wired communication between home appliances and it assists to save cost of wiring, easy to install, occupy lesser space, easy for maintenance and more reliable. There are several different types of wireless connection technologies such as GSM, Wi-Fi, ZigBee, Bluetooth, GPRS, UMTS, WiMax… etc was introduced to realize the interaction between the user interface and the home control board of the home automation system. Each of the connection has their own unique specifications and applications.

This project focuses on the design and development of a system to provide easy and effective means of controlling and monitoring various home appliances from a remote location. Also the system enables home security against intrusions in the absence of the home owner. This system controls by using SMS. SMS is a relatively simple communication system in GSM network. The Android application on the smart mobile phone make users of the SMS technology as a communication medium in GSM network to enable remote access to the various home appliances which are connected to the Arduino Uno PCB. A program written by using Arduino Software (IDE) is uploaded into the microcontroller (ATmeag328) on the Arduino Uno PCB to handle the controlling and monitoring processors of the system. This system allows the user to start and stop appliances as required from anywhere at any time through an SMS and feedback message inform the status (ON/OFF) of the required appliance.

Thus, this project facilitates to manage power consumption. For elderly and disabled persons, this system features provide assistance in maintaining the home and keeping safe. The system allows the provision of security such that system took no action against the instructions receive from unauthorized mobile number. The required task performed when the instructions received from the pre-configured mobile number in the system. Also, the mobile phone use of this system doesn't require Internet connectivity, because SMS doesn't depend on the Internet connection unlike the other instant messaging applications such as Viber and WhatsApp.

1.2 Problem Statement

Nowadays, people are struggling with their busy life style by doing their day to day activities. So there will be more chance to forget just simple things such as switching OFF the lights, air conditioner, electric iron and switching ON the security camera, washing machine as well as rice cooker. When house owners are on the outside, the normal condition is to come back and switch ON or OFF the appliance as required. But always it is not an easy task to do that.

The electrical devices connected in the home, office or any place, consumes electrical power and there is an absolute necessity of saving power as per present day situation. So it is necessary to control electrical devices more effectively and efficiently at anytime from anywhere. Besides that, home security has been a major issue, where crime is increasing and everybody wants to take proper measures to prevent intrusion in the absence of home owners. While those who are worrying about the security of their homes when they are away from their places, they unable to work in peace. Also, people with disabilities or elderly feel

uncomforted to connect and disconnect the power supply of electrical appliances without anyone's assistance.

Advancement in wireless technology nowadays has allowed the creation of various remote control systems, one of which is the famous Smart Home concept. A Smart Home is one that provides the capability to control home appliances remotely from any room in the home, as well as any location in the world by phone or Internet. Regardless of the technology, Smart Homes present some very exciting opportunities to change the way we live and work, and to reduce energy consumption at the same time.

1.3 Motivation

As a reason, advancement of the field of wireless communication technology the concept of smart home is conceived as one strategy to provide a level of independence at homes and improve their quality of life. The concept of smart home facilitates to provide improved convenience, comfort, energy efficiency and security.

The use of SMS continues to grow because it is simple, almost all mobile phones are enabled, doesn't require Internet access and cost effectiveness have motivated to use SMS technology as a communication medium in this project.

The Arduino Uno PCB is the main controller used to interface the appliances of the system. The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Arduino boards are relatively inexpensive compared to other microcontroller platforms. Simple and clear Arduino programming environment is easy-to-use for beginners. The Arduino software runs on windows, Macintosh, and Linux operating systems. Board equipped with a set of digital and analog input/output (I/O) pins. It increases the capability of connecting multiple devices. These factors have driven to use the Arduino Uno board as the control board of the system.

1.4 Aims and Objectives

The main objective of this project is to design and implement a prototype (low cost, reliable and scalable working model) that can be used to remotely control (switch ON or OFF) and monitoring (status or alert) of home appliances via SMS on GSM network with the help of the microcontroller on the Arduino Uno PCB. SMS is simple and work on most mobile phones. The simplicity of the technology and the limited bandwidth needed makes it an inexpensive

way of communicating. Therefore, this project mainly based on SMS as a communication medium between the mobile phone and the home appliances. This system provides an ideal solution to the problem faced by homeowners in daily life.

Also, the other objectives of this project is to

- ➢ Manage electrical power consumption
- ➢ Provides home security against intrusion in the absence of the homeowner
- ➢ Provide support in order to fulfill the needs of elderly and disabled in the home
- ➢ Two-way communication system between the home appliances and user's controlling device (feedback mechanism)
- ➢ Provides user a better safety against any current leakage
- ➢ Prevent unauthorized individuals from controlling home appliances
- ➢ Easier control of the system will improve people's lifestyle (productivity)

1.5 Scope of the Project

The proposed Home Automation system consists of following main functionalities.

- ➢ Control (switch ON/OFF) appliances by sending an SMS
- ➢ Check the condition (switch ON/OFF status) of appliances by sending a SMS
- ➢ Notify the change of appliance's status via SMS
- ➢ Operate servo motor to Open/Close garage roller door by sending a SMS
- ➢ Inform the user by sending a SMS alert message when any human movement is detected by the PIR motion sensor.
- ➢ Webcam attached to the PC automatically capture the images and save in database installed in the PC when human movement detected by the PIR motion sensor.
- ➢ Able to view saved images as a slide show by providing the time range, which they were captured by the webcam.

1.6 Structure of the Dissertation

This section contains the brief overview of the subsequent chapters of the report.

Chapter 01: This chapter simply describes the introduction of the topic, statement of the problem, motivation, aims and objectives and finally explains the scope of the project. Further, emphasizes the study area which specifically used to carry out the implementation activities and objectives that the programmer intends to cover from this project.

Chapter 02: This chapter includes the comprehensive overview of the background information and a review of similar systems available. In addition to that it presents the common automation protocols, GSM network and short message service, microcontroller solutions, Android and its architecture, and peripheral devices which help to develop the system.

Chapter 03: This chapter describes the analysis and design of the project. Analysis comprises the details that are related to the Software Requirement Specification (SRS) while design comprises the evidence of the methodical approach to the design of the solution.

Chapter 04: This chapter contains hardware and software implementation details related to the three main parts, namely Client, Server and Controller of the system. Besides that, describes the different types of technologies which have been used to accomplish the objectives in this system.

Chapter 05: This chapter initially describes the purpose of the testing, main stages involved in testing, techniques that can be used to test and how test plans are executed. The test case specification describes the prerequisites, the purpose of the specific test, required inputs and expected output, and outlines the pass/fail criteria for determining the acceptance. Also provides user evaluation of the system based on the results gathered from a questionnaire by putting the system into practice.

Chapter 06: This chapter describes the summary of work carried out, limitations of the current system, lessons learnt from this project work and how the system could be extended.

CHAPTER 02: BACKGROUND

This chapter will discuss about the reviews of related previous projects, journals and thesis that help to get an idea about the concepts, methodologies, technologies and any other information to improve the design of this project. Apart from, describe the common automation protocols, GSM network and short message service, microcontroller solutions, Android and its architecture, and peripheral devices that are used in the project.

2.1 Related Works

Home automation system is dominated to use information technology and computer science to control and monitor the home appliances. The home automation system becomes important, because it gives the user a comfortable and easy-to-use environment for home appliances. There has been significant research works has been carried out in the field of home automation.

Malik Sikandar, Hayat Khiyal, Aihab Khan, Erum Shehzadi (2009) **[3]** considers the controlling of home appliances remotely and providing security when the user is away from the place. The system is SMS based and uses wireless technology to revolutionize the standards of living. This system provides an ideal solution to the problems faced by home owners in daily life. The system is wireless therefore more adaptable and cost-effective. Also provide security against intrusion as well as automates various home appliances using SMS. The system uses GSM technology, thus providing ubiquitous access to the system for security and automated appliance control.

Mak Kwan Wuey (2011) **[4]** suggests a computer based wireless home automation system that uses Adobe Flash for the user interface, enabling users to control physical devices on their computer. This system uses low-rate wireless personal area networks (IEEE 802.15.4) in controlling various types of devices. It is developed as a low cost alternative in home automation technology as it doesn't need a dedicated hardware console. The system has achieved success in implementing core features such as plug and play coordinator setup, RFID control and integration, AES128 encrypted communication, communication fault detect and control extension to an Android smartphone device.

Faisal Baig, Saira Beg, Muhammad Fahad Khan (2012) **[5]** propose a system which provides a wireless communication link of home appliances to the remote user. The main objective of this work is to make such a system which controls the home appliances remotely. This system

provides two methods of controlling home appliances, one is via voice to text SMS and other is to use the mobile as a remote control. This system will provide a benefit to the elderly and disabled people and also to those who are unaware of typing SMS. The proposed wireless system reduces the wiring and complexity and making it a cost effective solution.

Tessema Gelila Berhan, Jiang Dening (2013) **[6]** focuses on control home electrical appliances utilizing the GSM supported hand phone. This is achieved by sending SMS from the authorized cell phone to the GSM SIM modem which, in turn, commands the microcontroller to carry out the switching by mean of power relays. This setup is useful for controlling devices where no wired connection to the place is available.

D. Jaya Sree M. Jhansi Lakshmi (2014) **[7]** presents a home automation system that is designed to assist and provide support in order to fulfill the needs of elderly and disabled in the home. Also, the smart home concept in the system improves the standard living at home. The main control system implements wireless Bluetooth technology to provide remote access from PC/laptop or smart phone. The design remains the existing electrical switches and provides more safety control on the switches with low voltage activating method. The switch status is synchronized with all the control system whereby every user interface indicates the real time existing switch status. The system intended to control electrical appliances and devices in a house with a relatively low cost design, user-friendly interface and ease of installation.

2.2 Common Automation Protocols

There are a wide variety of technology platforms, or protocols, on which a smart home can be built. Each protocol has their own sets of rules and standards for connecting various electronic devices and instructs them to perform functions. Choosing a smart home protocol is not an easy task. Obviously, it will require being support a large number of devices, as well as one that offers the best possible device interoperability. But there are also other factors to consider, such as power consumption, bandwidth and cost.

2.2.1 ZigBee

ZigBee is a wireless protocol that was developed as an International standard to enable wireless, machine to machine communication, and networks. This technology uses RF for signaling and control. It also consumes a very small amount of power, and uses a mesh network structure to offer excellent range and speedy communication between devices.

ZigBee devices are designed to not interfere with Wi-Fi networks and devices. They operate under the 802.15.4 standard and use the 868 MHz, 915 MHz, and 2.4 GHz frequency bands.

The ZigBee protocol currently has more than 1,200 products certified as compatible with a ZigBee hub. It is an open technology, so it's easy for developers to design new products that work with the ZigBee protocol. ZigBee enabled devices aid in home automation, security systems, wireless smoke and CO detectors, environmental controls, and automated appliances. In recent years, they have also been used to provide lighting control in homes as well as to automatically open and close drapes. The medical community has also started using ZigBee enabled medical monitoring devices that have transmission distances of up to 100 meters, depending on physical obstructions. ZigBee prides itself on its low power usage. In fact, ZigBee is so efficient that you can operate a ZigBee device on the same set of batteries for up to several years [8].

2.2.2 Z-Wave

Z-Wave is a wireless home automation protocol that uses RF to communicate with home automation devices. Its operating frequency varies with the region. In the United State the frequency is 908.42 MHz and in Europe 868.42 MHz. Each Z-Wave network is identified by a Network ID and each device is further identified by a Node ID thus making system secure. The Z-Wave protocol uses one central controller (hub) to set up and manage the home automation network. Once the network is set up, can add smart home devices, which can then be controlled using Z-Wave protocol.

There are more than 1,700 certified Z-Wave compatible devices on the market, giving consumers access to a wide range of options when automating their home. Z-Wave devices are known for being easy to set up and simple to use. In addition, protocol tends to consume less energy. Because the Z-Wave frequency is significantly lower than the frequency used for most other wireless devices, it has less chance of interference. This means fewer devices compete for the same frequency, which makes communication efficient and fast. One of the best things about Z-Wave home automation is that all Z-Wave compatible devices can communicate, regardless of their brand, type, or version. Even as products evolve over time, the Z-Wave network will remain operable with both older and newer versions of products [8].

2.2.3 X10 System

X10 is an international and open industry standard for communication among electronic devices used for home automation. It primarily uses power line wiring for signaling and

control, where the signals involve brief RF bursts representing digital information. A wireless radio based protocol transport is also defined. Household electrical wiring (the same which powers lights and appliances) is used to send digital data between X10 devices. This digital data is encoded onto a 120 kHz carrier which is transmitted as bursts during the relatively quiet, zero crossings of the 50 or 60 Hz alternating current waveform. X10 is inexpensive and many devices are available. This technology provides limited control over home devices **[9]**.

2.2.4 Bluetooth

Bluetooth is another wireless home automation technology that relies on radio waves to communicate. Bluetooth devices all contain a computer chip with a Bluetooth radio and software that makes it simple for devices to connect with each other. Although, able to use a central Bluetooth hub to control all the devices on a home automation network.

Any Bluetooth-enabled device can connect with any other Bluetooth-enabled device, which means there are hundreds of products that are compatible with Bluetooth home automation. The downside is that can't add a non-Bluetooth device to a Bluetooth hub. In addition, Bluetooth connections tend to have a limited range, so even if a device is compatible, it may stop working if it moves out of range of the Bluetooth hub.

Bluetooth is already included in so many devices that it is one of the fastest-growing sectors of home automation. In fact, Researches predict that Bluetooth will continue to become more important for all home automation devices in the near future. One of the biggest reasons that Bluetooth home automation is so desirable is how little power it uses. For people watching their energy consumption and carbon footprint, low-power home automation solutions, like Bluetooth, are ideal **[8]**.

2.2.5 Wi-Fi

Wi-Fi is protocol use used in home automation. It operates under the IEEE 802.11 standards and uses the 2.4 GHz ultra-high frequency and 5 GHz super-high frequency Industrial, Scientific and Medical bands. Every major Smart Home product has Wi-Fi capability. Wi-Fi was never intended to be a home automation protocol, but because it's so widely available and everyone has access to it, companies quickly adopted it for home use. Wi-Fi is not particularly power-efficient nor is it very strong when a lot of devices are connected. But it does have a big advantage. Smart Home devices connected via Wi-Fi do not require a smart hub for control. It's easy to set up Smart Home devices with a quick connection to the home's Internet **[10]**.

2.3 GSM Network and SMS

2.3.1 GSM Network

GSM is an acronym that stands for Global System for Mobile Communications. The original French acronym stands for Groupe Spécial Mobile. It was originally developed by the European Telecommunications Standards Institute in 1984 as a standard for a mobile telephone system that could be used across Europe. Now GSM is an international standard for mobile service and it offers high mobility. Subscribers can easily roam worldwide and access any GSM network.

The GSM system was designed as a 2G cellular phone technology. One of the basic aims was to provide a system that would enable greater capacity to be achieved than the previous 1G analogue system. GSM achieved this by using a digital TDMA. By adopting this technique more users could be accommodated within the available bandwidth.

GSM is a circuit-switched system that divides each 200 kHz RF channel into eight 25 kHz time-slots. GSM networks operate in a number of different carrier frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G), with most 2G GSM networks operating in the 900 MHz or 1800 MHz bands. Where, these bands were already allocated, the 850 MHz and 1900 MHz bands were used instead (for example in Canada and the United States). In rare cases the 400 and 450 MHz frequency bands are assigned in some countries because they were previously used for first-generation systems. Most 3G networks in Europe operate in the 2100 MHz frequency band **[11]**.

2.3.2 Short Message Service (SMS)

Short Message Service is also commonly referred to as a "text messaging". It's a way of sending short, text only messages from one mobile device to mobile devices, including cellular phones, smartphones and PDAs. It is a quick and convenient way of sending a short message to someone. SMS was originally standardized and implemented in GSM networks, but SMS has also been introduced in fixed networks (PSTN/ISDN). SMS messages can also be initiated from the Internet. SMS allows for text messages of 160 characters (letters, numbers and symbols) in length. or for other alphabets such as Chinese or Arabic, the maximum message size is limited to just 70 characters. Longer messages will automatically be split up into several parts.

2.3.3 SMS Gateway

Short Message Service Gateway software utility enable user to easily send and receive text "Short Messages" over GSM cellular telephone through the network. SMS Gateway is a service through which companies can instantly and cost-effectively send information to any number of GSM mobile phones in the world. SMS Gateway works simply by connecting server to the client database. The client supplies the destination GSM number, message content (text or binary), and an optional identification number for tracking purposes. The SMS Gateway software then converts the data into SMS format and sends the message to any number of mobile phones.
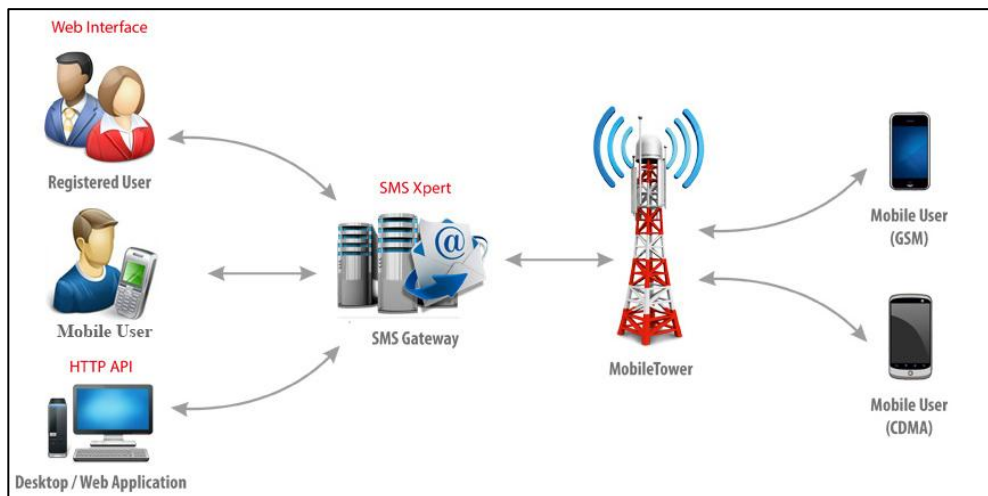
Figure 2-1: SMS Gateway

2.3.4 How Does SMS Work

SMS messages are created by mobile phones or other devices. These devices can send and receive SMS messages by communicating with the GSM network. All of these devices have at least one MSISDN number. They are called Short Messaging Entities. Following figure shows a typical organization of network elements and their roles in a GSM network supporting SMS.
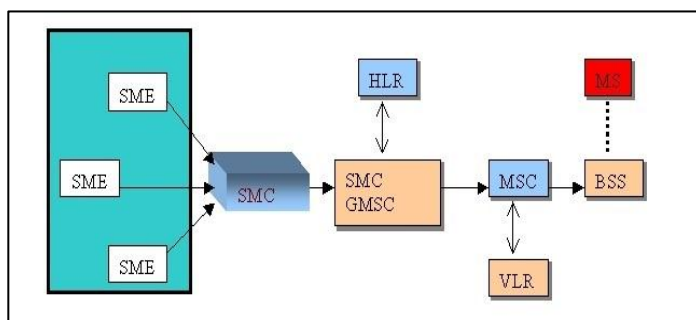
SME: Short Messaging Entity
SMSC: Short Message Service Center
MSC: Mobile Switching Center
BSS: Base Station System
VLR: Visitor Location Register
HLR: Home Location Register
MS: Mobile Station
SMS-GMSC: SMS Gateway Mobile Switching Center

Figure 2-2: GSM Network Supporting SMS

The SMC is the entity that stores and forwards the messages to and from the mobile station. Each network has a GMSC, and this is the mobile network's point of contact with other networks. On receiving the message from the SMC, GMSC uses the SS7 (Signaling System 7) network to interrogate the current position of the mobile station from the HLR. The HLR is the main database on a mobile network. It holds information on the subscription profile of the mobile and also about the routing information for the subscriber, i.e. the area (covered by a MSC) where the mobile is currently situated. The GMSC is thus able to pass on the message to the correct MSC. MSC is in charge of switching the connection over to the correct mobile station. VLR attached to each MSC, which helps to narrow down the exact location of the cell where the receiving handset is currently located. The message is then finally transferred to the corresponding BSS. The BSS consists of transceivers which send and receive information over the air, to and from the mobile station. This information is passed over the signaling channels so the mobile can receive messages even if a voice or data call is going on **[12]**.

2.4 Microcontroller Solution

A microcontroller is a self-contained system with peripherals, memory and a processor that can be used as an embedded system. Most programmable microcontrollers that are used today are embedded in other consumer products or machinery including phones, peripherals, automobiles and household appliances for computer systems. Due to that, another name for a microcontroller is "embedded controller". Some embedded systems are more sophisticated, while others have minimal requirements for memory and programming length and a low software complexity.

2.4.1 Arduino Development Board

Arduino is a powerful open-source electronics platform based on flexible, easy-to use hardware and software. That designs and manufactures single-board microcontroller and microcontroller kit for building digital devices and interactive objects that can sense and control objects in the physical world. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog I/O (Input/Output) pins that may be interfaced to various expansion boards (shields) and other circuits. The boards feature serial communications interfaces, including USB on some models, which are also used for loading programs from personal computers.

The Arduino project provides the Arduino IDE, which is a cross-platform application and written in the programming language Java. The Arduino IDE is used to write the program that

will interact with Arduino and the devices connected to it. In the Arduino world, such a program is called a sketch, and the coding language that uses is very much similar to C++ with some simplifications and modifications.
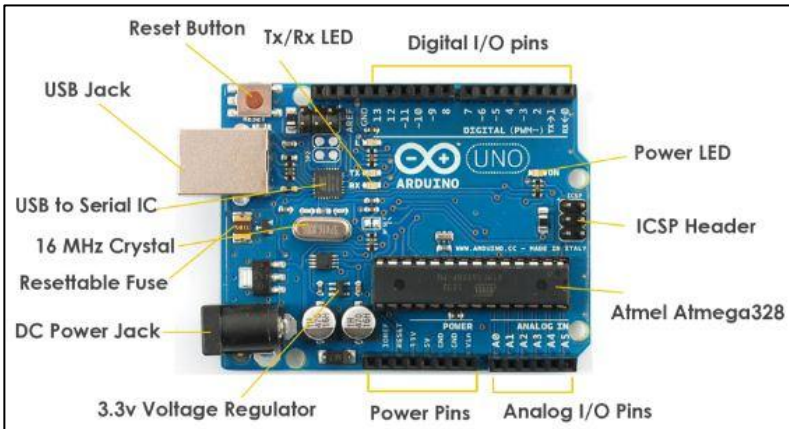
Figure 2-3: Arduino Board Component Layout

2.4.2 Raspberry Pi Development Board

Raspberry Pi is a credit card sized single computer board. It can be used for many of the things that desktop PC does, like spreadsheets, word-processing, games and it can also play high definition video. Raspberry Pi runs on a customized Debian Linux called Raspbian, which provides an excellent user experience.

The raspberry pi has been ready for public consumption since 2012 with the idea of producing a cheap educational microcomputer for students and children. It is created to be something to encourage learning, innovation and experimentation. The raspberry pi computer is portable and less expensive. Most of the raspberry boards are used to build raspberry pi projects, mobile phones and also used in solar street lights.

The system comes in two different models that is model-A and model-B. The main differences between these two are USB ports. The model-A board, does not include an Ethernet port and will consume less power. The model-B board includes an Ethernet port. The raspberry pi comes with a set of open source technologies that is communication and multimedia of web technologies and ability to interact with microcontroller. It is the portability of a mobile device **[13]**.
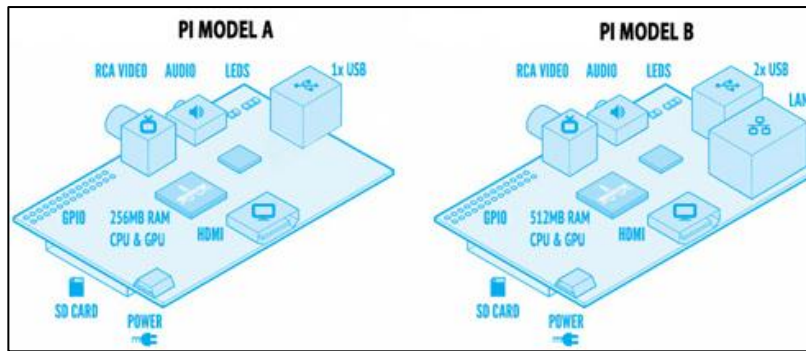
Figure 2-4: Raspberry Pi Boards Component Layout

2.5 Android

Android is an open source operating system for mobile devices such as smartphones and tablet computers. It is based on Linux kernel and released under the Apache v2 license. It was designed, engineered, and maintained by the OHA - a large consortium of 84 technology and mobile companies comprising Google, HTC, Sony, Dell, Intel, Motorola, Qualcomm, Texas Instruments, Samsung Electronics, LG Electronics, T-Mobile, and many others. Java is the primary programming language used to write the Android code and also it is possible to develop C and C++ applications using the NDK. Each version of Android since version 1.5 has been developed with a specific code name. These code names are chosen alphabetically, and have thus far all been dessert items such as Lollipop, Kitkat, Jelly Bean, Ice Cream Sandwich, Froyo, Ecliar, Donu. Some code names are associated with more than one version number, while others are limited to only a specific one.

2.5.1 Architecture of Android

The Android operating system is a stack of software components which is roughly divided into five sections and four main layers as follows.
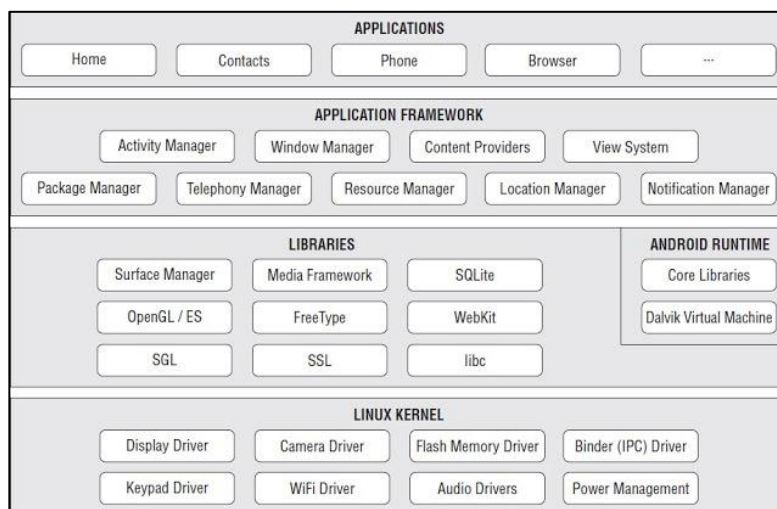
Figure 2-5: Layers of Android Operating System

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- **Linux Kernel:** Kernel is the main component of the OS that creates a bridge between the software (an application) and hardware, providing the lowest level of abstraction that application software must control to perform its function. The kernel would typically include memory management programs, power management and several device drivers to control hardware devices likes the camera, keypad, audio, etc.

- **Libraries and Android Runtime:** This gives the kernel instruction to perform specific tasks. Located on the same level as the libraries layer, the Android runtime layer includes a set of core Java libraries that allow Android applications to build their apps using Java programming language along with the Dalvik virtual machine.

- **Application Framework:** This includes the programs that manage the phone's basic functions like resource allocation, location management, notification management, etc. Being an open development platform, application developers have full access to the Android's application framework, allowing them to build extremely rich applications.

- **Applications:** This comprised of applications that are built-in (developed by the Android team) or any other third party applications that have been installed on the device. Applications that you develop are also installed in this layer. Typical applications include: Camera, Alarm, Clock, Calculator, Contacts, Calendar, Media Player, and so forth **[14]**.

2.6 Peripheral Devices

2.6.1 PIR Motion Sensor Module

PIR motion sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensor range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses.

2.6.2 GSM Modem

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. When a GSM modem is connected to a computer, this allows the computer to use the GSM modem to communicate over the mobile network. While these GSM modems are most frequently used to

provide mobile internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

2.6.3 Webcam

A webcam is short for "web camera". It is an input device because it captures video images of the scene in front of it. It is either built into the computer (e.g. Laptop) or it is connected to the USB or FireWire port on the computer. The video signal is made up of a series of individual "image frames" which are an instant snapshot of the scene in front of it. Each image frame is sent to the computer for further processing by webcam software. If the frame rate is fast enough (more than 25 frames per second) it appears as motion video.

2.6.4 LED Bulbs

LED stands for "Light-Emitting Diode". An LED is an electronic device that emits light when an electrical current is passed through it. Early LEDs produced only red light, but modern LEDs can produce several different colors, including red, green, and blue (RGB) light. Recent it produce white light as well.
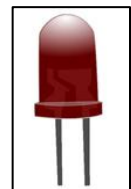
2.6.5 Servo Motor

There are different types of servo motors classified based on their application. The positional rotation servo motor is used in some applications like precise position control. Usually, its shaft can rotate approximately 180 degrees. Servo motors comprise of three wires namely power, control signal, and ground. The control signal is the input, either analog or digital, which represents the final position command for the shaft.

2.6.6 Direct Current (DC) Motor

DC motor transforms electric energy into mechanical energy in the form of rotation. It has just two leads, one positive and one negative. Connect these two leads directly to a power source, the motor will rotate. Reverse the leads, the motor will rotate in the opposite direction. Supply voltage magnitude controls motor speed.
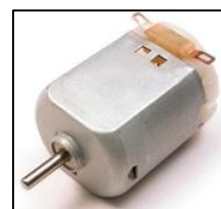
CHAPTER 03: ANALYSIS AND DESIGN

This chapter describes the analysis of the existing home appliances controlling systems and main functions that addressed by the proposed system. It also describes the non-functional requirements, hardware and software requirements. The design section contains with a simple block diagram of the proposed system as well as data flow diagrams for different levels.

3.1 System Analysis

3.1.1 Analysis of Existing Systems

Most of the home automation systems use smart phones to communicate with microcontrollers using different types of communication technologies such as Bluetooth, Voice Recognition, ZigBee, GSM, Internet, Wi-Fi etc. Each technology has its own advantages and disadvantages.

Bluetooth based home automation systems give complete control over home appliances as long as the user is in range of Bluetooth network. Bluetooth network has limited range of 10 meters to 100 meters if the smart phone is out of range, then it will not be able to control the home appliances. This is one of the main disadvantages of the Bluetooth based home automation system.

Voice recognition based home automation systems have greater security because of voice of every human contains unique features. The main drawback of these systems is that communication between user and voice recognition tool depends on the signal-to-noise ratio (SNR), if voice signal is noisy the communication can highly effect and the system will fail to show accuracy.

ZigBee technology is almost same to Bluetooth and its advantages and disadvantages are also similar to Bluetooth. It has a physical range between 10 meters to 20 meters, which can increase up to 150 meters.

Internet base home automation systems can access and control by the homeowner from anywhere in the world if the system is connected to the Internet. But connecting the home to the Internet opens it up to the world. That means anyone with an Internet connection can try to access the home. Besides to that availability of the Internet connection and required bandwidth are still a major challenge to some parts of the geographical areas.

SMS text messaging service in the GSM network that effectively allows control and monitor home appliances from anywhere at any time. Although, the SMS does not depends on the Internet connection unlike the other instant messaging applications such as Viber and WhatsApp. Therefore, it has high availability when compared to the other technologies.

3.1.2 Functional Requirements

This section categorizes the requirements for creating the system as follows.

User's perspective,

- **Control appliances:** User requires to starts or stops (switch ON/OFF) appliances afar by sending a SMS.
- **Notify change of appliance' status:** Report appliance's status change to the user by a SMS.
- **Check status of appliances:** Send back a SMS message to inform the user, the status of the appliance under consideration.
- **Intrusion detections:** Any human movement detected by the PIR sensor will inform the user by sending a SMS alert message.
- **View captured images:** Save captured images relevant to the intrusions and able to view later.

Systems' perspective,

- **Android application:** Application should be able to generate SMS messages and send it to the target mobile number as well as display the status of the appliances received via SMS.
- **Transfer SMS message to a control command and appliance's status to a SMS message:** The program running on PC will be able to read the SMS messages received to the connected GSM modem, convert message content into a command and transfer it to the control unit (Arduino board). Although the program will be able to send status/alert SMS messages to the particular mobile number according to the triggers receive from the control unit.
- **Control and monitor electrical appliances:** The program running on microcontroller of the control unit should read/write relevant digital pin to control and monitor electrical appliances.

3.1.3 Non-Functional Requirements

➤ **Security:** System allows the provisions of security such that system accepts SMS messages receive only from the pre-configured mobile number in the system. Likewise the system will not take any action against the instructions receives from SMS is not in pre-defined format.

➤ **Safety:** Home appliances switched ON/OFF by sending a SMS without actually going near to the switchboard or regulators.

➤ **User friendliness:** Simple graphical user interface of the android application helps user to eliminate typing mistakes when sending SMS messages and also indicate the status of an appliance in an understandable way.

➤ **Availability:** User can control and monitor home appliances via a user friendly interface from anywhere and anytime (24/7) through the SMS.

3.1.4 Hardware and Software Requirements

Following are the list of identified hardware and software requirements in order to develop the system.

Hardware Requirements

- PC/Laptop with Windows 7 (64-bit/32-bit) operating system
  2 GHz or faster processor, 4 GB RAM, 100 GB Hard disk, 3 USB 2.0 ports
- 2G/3G USB GSM Modem (Dongle) with a SIM card
- Android phone with a SIM card
- Arduino Uno R3 board (ATmega328 microcontroller) and USB A/B cable
- Webcam (Logitech C170 with video resolution 1024 x 768)
- PIR motion sensor module
- Micro Servo motor (Tower Pro Micro Servo SG90)
- DC toy motor
- Two Light Emitting Diodes (LED)
- Buzzer
- One PN2222 Transistor, one 1N4001 Diode, two 2.2 KΩ Resistor
- Jumper wires (male-to-male, male-to-female, female-to-female)

Software Requirements

- Arduino Software (IDE) with USB driver (CH340)
- Microsoft Visual Studio development environment for C#
- .NET Framework 3.5 or higher
- GSM Communication Library for .NET framework
- Webcam driver (Logitech Webcam C170 drivers for Windows 7)
- MySQL database
- Android Studio
- Java Development Kit (JDK) 8.0

3.2 System Design

To accomplish the functionalities described above, the system divides into three parts, namely client, server and controller.

Client

The client which is a smart phone with Android application that makes easier and faster way of selecting the appliance and the operation intended to perform on the appliance. This device communicates with the GSM Modem connected in the server by using SMS.

Server

The server, which is a PC consists with a GSM Modem, a Webcam and a Database. GSM Modem is to receive SMS messages and send feedback SMS as well as security alerts from/to the client. The PC contains a program to make communication between GSM Modem and microcontroller in Arduino Uno PCB. Besides that, the program facilitates to capture images through Webcam and save in database and retrieve captured images as user required.

Controller

An Arduino Uno PCB is the controller use to interface the appliances. It uses certain peripheral drivers and relays to achieve this interfacing. The program running inside the microcontroller performs the required controlling and monitoring process of the appliances.

3.2.1 System Block Diagram
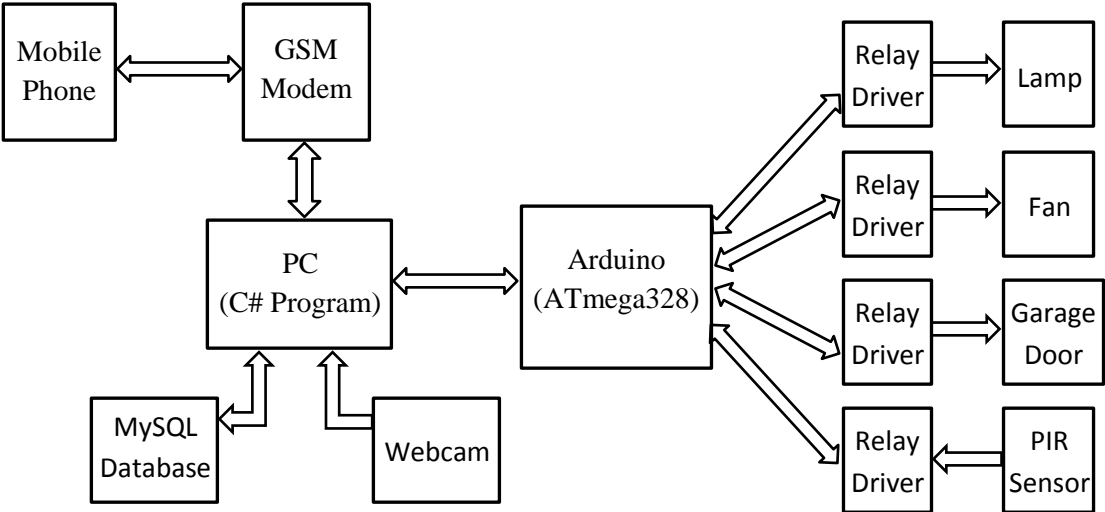
Figure 3-1: Block Diagram of the System

The figure shown above is the block diagram of the system. It illustrates the various hardware components involved in the system and how this SMS based communication works, gets help user to controlling and monitoring home appliances.

The user sends the SMS message to the GSM modem via the GSM network as a text message with a predefined format. Once the GSM modem receives the message, the program running on the PC will read and extract the message content. The program accepts SMS messages receive only from pre-configured mobile number in the system. The content of the message is examines to know what operation the user wants to perform. Then generate the appropriate command and transmit command to the Arduino board through USB-to-Serial interface.

The program running on microcontroller on the Arduino board reads the receive command and perform the appropriate action. If the command is to switch ON/OFF the appliance then write the high/low value to the specified digital pin. If the command is to check the appliance's status, then read the high/low value of the particular digital pin and send back the status to the PC. Likewise, human movement detected by the PIR motion sensor will notify the PC to capture the images through webcam and save it in database to view later. Subsequently, PC generates a text message about the appliance's status/security alert and sends that message from GSM modem to the pre-configured mobile number through the GSM network.

3.2.2 Data Flow Diagram

Following is the physical data flow diagram for the system and it represents how the system will be implemented, including the hardware, software, files, and people involved in the system as well as the flows of data into and out of these entities.

Context Diagram
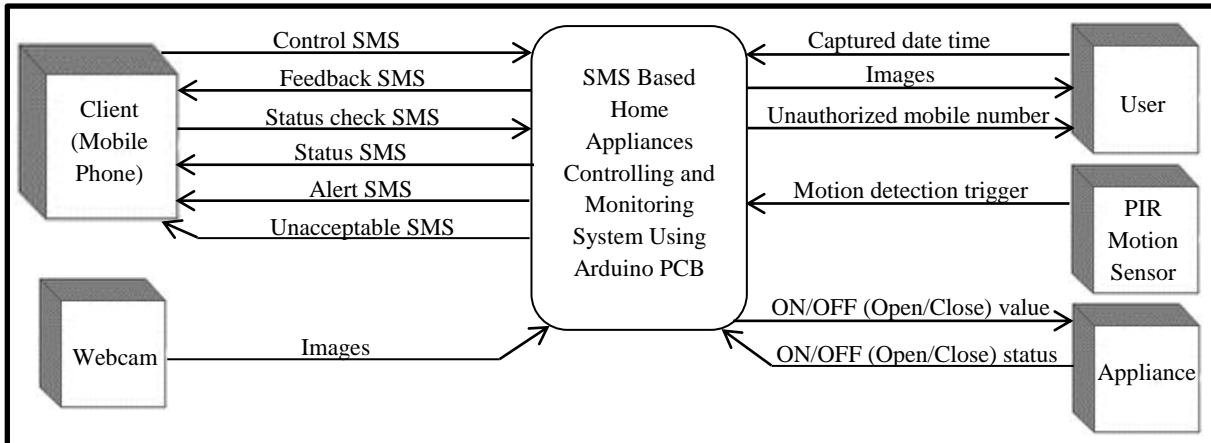
Figure 3-2: Context Diagram

Level 1 Diagram
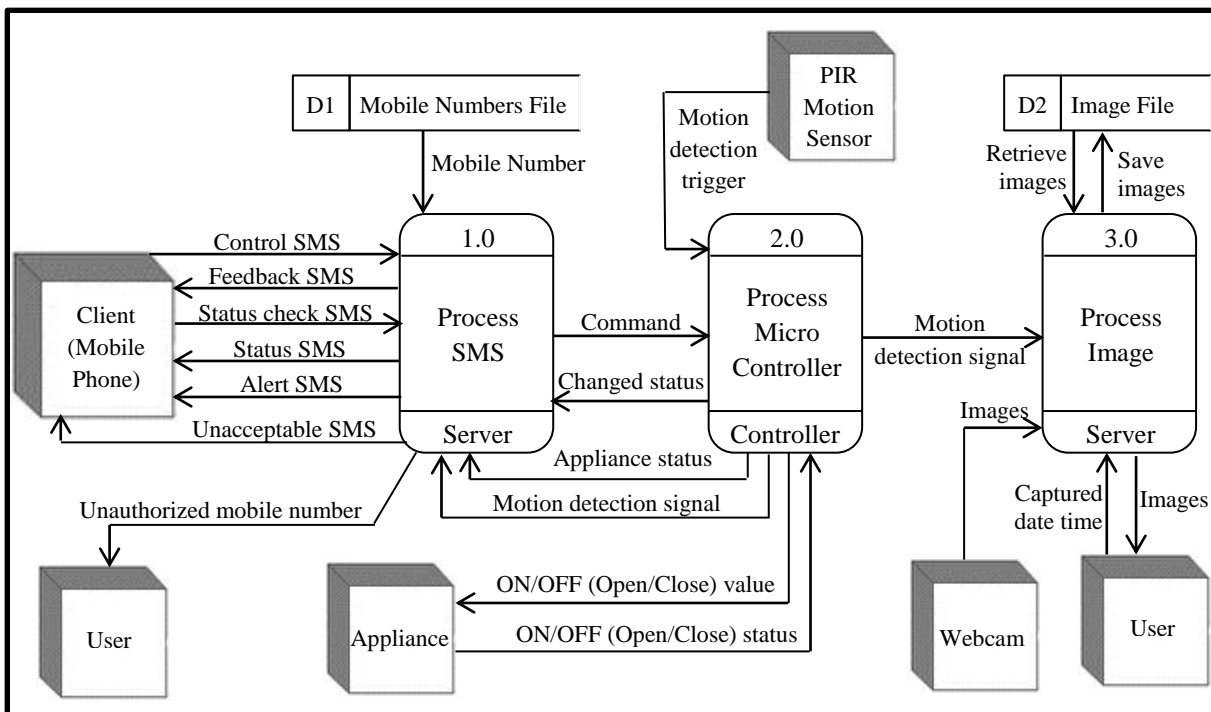
Figure 3-3: Level 1 Diagram

❖ **Refer Appendix A for succeeding levels of the data flow diagrams.**

CHAPTER 04: IMPLEMENTATION

This chapter contains hardware and software implementation details related to the three main parts, namely Client, Server and Controller of the system. Besides that, describes the different types of technologies which have been used to accomplish the objectives in this system.

4.1 Main Technologies Used in this System

There are many good reasons for selecting the main technologies such as SMS as a communication medium to remotely connect to the system and Arduino Uno as a controller board to connect numerous electronic appliances.

4.1.1 Why Choose SMS as a Communication Medium

Choosing the most effective communication medium is an essential to make a better interaction between the user and the automation system. The benefits of SMS are hard to ignore and there are many good reasons to use SMS as a communication medium.

- ➢ **Instant:** Mobile phone users have constant access to their devices and SMS. Also, messages can be received and read immediately.
- ➢ **Reliable:** SMS messaging is not depending on Internet connectivity issues, device or operating system. Every mobile phone is capable of receiving text messages.
- ➢ **Direct:** Messages are sent directly to the intended recipient's hand.
- ➢ **Simple:** Due to its simplicity and reach, SMS have become globally accepted communication channel.
- ➢ **Inexpensive:** When compared with other communication methods, SMS can be done with a significantly lesser amount.

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- **Simple:** Due to its simplicity and reach, SMS have become globally accepted communication channel.
- **Inexpensive:** When compared with other communication methods, SMS can be done with a significantly lesser amount.

4.2 Programming the Controller

Arduino Uno is a microcontroller board based on 8-bit ATmega328 microcontroller. It is running at 16MHz clock speed. It has 32KB of flash memory (store sketch), 2KB of SRAM (create & manipulate variables when sketch runs) and 1KB of EEPROM (store long-term information).

The board consists of 14 digital I/O pins and 6 analog input pins to attach various devices. Each digital pin operates at 5V. Also, every pin has an internal pull-up resistor and disconnected by default. Each analog input pin provides 10 bits of resolution (1024 different values). By default they measure from ground to 5V.

In order to get started, the board can be powered via USB connection or an external power supply with a recommended range 7V to 12V. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). These pins are connected to the corresponding pins of the ATmega8U2 chip. The Atmega8U2 programmed as a USB-to-serial converter and appears as a virtual COM port to software on the computer.
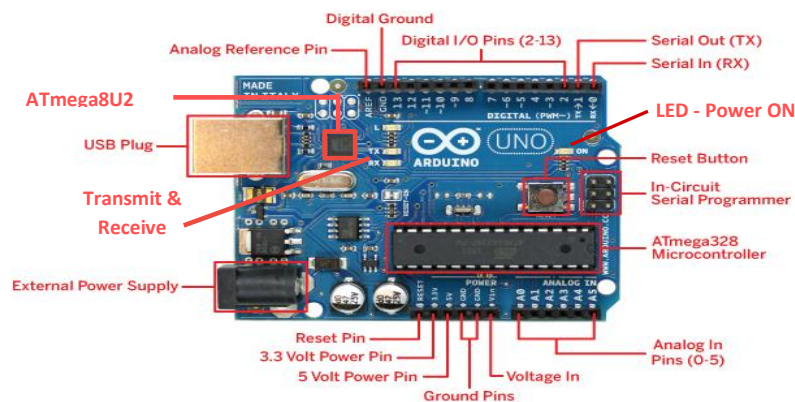
Figure 4-1: Arduino Uno Board

4.2.1 Serial Communication

Serial communication between two devices allows messages to be sent in the form of series of voltage pulses that encode a sequence of zeros and ones. There are two main serial communication protocols, TTL and RS232. The major difference between them is the voltages that encode the bits. TTL encodes zeros with a 0V and ones with a +5V (or +3.3V). RS232 encodes zeros as +3V and ones as -3V. Arduino's serial communication uses the TTL protocol.

Serial communication can be further classified as

- **Synchronous** − Synchronous communication requires that the clocks in the transmitting and receiving devices running at the same rate. No start or stop bits are required. Data is not sent in individual bytes, but as frames of large data blocks.
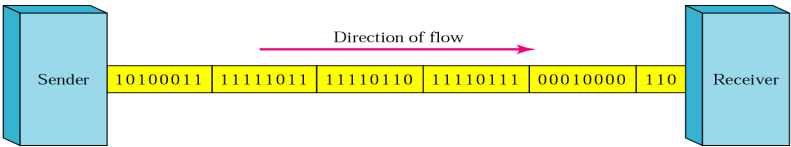
Figure 4-2: Synchronous Data Transmission

- **Asynchronous** − Devices that are asynchronous, have their own clocks and are triggered by the output of the previous state. This type of transmission sends only one byte at a time. The asynchronous serial protocol has a number of built-in rules. These rules help to ensure robust and error-free data transfers. The first bit is always the START bit (beginning of the data packet), followed by DATA bits (usually 8-bits), and followed by one or more STOP bits (ending of the data packet). There may be a PARITY bit (optional) just before the STOP bit. The START bit is always low (0) while the STOP bit is always high (1). The UART TTL module of the Arduino is asynchronous.
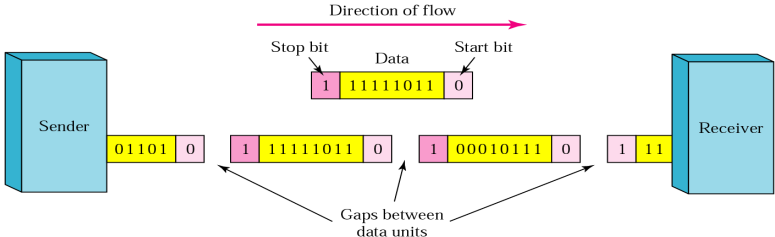
Figure 4-3: Asynchronous Data Transmission

4.2.2 Arduino Software (IDE)

Arduino Software (IDE) is the open source software to write code and upload it to the Arduino board. Arduino IDE runs on Windows, Mac OS X, and Linux. Programs written using this software are called "sketches" and have the file extension ".ino".
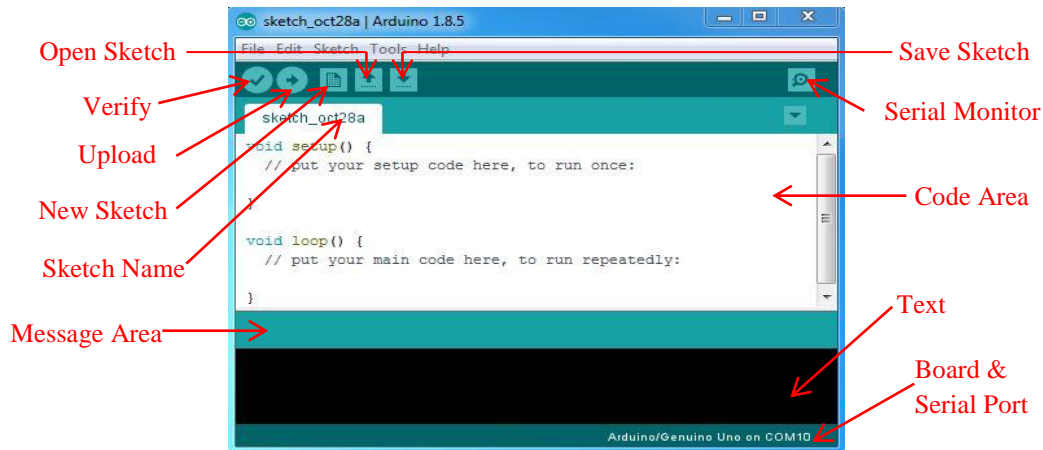
Figure 4-4: Arduino Software (IDE)

Arduino IDE has several features that can be a great help to write and debug sketches or controlling Arduino from the computer.

Serial Monitor

The Serial Monitor is a pop-up window and acts as a separate terminal that communicates by sending and receiving serial data with selected baud rate. It helps to debug sketches or to view data sent by a working sketch.

Verify/Compile

Verify/Compile, process builds written sketch according to the rules defined in board, board options and build options. Also displays status and possible errors in a console-like view at the bottom of the window. The Arduino environment performs compiling process with the use of the C / C++ compiler (avr-g++).

Libraries

The Arduino programming environment can be extended through the use of libraries. Libraries provide extra functionality for use in sketches. A number of libraries installed with an IDE such as Robot Control, Servo, Keyboard, GSM, etc. But can also download or create own one.

4.2.3 Program Structure and Important Functions

The basic structure of the Arduino programming language is simple and runs in at least two parts. These two required parts or functions are enclosing blocks of statements.

```
void setup()          void loop()
{                     {
   statements;            statements;
}                     }
```

Where setup() is the preparation, loop() is the execution.

- **setup ()**

  This function is called when a sketch starts. Use it to initialize variables, pin modes, initialize serial communication, start using libraries, etc. The setup function will only run once, after each power up or reset of the Arduino board.

- **loop ()**

  This function follows next and includes the code to be executed continuously allowing the program to read inputs, triggering outputs, etc. This function is the core of all Arduino programs and does the bulk of the work.

- **Serial.begin (speed, config)**

  This function opens the serial port and set data rate in bits per second (baud) for serial data transmission. The typical baud rate for communicating with the computer is 9600, although other speeds 300, 1200, 2400, 4800, 14400, 19200, etc. are supported. The optional second argument configures the data, parity, and stop bits. The default is 8 data bits, no parity, and 1 stop bit. Valid configurations values are SERIAL_6N1, SERIAL_8N1 (default), SERIAL_5N2, SERIAL_8E1, SERIAL_8O1, etc.

- **Serial.available ()**

  This function gets the number of bytes available for reading from the serial port. This is data that's already arrived and stored in the serial receive buffer (holds 64 bytes).

- **Serial.read ()**

  This function reads the first byte of incoming serial data available.

- **Serial.readBytes (buffer, length)**

  This function reads characters from the serial port into a buffer (char[] or byte[]) and returns the number of characters placed in the buffer. The function terminates if the determined length has been read, or it times out.

- **pinMode (pin, mode)**

  This function used in setup() to configure the specified pin to behave as input or output. Arduino declared digital pins default to inputs, so don't need to be explicitly declared as inputs with pinMode(). Pins configured as INPUT is said to be in a high-impedance state and pins configured as OUTPUT are said to be in a low-impedance state.

- **digtalRead (pin)**

  This function reads values from a given digital pin with the results either HIGH/LOW.

- **digitalWrite (pin, value)**

  This function outputs either logical level HIGH or LOW at (turn ON or OFF) a specified digital pin. If the pin has been configured as an OUTPUT with pinMode(), its voltage will be set to the value +5V (or +3.3V) for HIGH, 0V (ground) for LOW. If the pin is configured as an INPUT, digitalWrite() will enable (HIGH) or disable (LOW) the internal pull-up on the input pin.

4.2.4 Operations of Different Electronic Appliances

4.2.4.1 Passive Infrared (PIR) Motion Sensor Module

The PIR motion sensor detects or measures IR radiations emitted by any object in its field of view. So, it can detect motion based on changes in infrared light in the environment. It is ideal to detect if a human has moved in or out of the sensor range.
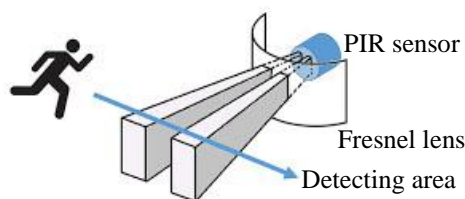
Figure 4-5: Detect Object in Sensor's Range

Sensor circuit has two potentiometers. One for adjusting the sensitivity of the sensor and other for adjusting the time the output signal stays high when an object is detected.
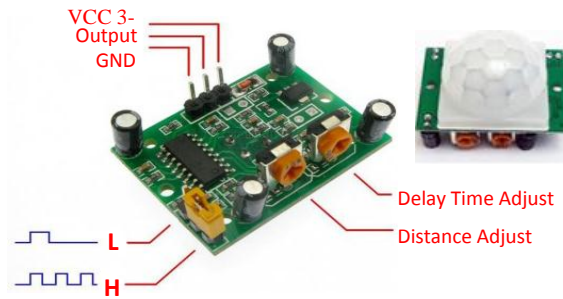
Figure 4-6: PIR Circuit

- **Sensitivity (Distance) Adjustment Potentiometer**

  Clockwise to High and Counter-Clockwise to Low (Distance Range: 3m)

- **Delay Time Adjustment Potentiometer**

  Clockwise to Extend (to 5 minutes) and Counter-Clockwise to Shorten (to 0.3 seconds)

- **Jumper Pins**

  The module has three pins with a jumper between two of them. These pins are for selecting the trigger modes.

  H (Repeat Trigger): When the sensor output is high and the delay time is over, the output will automatically change from high to low level.

  L (Can't Repeat Trigger): Will keep the output high all the time until the detected object is present in the sensor's range.
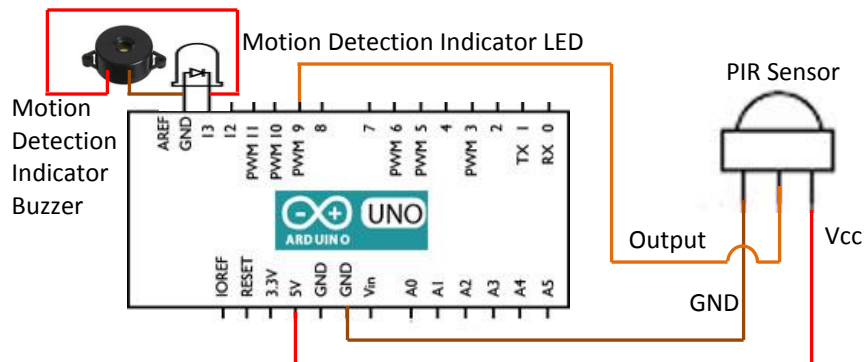
Figure 4-7: PIR Sensor connect to Arduino

A PIR sensor module has 3 pins. Vcc pin (Red wire) which is a +5V input, ground pin (Brown wire) and digital output pin (Orange wire). Digital output pin has 2 possible output values either a HIGH or a LOW. By default, when there is no object in the range of PIR sensor it outputs a LOW value (0V) at the output. When an object is identified inside the range of PIR sensor it immediately outputs a HIGH value (+5V) at the output. When PIR sensor detects a motion, then the LED will flash and the buzzer will sound for a period of time the output signal stays high.

4.2.4.2 Tower Pro Micro Servo SG90 Motor

The Servo motors can use to position the motor shaft at a specific position using control signal. The motor shaft will hold in this position as long as the control signal not changed. Usually, servo motors have an arm that can rotate approximately 180 degrees. Using the Arduino, can tell a servo to go to a specified position and it will go there.

The SG90 micro servo motor has a 3 wire interface in which the connections should do as follows. Red wire is for the power supply (+5V pin), Brown wire is for the ground (GND pin) and Orange wire for the control signal.
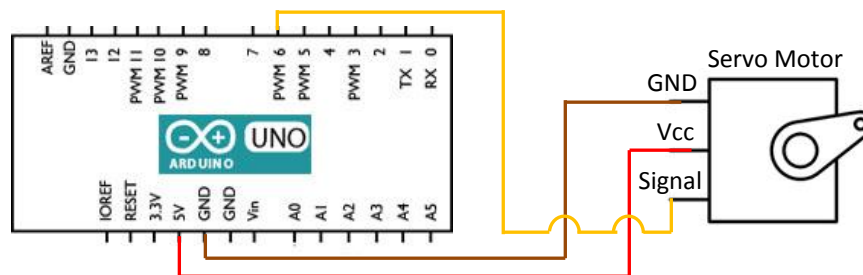
Figure 4-8: Servo Motor connect to Arduino

There are 2 methods of rotating motor's shaft into a desired position. One method is setting servo position in degrees of angle. In that case, connects the control signal wire to any digital pin on the Arduino board. Other method instructs servo to adjusting to a required position by giving the exact duration of the pulse width. In this case it is necessary to connect the control signal wire to one of the digital PWM pins 3, 5, 6, 9, 10, or 11.
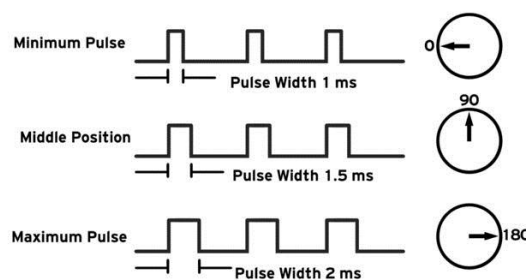
Figure 4-9: Variable Pulse width control servo position

Servos accept duration of pulse width from 1000 μs (1ms) to 2000 μs (2ms). A 1500 μs pulse will make the motor turn to the 90° position. Shorter than 1500 μs moves it in the counter-clockwise direction toward the 0° position, and any longer than 1500 μs will turn the servo in a clockwise direction toward the 180° position.

Servo Library and Supported Functions

Servo Library is one of the standard libraries installed with Arduino software IDE. The library provides a set of functions to control servo motors precisely. In order to use functions of this library needs to include its header file as "#include <Servo.h>"

- **servo.attach (pin)**

  This function is used to attach the servo variable to a pin.

- **servo.write (angle)**

  This function is used to write a value (angle in degrees) to the servo, controlling the shaft accordingly.

- **servo.read ()**

  This function is used to read the current angle of the servo.

- **servo.writeMicroseconds (μs)**

  This function is used to write a value in microseconds (μs) to the servo, controlling the shaft accordingly.

4.2.4.3 Direct Current Motor (DC Motor)

DC motors normally have just two leads, positive and negative. Do not connect the motor straight to an Arduino board pin, there is a good chance that it could damage the Arduino board. Use a driver circuit or an IC.
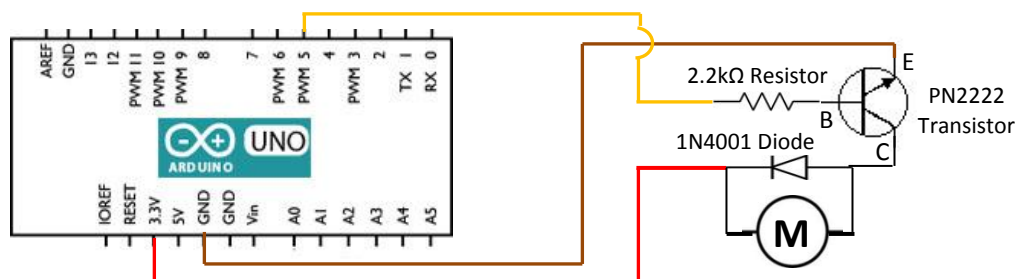
Figure 4-10: DC Motor connect to Arduino

The transistor acts like a switch, controlling the power of the motor. Arduino digital pin 5 is used to turn the transistor on and off. The Motor will spin at full speed when the pin state goes high. The transistor has three leads. Most of the electricity flows from the Collector to the Emitter, but this will only happen if a small amount is flowing into the Base connection. This small current is supplied by the Arduino digital output. This digital pin connected to the resistor. This limits the current flowing into the transistor through the base.

There is a diode connected across the connections of the motor. It allows current to pass in one direction from positive to negative, but will block any stray current that tries to go in the opposite direction, which might have undesirable effects on Arduino board.

4.2.4.4 LED Bulb

LED bulbs have a polarity, which means they will only light up if place the legs properly. The long leg is typically positive, and should connect to a digital pin on the Arduino board. The short leg goes to GND pin. In order to protect the LED, will also need to use a resistor "in series" with the LED. Connection diagram is as follows.
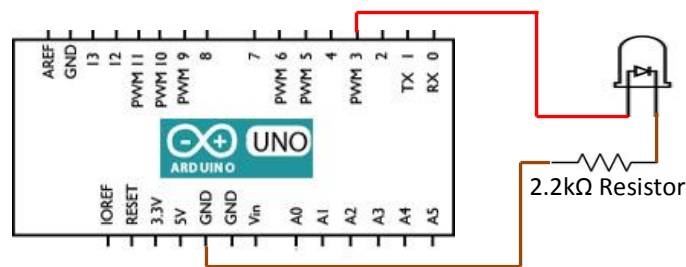
Figure 4-11: LED connect to Arduino

The LED turns ON when the digital pin 3 is set to HIGH and turns OFF when is set to LOW.

4.3 Programming the Server

The server which is a personal computer consists of a GSM Modem, a Webcam and a MySQL Database. It contains a program written in Visual C# to make bidirectional communication between the GSM Modem and the microcontroller in Arduino board. GSM Modem is to receive messages and send feedback messages as well as security alerts from/to the client. Besides that, the program facilitates to capture images through Webcam and save into database for future reference.
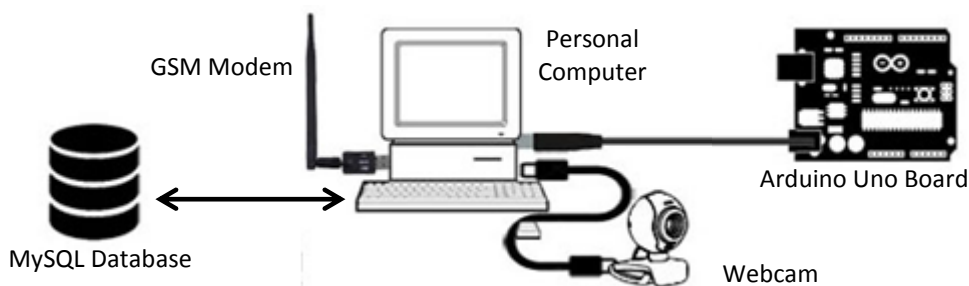
Figure 4-12: How Devices Connect to PC

4.3.1 Server Programming Environment

Microsoft Visual Studio

Microsoft Visual Studio is a collection of applications which allows developers a compelling development environment for the Windows and .NET platforms. Visual Studio can be used to write console applications, Windows applications, Windows services, Windows Mobile applications, and ASP.NET applications, in choice of C++, C#, VB.NET, J#, and more.

Visual C# Programming Language

The Visual C# is a general purpose object oriented programming language that provides developers to build a variety of secure and robust applications that run on the .NET Framework. C# can be used to create client-server applications, XML Web services, database applications, and more. It provides an advanced code editor, convenient user interface designer, integrated debugger, and many other tools to make it easier to develop applications based on the C# language and the .NET Framework.

.NET Framework

The .NET Framework is a software framework that runs primarily on Microsoft Windows. It includes a large library and supports several programming languages. Programs written for the .NET Framework execute in a software environment, known as the CLR, an application virtual machine that provides important services such as security, memory management, and exception handling. The class library and the CLR together constitute the .NET Framework.

4.3.2 Database Connectivity

MySQL is an open source RDBMS based on SQL. It runs on several platforms including Linux, UNIX, and Windows. Top features include its scalability, platform independence, ease of use, compatibility with database systems, high speed, security, and flexibility.

MySQL Connector/NET is a reliable ADO.NET driver specially designed to connect .NET supported applications with MySQL database in order to execute queries and statements, and manage query results. Once the connector is installed, it is required to add a "**MySql.Data**" as a reference to the project and then import **MySql library** to the project.

```
//Define Database Connection
private MySqlConnection con;

server = Globals.dbServerPath;        // Server name (or IP address)
database = Globals.dbName;            // Database name
uid = Globals.dbUserID;               // User name to connect to database
password = Globals.dbUserPassword; // Password to connect to database
string connectionString = "SERVER=" + server + ";" + "DATABASE=" + database + ";"
                        + "UID=" + uid + ";" + "PASSWORD=" + password + ";";
con = new MySqlConnection(connectionString);
```

Figure 4-13: Code Block for Database Connectivity

4.3.3 Application Modules

4.3.3.1 User Login Module

Individual gain access to the system is restricted by using a login screen. In here user required to provide the login credentials, user name and password in order to log in to proceed. Each of the user login account has a user type category. That defines the access privileges for every module in the system.

ID	UserType	PhoneSetting	WebcamSetting	UserManage	ViewImages	Monitoring
1	Admin	1	1	1	1	1
2	Home1	1	1	0	1	1
3	Home2	0	1	0	1	0
4	Home3	0	0	0	0	1

Figure 4-14: User Type Privileges

4.3.3.2 System Main Menu

The System Main Menu is a user interface, which consists of buttons for accessing the different sections of the system. Accessibility for each part depends on the user type privileges of the logged user. Main Menu presents buttons for access to the 5 main functionalities describe as follows.

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Figure 4-15: System Main Menu

- **Mobile Phone Number Setting**

In this interface, allow user to set mobile phone number which communicates with the system. The system accepts SMSs received only from this mobile phone number as well as send feedback and alert SMSs to this number.

- **Webcam Setting**

Prior to starting the controlling and monitoring process required to check the functionality of the Webcam and setup device related settings such as resolution, brightness, contrast, zooming level, etc. which meets the required properties of the images.

Capturing images from the video stream receiving through the Webcam, need to have an API. The webcam library for windows operating system "**webcam_capture.dll**" provides an interface to access the functions of attached Webcam. In order to access the device's functions, it is required to add "**webcam_capture.dll**" file as a reference to the project and then import **Webcam_Capture** library to the project code.

- **User Login Management**

Initially this interface is only accessible for the user type category "Admin" of the system. Under this module there are four sub modules called "Add New User", "Change User Password", "Delete User", and "Change User Type Privileges".

- **View Captured Images**

This user interface facilitates user to download captured images at the time of intrusion detections by giving the period of time and view captured images as a slide show. Also

the user has facility to save currently displaying image to a file with one of the file extension jpg, bmp, or gif. Captured images are stored in the database as Medium Binary Large Object (**MEDIUMBLOB** data type).

- **Controlling and Monitoring**

This is the main interface of the system and allow user to connect the GSM Modem and Arduino Uno board to start the two-way communication between them to accomplish the controlling and monitoring process of home electronic appliances through the smart mobile phone. It must essential to set the mobile phone number in the system prior to access this module.

Prior to starting the controlling and monitoring process, need to open the **USB virtual COM** ports successfully which the GSM modem and Arduino Uno board are connected. A USB virtual COM port is a software interface that enables applications to access a USB device as a built-in serial port.
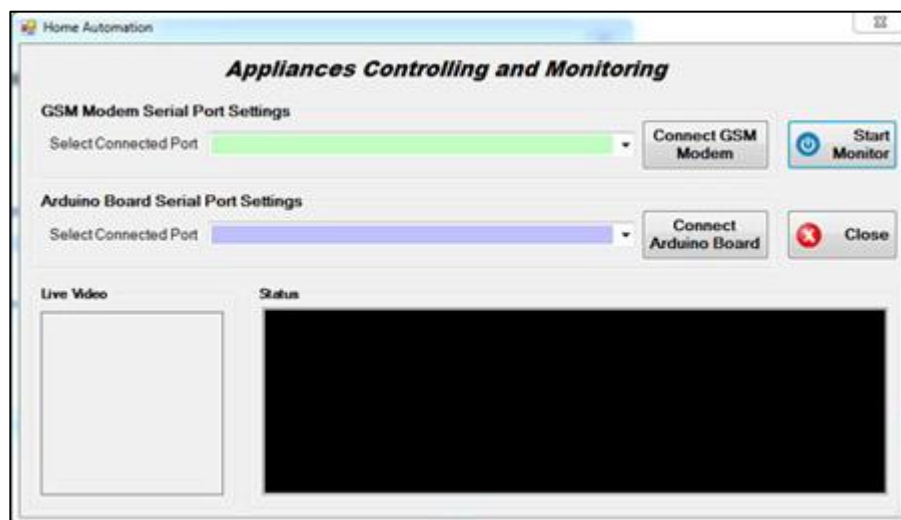
Figure 4-16: Appliances Controlling and Monitoring Interface

.NET's **SerialPort** class provides facility to get the list of traditional COM ports as well as USB virtual COM ports of the PC to the application. In addition to COM port names, application get information on each port by adding reference to **System.Management** namespace and running Windows Management Instrumentation (WMI) query.

```
 private DataTable fnPortList()
 {
   using (var searcher = new ManagementObjectSearcher("SELECT * FROM
                    Win32_PnPEntity WHERE Caption like '%(COM%'"))
   {
     var portnames = SerialPort.GetPortNames();//Get port names(COM4,COM5,..)
     //Get devices connected for ports
     var ports = searcher.Get().Cast<ManagementBaseObject>().ToList().Select(p =>
                                           p["Caption"].ToString());
     var portList = portnames.Select(n => n + " : " + ports.FirstOrDefault(s =>
                                          s.Contains(n))).ToList();
     int noOfPorts = portList.Count; //Number of available ports
     DataTable table = new DataTable();
     table.Columns.Add("PortName"); //Add column "Port Name" to table
     table.Columns.Add("DeviceName"); //Add column "Device Name" to table

     for (int i = 0; i < noOfPorts; i++) {
       DataRow newRow = table.NewRow(); //Create new row
       for (int j = 0; j < 2; j++) {
         if (j == 0) newRow[j] = portnames[i]; //Port Name
         if (j == 1) newRow[j] = portList[i]; //Device Name
       }
       table.Rows.Add(newRow); //Add COM port data to a rows in table
     }
   return table;
   }
 }
```

Figure 4-17: Code Block for Getting COM Ports with Connected Devices

4.3.3.3 Sending and Receiving SMS via GSM Modem

The system requires a mechanism to listen to incoming SMS messages to GSM Modem and extract message contents from SMS inbox, also send SMS messages to mobile phone number. "**GSMComm**" library for .NET framework provides numerous features to handle SMS related activities. In order to use those features in application required to add references for 4 .dll files "**GSMCommServer.dll**", "**GSMCommShared.dll**", "**GSMCommunication.dll**", "**PDUConverter.dll**" and then import namespaces to the project.

```
using GsmComm.GsmCommunication;
using GsmComm.Interfaces;
using GsmComm.PduConverter;
using GsmComm.Server;
```

- **Listen for Incoming SMS to GSM Modem**

"MessageReceived" event of the GSM Modem connected port, need to register with "MessageReceivedEventHandler" event handler when the connection is opened in order to invoke the "comGSM_MessageReceived" method to read newly arrives SMS message.

```
//Register MessageReceived Event with MessageReceivedEventHandler
comGSM.MessageReceived += new
                    MessageReceivedEventHandler(comGSM_MessageReceived);
…………………………..
//Listen for messages receiving to GSM Modem
private void comGSM_MessageReceived(object sender, MessageReceivedEventArgs e)
{
    var obj = e.IndicationObject; //Take newly received message object
    if (obj is MemoryLocation) //Is message saved in a memory location
    {
        //Read and decode all unread messages from SIM card memory
        DecodedShortMessage[] messages =
                    comGSM.ReadMessages(PhoneMessageStatus.ReceivedUnread,
                    PhoneStorageType.Sim);
        ……………………….
    }
}
```

Figure 4-18: Code Block for Listen & Extract Newly Received SMS from GSM Modem

Once the message has been decoded, passed it to the "fnExtractReceivedMessageContents" function to extract the message contents. Prior to extraction, this function check message containing PDU is satisfied with SmsDeliverPdu format. If it satisfied, then convert into a SmsDeliverPdu object to do the content extraction. Then check message is received from the authorized mobile phone number to perform the controlling and monitoring process.

- **Send SMS from GSM Modem**

"fnSendMessage" function is used to send alert messages when intrusion detection and send feedback messages to notify the current status of the appliances. This function creates a SmsSubmitPdu object containing the message and sends it to authorized mobile phone number in PDU mode.

```
//Generate and Send SMS to Authorized Mobile Phone Number
private void fnSendMessage(String msg)
{
    try
    {
        …………………
        //Generate SMS Submit PDU object
        SmsSubmitPdu pdu = new SmsSubmitPdu(msg, authorizedPhoneNumber, "");
        //Send SMS
        comGSM.SendMessage(pdu);
        ……………………….
}
```

Figure 4-19: Code Block for Send SMS from GSM Modem

- **Listen for Data Receive from Arduino Board**

"DataReceived" event of the Arduino board connected port, need to register with "SerialDataReceivedEventHandler" event handler when the connection is opened in order to raise the "comARD_DataReceived" method when Eof character is received. This event is raised on a secondary thread, and not the main thread. If attempting to modify some elements in the main thread, could raise a threading exception. To avoid it, post change requests back using BeginInvoke, which will do the work on the proper thread.

```
//Register DataReceived Event with SerialDataReceivedEventHandler
comARD.DataReceived += new
                  SerialDataReceivedEventHandler(comARD_DataReceived);
...........................
//Listen for data receiving from serial port
private void comARD_DataReceived(object sender, SerialDataReceivedEventArgs e)
{
    string line = comARD.ReadLine(); //Read line of data
    //Created thread will not block the caller (UI  Windows form)
    this.BeginInvoke(new LineReceivedEvent(LineReceived), line);
}
```

Figure 4-20: Code Block for Listen & Capture Data Receive from Arduino Board

- **Write Commands to Arduino Board**

Based on the message contents contains in the SMS, write appropriate command text to the Arduino board's microcontroller through the serial port to control and monitor home electronic appliances.

```
//Write Command Text to Arduino Board through Serial Port
private void fnWriteToArduinoBoard(string msg)
{
    try
    {
        switch (msg.Trim().ToUpper())
        {
            case Globals.LIGHT_ON: comARD.WriteLine(Globals.LIGHT_ON_CMD);
                            break; //Switch ON Light
            case Globals.LIGHT_OFF: comARD.WriteLine(Globals.LIGHT_OFF_CMD);
                            break; //Switch OFF Light
            ...............................
            default: string msgSend = "Unidentified Command";
                    fnSendMessage(msgSend);
                    break;
        }
    }
    ..........................
```

Figure 4-21: Write Command Text to Arduino Board

If unrecognized content received via SMS to control and monitor appliances, then the system will send back "Unidentified Command" SMS message to the authorized mobile phone number.

4.4 Programming the Client

The client is one of the most important part of this system. The client which is a smart mobile phone with an Android application that makes easier and faster way of remotely controlling and monitoring of home electronic appliances from anywhere at anytime by sending a SMS.

4.4.1 Client Programming Environment

Android Studio

Android studio is a powerful development framework. That includes all the API required to develop applications on a wide variety of Android devices such as phones, tablets and more. Technically, it is an official IDE for developing applications. It can be installed on Windows, OSX, and Linux operating systems and is recommended to have at least 4GB of memory and 1GB of free hard disk space.

Java is the programming language needed to write programs. The Android SDK is an extension to the Java code that allows it to run smoothly on Android devices and take advantage of the native hardware. Android studio has a very useful Gradle toolkit that enables to create an Android Application Package (APK). Android Studio also enables to run code, either through an emulator or through a device connected to your PC.

Gradle Toolkit

Gradle is the official build system for Android Studio. It compiles Java source code, XML layout, application resources, and package them into a application package file (APK) that can test, deploy, sign and distribute. Every Android Studio project contains two kinds of Gradle build files. One build.gradle file, located in the root project directory, defines the configuration options common to all the modules that make up the project. Also, each module has its own build.gradle file and that contains module specific build settings.

Android Virtual Device (AVD)

An Android Virtual Device is a device configuration that defines the characteristics of an Android phone, tablet, and more. That lets developers to test the application by simulating the real device capabilities in the Android Emulator.

Project Structure

There are several files available in an Android project. Among these, some files play an important role in the project.

- **AndroidManifest.xml**

  This file contains information about the application essential to the Android system, which the system must have before it can run any of the app's code. This information includes package name, minimum Android version, permission to access Android device capabilities and others. It also describes the components of the application such as activities, services, broadcast receivers, and content providers. When the app starts, Android system will read this file first and create the main activity (startup) component configured in it.

```
<activity android:name=".MainActivity">  ←————————————  Activity name
    <intent-filter>
        <action android:name="android.intent.action.MAIN" />  ←——— Mentioned
        <category android:name="android.intent.category.LAUNCHER" />    as startup
    </intent-filter>                                                     activity
</activity>
```
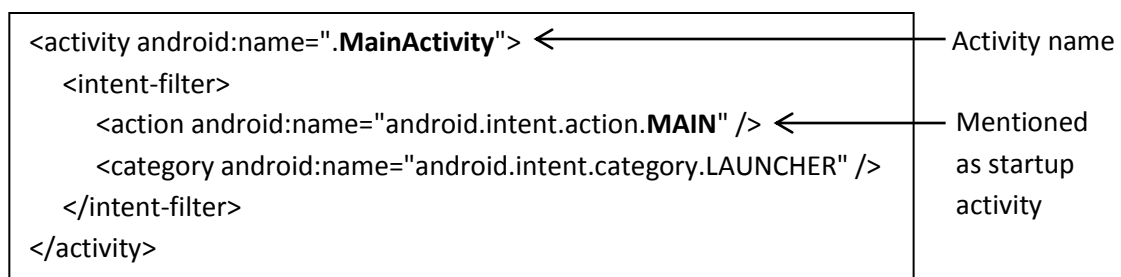
Figure 4-22 : Set Startup Activity of Android Application

- **MainActivity.java**

  An activity provides a window in which to draw its user interface where users can interact in order to do something. Most apps comprise of multiple activities. Typically, one activity in an app is specified as the main activity, which is the first screen to appear when the user launches the app. Each activity file contains the Java source code relevant to its operations and activity's layout is defined in a separate XML file. The onCreate() callback method of the activity is executed in order to do their initial setup. The setContentView() method in the onCreate() method is used to load the layout for the activity's user interface.

```
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
    ………………..
}
```

Figure 4-23 : EntryPoint and Set Layout of the Activity

- **activity_main.xml**

  Each activity has its own layout file. That specifies the layout of the screen with XML descriptors. Android studio provides two views of this file, namely "Design" and "Text".

4.4.2 Sending, Receiving and Navigating SMS

The Android Framework provides full access to send and receive SMS (text, data/binary, pdu) operations using the SmsManager class, where it is placed in the android.telephony package.

4.4.2.1 Sending SMS

In order to send SMS messages it is required to get the SEND_SMS permission. The application must declare send SMS permission in the AndroidManifest.xml file as follows.

<uses-permission android:name="android.permission.**SEND_SMS**" />

The sendTextMesssage() method of the SmsManager class is used to send SMS to a specific phone number.

```
public void sendMessage(View view) {
  if (ContextCompat.checkSelfPermission(this, Manifest.permission.SEND_SMS) !=
                                              PackageManager.PERMISSION_GRANTED) {
    getPermissionToReadSMS();
    } else {
      try {
        smsManager.sendTextMessage(GlobalConstants.PHONE_NUMBER, null,
                                              sendMessageContents, null, null);
      Toast.makeText(this, "Message sent!", Toast.LENGTH_SHORT).show();
      } catch(Exception e) {
      Toast.makeText(this,"Sending SMS failed.", Toast.LENGTH_LONG).show();
……………………….
```

Figure 4-24 : Send Controlling/Monitoring SMS to a Specific Phone Number

4.4.2.2 Receiving and Navigation SMS

Besides sending SMS messages, it is required to listen to incoming SMS messages and read messages from the SMS inbox. To do so, need to get RECEIVE_SMS and READ_SMS permissions. These permissions must declare in the AndroidManifest.xml file as follows.

<uses-permission android:name="android.permission.**RECEIVE_SMS**" />
<uses-permission android:name="android.permission.**READ_SMS**" />

The permissions in Android are organized as groups. If request permission for one thing in the group and then automatically gain permission for all actions in that group.

The onCreate() method of the MainActivity class initializes an ArrayAdapter to load SMSs from the SMS inbox and then display the message contents in listview component. The

getContentResolver() method is used to query the SMS inbox to read unread SMSs received from the specific phone number and arrange them in descending order of received date.

```
public void refreshSmsInbox() {
   String[] projection = new String[] { "_id", "address", "person", "body", "date", "type" };
   Cursor smsInboxCursor = getContentResolver().query(Uri.parse("content://sms/inbox"),
                               projection, "address='"+GlobalConstants.PHONE_NUMBER+
                               "' AND read=0", null, "date desc");
   ………………………..
   do {
      ………………………..
      String str = "SMS From: " + smsInboxCursor.getString(indexAddress) + "\n" + dateText +"\n" +
                                       smsInboxCursor.getString(indexBody) + "\n";
      arrayAdapter.add(str);
   } while (smsInboxCursor.moveToNext());
}
```

Figure 4-25 : Load & Display Messages from Phone Inbox

The application also requires to listen for incoming SMS messages. To achieve this, create a Java class which extends the BroadcastReceiver and then register it in the AndroidManifest.xml file.

```
<receiver android:name=".SmsBroadcastReceiver" android:exported="true" >
   <intent-filter android:priority="999" >
      <action android:name="android.provider.Telephony.SMS_RECEIVED" />
   </intent-filter>
</receiver>
```

Figure 4-26: Register Broadcast Receiver Class in AndroidManifest file

Whenever there is an incoming SMS, the onReceive() method of the SmsBroadcastReceiver class will be called and get the SMS data from the intent getExtras() method. All the SMS data bundled as PDUs.

```
public class SmsBroadcastReceiver extends BroadcastReceiver {
  public static final String SMS_BUNDLE = "pdus";

  public void onReceive(Context context, Intent intent) {
    Bundle intentExtras = intent.getExtras();

    if (intentExtras != null) {
      Object[] sms = (Object[]) intentExtras.get(SMS_BUNDLE);
      …………………………
        for (int i = 0; i < sms.length; ++i) {
          String format = intentExtras.getString("format");
          SmsMessage smsMessage = SmsMessage.createFromPdu((byte[]) sms[i], format);

          address = smsMessage.getOriginatingAddress();

          if(!address.equals(GlobalConstants.PHONE_NUMBER))
            continue;
          …………………………
          smsMessageStr += "SMS From: " + address + "\n" + dateText + "\n" + smsBody + "\n";
        }
  …………………………
```

Figure 4-27: Listening for Incomming SMS & Update Message Display

Then loop through each PDU and convert each PDU into SmsMessage instance by using createFromPdu() method. Extract SMS text and SMS metadata received only from a specific phone number and form a big string with extracted data. This big string is passed into the MainActivity to refresh the SMS displaying ListView.

CHAPTER 05: TESTING AND USER EVALUATION

This chapter initially describes the purpose of the testing, main stages involved in testing, techniques that can be used to test and how test plans are executed. The test case specification describes the prerequisites, the purpose of the specific test, required inputs and expected output, and outlines the pass/fail criteria for determining the acceptance. Also provides user evaluation of the system based on the results gathered from a questionnaire by putting the system into practice.

5.1 Testing

A test strategy can be described as a plan on how one is going to approach project testing. It involves both verification and validation. Verification involves checking that the program conforms to its specification, while validation involves checking that the program as implemented meets the user requirements stated at the beginning of the project. As a result, we can say that the developed software was tested for errors, project logic errors and missing requirements before it will be finally released to the public.

5.1.1 Testing Stages
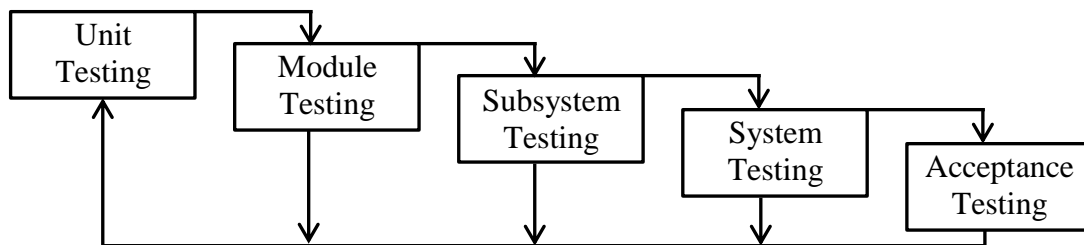
Figure 5-1: Stages of Testing Process

- **Unit Testing**

  This is the basic level of testing, where individual components (functions or objects) are tested to ensure that they operate correctly. Unit testing considers each component to be a stand-alone entity which does not require other system components to be present during the testing process.

- **Module Testing**

  A module is a collection of interdependent components. After each program unit has been tested, the interaction of these components when they are put together must be tested. A module encapsulates related components and it should be possible to test a module as a stand-alone entity.

- **Subsystem Testing**

  Subsystem testing involves collection of modules, which have been integrated to form a subsystem. It is also called "integration" or "interface" testing. Test process should concentrate mainly on the detection of integration and interface errors where one module communicates with another module.

- **System Testing**

  System testing is carried out when the subsystems are integrated to make up the entire system. At this stage, the testing process is concerned with finding errors with interaction between subsystems. It also validates that the overall system meets its functional/nonfunctional requirements specified in the system.

- **Acceptance Testing**

  Acceptance testing is one type of user testing where customers formally test a system to decide whether or not to approve the system or if further development is required. It may involve functionality, usability, performance, and user interface of the system. It is also known as user acceptance testing (UAT), operational acceptance testing (OAT), and end-user testing.

5.1.2 Testing Techniques

There are different techniques that can be used for software testing. White Box testing and Black Box testing are two such testing methods that are commonly used by software testers.

- **White Box Testing**

  White box testing is the software testing method in which the internal structure, design and implementation of the item being tested known to the tester. The tester uses this knowledge to develop test cases that will examine the control flow, data flow, branches, paths, exception and error handling, etc. Generally, this type of testing is applicable to lower levels of testing such as Unit Testing, Module Testing and Integration Testing.
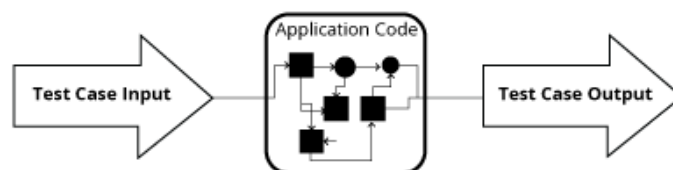
Figure 5-2: White Box Testing Approach

- **Black Box Testing**

    Black-box testing is a method of software testing that examines the functionality of an application without knowing its internal structure, design and implementation. Typically, while performing a black-box test, a tester will interact with the system's user interface by providing inputs and examining outputs without knowing how and where the inputs are worked upon. Mainly, this type of testing is applicable to higher levels of testing such as System Testing, Acceptance Testing.

Figure 5-3: Black Box Testing Approach

5.1.3 Test Plan

Development of the system is divided into three subsystems, namely Client (Android Application), Server (Visual C# Program), and Controller (Microcontroller Program). Client subsystem comprises of 2 modules to create & send SMSs, read & display received SMSs. Server subsystem is a collection of several modules to execute interrelated activities. Those are User Login, System Main Menu, Mobile Phone Number Setting, Webcam Setting, User Login Management (Add, Delete, Change Password, and Set User Type Privileges), View Captured Images, and Controlling & Monitoring of Appliances. Also Controller subsystem includes two modules. One module is used to read commands from a serial port and control appliances according to that and other module is used to write appliances status to serial port.

During the development of each module, individual functions within the module are tested to ensure that they operate correctly. Then each module was tested individually and gradually modules are integrated while performing integration testing. Finally, three subsystems are integrated to make up the complete system and accomplished the system testing.

Microcontroller consists of both hardware and software components. A key challenge here is to test software component. Unlike in the computer, blink of LED (TX and RX) is the only way of having a clue about passing through a code segment. Though it passes it doesn't guarantee that it successfully executed or not. Serial Monitor is a tool that comes with the Arduino Software IDE to send data to the Arduino board and visualize incoming data from the Arduino board.

5.1.4 Test Cases

Following table (Table 5-1) represents the test cases for Database Server Connectivity.

No.	Test Case	Purpose	Output	Status
MySQL Database Server Connectivity
01	Execute application without starting MySQL Database Server	To test database connectivity	Show error message "MySQL Database Server is not running" on splash screen & exit from the application.	Pass
02	Execute application when MySQL Database Server is running	To test database connectivity	Splash screen redirects to User Login screen	Pass

Table 5-1: Test Cases for Database Server Connectivity

Following table (Table 5-2) represents the test cases for Home User/Administrator Login

No.	Test Case	Purpose	Output	Status
Home User/Administrator Login				
Required Information: • MySQL Database Server is running				
01	Click "Login" without inserting any field	To validate empty fields	Show error message "Please enter User Name" & remains in the screen	Pass
02	Insert special characters in user name field & click "Login"	To check ability to do SQL injection	Show error message "User Name has invalid characters" & remains in the screen	Pass
03	Insert special characters in password field & click "Login"	To check ability to do SQL injection	Show error message "Password has invalid characters" & remains in the screen	Pass
04	Insert user name & skip password & click "Login"	To test user login without password	Show error message "Please enter Password" & remains in the screen	Pass
05	Insert password & skip user name & click "Login"	To test user login without user name	Show error message "Please enter User Name" & remains in the screen	Pass
06	Insert correct user name & incorrect password & click "Login"	To test login with invalid password	Show error message "Incorrect user login details" & remains in the screen	Pass
07	Insert incorrect user name & correct password & click "Login"	To test login with invalid user name	Show error message "Incorrect user login details" & remains in the screen	Pass
08	Insert correct user name & correct password & click "Login"	To check valid login	Redirects to System Main Menu screen	Pass

Table 5-2: Test Cases for Home User/Administrator Login

Following table (Table 5-3) represents the test cases for Connecting System Devices.

Connecting System Devices				
Required Information:				
• LED bulb, DC motor, Micro Servo Motor, PIR Motion Sensor and Buzzer connected to appropriate pins in Arduino board.				
• Controller program is downloaded into microcontroller of Arduino board.				
• Arduino Uno board connected to PC's USB port.				
• GSM Modem (dongle) connected to PC's USB port.				
• Authorized mobile phone number is already setup.				
• Webcam connected to PC'S USB port.				
• MySQL Database Server is running				
No.	**Test Case**	**Purpose**	**Output**	**Status**
01	Screen display	To confirm 2 lists filled with virtual COM ports & COM ports available in the PC	GSM Modem Connected Port list & Arduino Board Connected Port list filled with virtual COM ports and COM ports available in the PC.	Pass
02	Skip selecting GSM Modem connected port & click "Connect GSM Modem"	To test connect to GSM Modem without selecting a port	Show message "Please select GSM Modem connected port" & remains in the screen.	Pass
03	Select different port of GSM Modem connected & click "Connect GSM Modem"	To test connect to GSM Modem from different port	Show message "Please select exact port of GSM Modem connected" & remains in the screen.	Pass
04	Select exact port of GSM Modem connected & click "Connect GSM Modem"	To confirm successfully open the virtual COM port & connect to GSM Modem	Show message "COM4 port is Opened......" If successfully connect then show message "GSM Modem is connected to COM4 port". Otherwise show messages "GSM Modem is not connected to COM4 port. Remains in the screen.	Pass
05	Skip selecting Arduino Board connected port & click "Connect Arduino Board"	To test connect to Arduino Board without selecting a port	Show message "Please select Arduino Board connected port" & remains in the screen.	Pass
06	Select different port of Arduino Board connected & click "Connect Arduino Board"	To test connect to Arduino Board from different port	Show message "Please select exact port of Arduino Board connected" & remains in the screen.	Pass
07	Select exact port of Arduino Board	To confirm successfully open	Show message "COM10 port is Opened......"	Pass

No.	Test Case	Purpose	Output	Status
	connected & click "Connect Arduino Board"	the virtual COM port & connect to Arduino Board	If successfully connect then show message "Arduino Board is connected to COM10 port". Otherwise show messages "Arduino Board is not connected to COM10 port. Remains in the screen.	
08	Click "Start" without connected to GSM Modem	To confirm starting of controlling & monitoring process	Show message "Cannot start monitoring. GSM Modem is not connected" & remains in the screen.	Pass
09	Click "Start" without connected to Arduino board	To confirm starting of controlling & monitoring process	Show message "Cannot start monitoring. Arduino board is not connected" & remains in the screen.	Pass
10	Click "Start" after successfully connected to GSM Modem & Arduino board	To confirm starting of controlling & monitoring process	Show message "Controlling and monitoring process started successfully.....". Displaying live video streams receiving from Webcam.	Pass
11	Click "Start" again after starting of Controlling and Monitoring process	To ignore abnormal starting of controlling & monitoring process	Show message "Controlling and Monitoring process already started" & remains in the screen.	Pass
12	Click "Close"	To test successfully close the screen	Close the screen & redirects to System Main Menu screen.	Pass

Table 5-3: Test Cases for Connecting System Devices

Following table (Table 5-4) represents the test cases for integrated system. This involves controlling and monitoring of appliances via Android application.

Controlling and Monitoring of Appliances via Android Application				
Required Information:				
• LED bulb, DC motor, Micro Servo Motor, PIR Motion Sensor and Buzzer connected to appropriate pins in Arduino board.				
• Controller program is downloaded into microcontroller of Arduino board.				
• Arduino Uno board connected to PC's USB port.				
• GSM Modem (dongle) connected to PC's USB port.				
• Authorized mobile phone number is already setup.				
• Webcam connected to PC'S USB port.				
• MySQL Database Server is running				
• Android application is opened to send and receive SMS to/from GSM Modem.				
No.	**Test Case**	**Purpose**	**Output**	**Status**
01	Open Android application on mobile phone	To test displaying of unread SMSs from "+94759907097" phone number	If unread SMSs from "+94759907097" phone number exists then display they on inbox of the application.	Pass

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02	Touch on "LIGHT ON" button	To check switch ON LED bulb	Show message "Message sent!". If LED bulb is switched OFF then switch ON and receives feedback SMS "Control: Bulb ON". Otherwise receives feedback SMS "Control: Bulb Already ON".	Pass
03	Touch on "LIGHT OFF" button	To check switch OFF LED bulb	Show message "Message sent!". If LED bulb is switched ON then switch OFF and receives feedback SMS "Control: Bulb OFF". Otherwise receives feedback SMS "Control: Bulb Already OFF".	Pass
04	Touch on "LIGHT STATUS" button	To check switched ON/OFF status of LED bulb	Show message "Message sent!". If LED bulb is switched ON then receives feedback SMS "Status: Bulb is ON". Otherwise receives feedback SMS "Status: Bulb is OFF".	Pass
05	Touch on "FAN ON" button	To check switch ON Fan	Show message "Message sent!". If Fan is switched OFF then switch ON and receives feedback SMS "Control: Fan ON". Otherwise receives feedback SMS "Control: Fan Already ON".	Pass
06	Touch on "FAN OFF" button	To check switch OFF Fan	Show message "Message sent!". If Fan is switched ON then switch OFF and receives feedback SMS "Control: Fan OFF". Otherwise receives feedback SMS "Control: Fan Already OFF".	Pass
07	Touch on "FAN STATUS" button	To check switched ON/OFF status of Fan	Show message "Message sent!". If Fan is switched ON then receives feedback SMS "Status: Fan is ON". Otherwise receives feedback SMS "Status: Fan is OFF".	Pass
08	Touch on "GARAGE DOOR OPEN" button	To check opening the Garage Door	Show message "Message sent!". If Garage Door is closed then open and receives feedback SMS "Control: Garage Door Open". Otherwise receives feedback SMS "Control: Garage Door Already Opened".	Pass
09	Touch on "GARAGE DOOR CLOSE" button	To check closing the Garage Door	Show message "Message sent!". If Garage Door is opened then close and receives feedback SMS "Control: Garage Door Close". Otherwise receives feedback SMS "Control: Garage Door Already Closed".	Pass

	Touch on "GARAGE DOOR STATUS" button	To check opened/closed status of Garage Door	Show message "Message sent!". If Garage Door opened then receives feedback SMS "Status: Garage Door Open". Otherwise receives feedback SMS "Status: Garage Door Close".	Pass
10				
11	Human movement within the detecting area of PIR Motion Sensor	To check alerting & image capturing when motion detected ((Intrusion Detection)	Receives alert SMS "Motion Detected". Buzzer starts to play beep tone for a few seconds. LED indicator bulb switch ON for a few seconds. Save captured images in database.	Pass
12	Click "Close"	To test successfully close the screen	Close the screen & redirects to System Main Menu screen.	Pass

Table 5-4: Test Cases for Controlling and Monitoring Appliances via Android Application

❖ **Refer Appendix B for Remaining Test Cases**

5.1.5 Test Results

Following screenshots show the results obtained by performing some test cases mentioned in the Table 5-4.

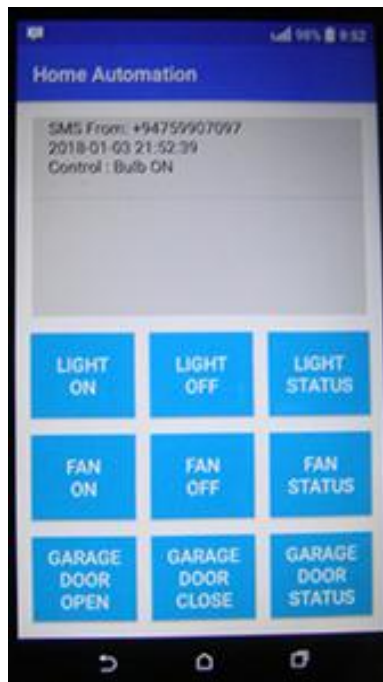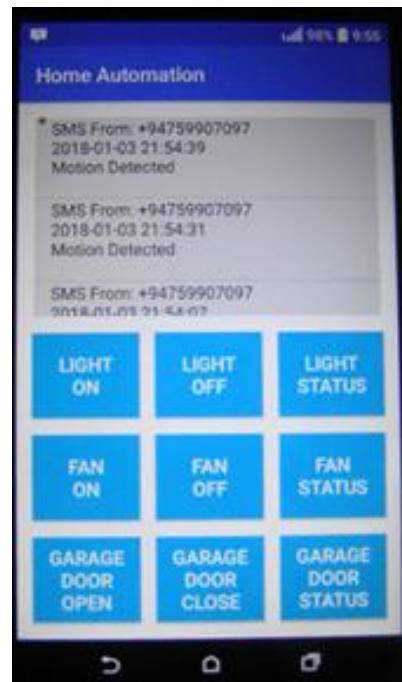**Figure 5-4:** Send Control SMS **Figure 5-5:** Feedback SMS **Figure 5-6:** Motion Detected Alert

5.2 User Evaluation

Evaluation is a process that critically examines a program through collecting and analyzing information about the program's activities, features, and results to make decisions about a

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program and to improve its quality. In here, concentrates on user evaluation of a software product. User evaluation focuses on how well users can learn and use a product to achieve their goals. It also refers to how users are satisfied with the product. Practitioners use a verity of methods to gather this information. Here, user evaluation is carried out by selecting a sample of 10 people and requested them to practice the system and give their feedback through the questionnaire.

❖ **Refer Appendix C for User Evaluation Questionnaire**

5.2.1 User Evaluation Results

After collecting all the data from the questionnaires, summarized all the relevant information as follows.

1) General				
i) Level of Computer Literacy:	**Excellent**	**Good**	**Fair**	**Poor**
	60%	30%	10%	0%

ii) Have you any experience of using this kind of system?	**Yes**	**No**
	10%	90%

2) System Outcomes					
Question	**Strongly Agree**	**Agree**	**Undecided**	**Disagree**	**Strongly Disagree**
i) Do you think this system will facilitate to manage power consumption?	100%	0%	0%	0%	0%
ii) Does this system enable home security against intrusions?	80%	20%	0%	0%	0%
iii) Are you agreed this system provide assistance to the elderly and disable people those who are at home alone?	80%	20%	0%	0%	0%
iv) Is this system gives user a better safety against any current leakage?	50%	40%	10%	0%	0%
v) Easier controlling & monitoring of appliances from anywhere at any time will improve the people's lifestyle?	100%	0%	0%	0%	0%
vi) Is this system helpful for people who are unaware of typing SMS and mistakes occur when typing SMS?	100%	0%	0%	0%	0%

3) System Characteristics					
Characteristics	**Excellent**	**Good**	**Average**	**Fair**	**Poor**
Easy to use and learn (Usability)	80%	20%	0%	0%	0%
Security	100%	0%	0%	0%	0%
Performance	80%	10%	10%	0%	0%
Reliability	70%	30%	0%	0%	0%
Availability	70%	20%	10%	0%	0%
Usefulness	100%	0%	0%	0%	0%
Meets Expectations	60%	20%	20%	0%	0%
4) System Characteristics					
Please comment on any positive or negative aspects that you feel to improve this system.					
Cannot evaluate numerically					

Table 5-5: Summary of User Evaluation Results

Following (Figure 5-7) is the graphical representation of summarized data about the level of agreement provided for each question under the System Outcomes.
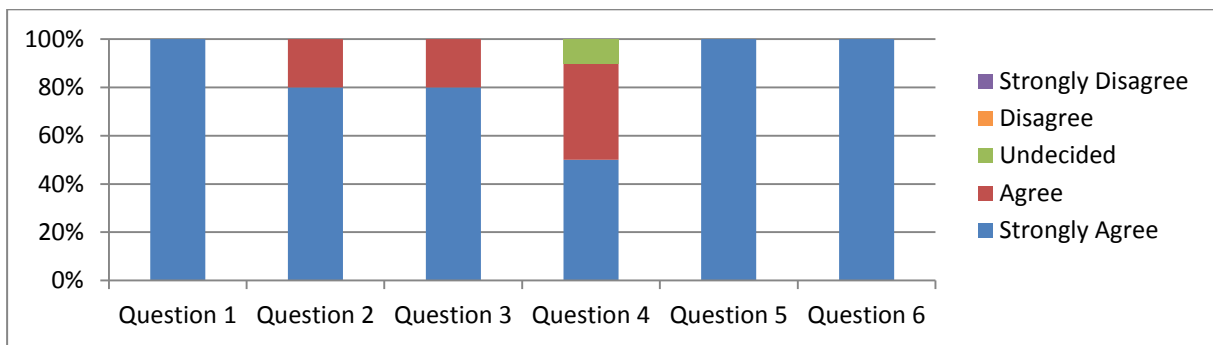

Figure 5-7: Results about the System Outcomes

Following (Figure 5-8) is the graphical representation of summarized data about the overall opinion of different characteristics of the system.
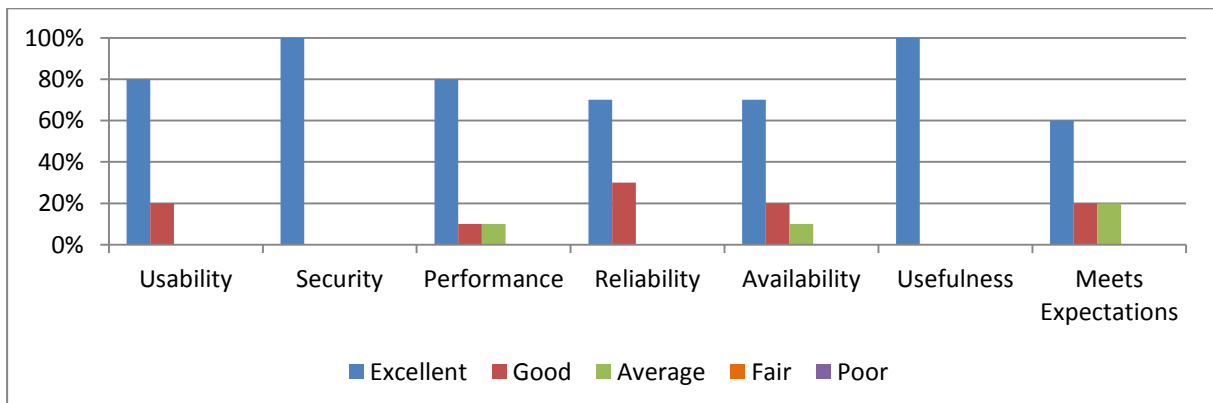

Figure 5-8: Results about the System Characteristics

Following are the areas that the user suggested to improve on the system.

- The current system is limited to most primitive functionalities such as switch ON, Switch OFF, and check switch ON/OFF status of appliances. It is not supporting extended operations such as increases or decreases the volume or change channels of a television.

- Cannot assure the proper operation of the appliance. It is just capable of read or write the logical levels HIGH (turn ON) or LOW (turn OFF) at a specified digital pin. If the appliance is burnt out, it will not work. But the system will perform the operations well without knowing it.

- PIR sensors cover a limited area. So, if an event occurs outside that area, the sensor will not be able to detect it. Hence notification fails. To avoid such situations, place more than one PIR sensors in proper places and automatically change the direction the webcam is pointing.

- Use IP camera instead of a Webcam to remotely monitor from any location.

- Use a microcontroller based embedded system instead of PC to connect devices and make communication between them.

CHAPTER 06: CONCLUSION AND FUTURE WORKS

6.1 Summary of the Work

There are wide varieties of technology platforms, or protocols on which home automation systems can be built. Choosing the most effective one from them is an essential to make better interaction between the user and the automation system. The ZigBee wireless protocol based home automation systems uses RF for signaling and controlling. Its low transmission rate and its coverage limited to short distance. The Z-Wave technology is also similar to ZigBee. The Bluetooth based home automation systems allows user to control home appliances within Bluetooth network. Its range limits up to 100 meters. When considering the Internet based home automation systems, connecting a home to the Internet means home is opens to the world. So, an intruder or attacker can access the home. The availability of Internet connection is also a problem in some part of the world.

After carefully studying the technologies used in existing systems, the proposed system has been designed. It uses SMS text messaging service in the GSM network to make effective communication between user and the automation system. The design and development of this system mainly focused on the controlling and monitoring of the home appliances remotely and providing security via SMS when user is away from home. SMS technology provides numerous benefits over other technologies such as instant accessibility, simplicity, cost effectiveness, messages send directly to the intended recipient's hand, almost all mobile phones are enabled and does not depend on Internet connection issues or device or operating system.

When I was implementing the system I mainly go through the objectives stated at the beginning of the project and successfully achieved almost all of the objectives. This system facilitates to manage electrical power consumption by controlling home appliances more effectively and more efficiently from anywhere at any time. In the meantime, system will benefit for people who are worrying about the security of their homes when they are away from their places. The centralized controlling and monitoring feature of the system support in order to fulfill the needs of elderly and disabled persons in the home and keeping safe if there is no one at home. The feedback mechanism of the system will verify the success of the intended operation of a particular home appliance. Likewise, this system provides user a better safety against any current leakage, because user doesn't need to touch the conventional switch to ON/OFF appliances. Also, this system helpful for people who are unaware of typing

SMS messages and mistakes occur when typing SMS messages. The system allows the provisions of security such that system accepts SMS messages receive only from the pre-configured mobile number in the system. Likewise the system will not take any action against the instructions receives from SMS is not in pre-defined format. Besides that, easier controlling and monitoring of appliances from anywhere at any time will improve the people's lifestyle.

6.2 Limitations of the Current System

Currently the system is at the prototype stage. So, there are limitations for this system which brings about the need for further improvements.

The Arduino board equipped with a limited number of digital and analog I/O pins. Hence, the system can connect few numbers of appliances. Also, this system provides user to most primitive functionalities such as switch ON/OFF and check ON/OFF status of the appliances. The user cannot assure the proper operation of the appliance, because system gives only the logical level HIGH/LOW at a specified digital pin of the board which the appliance is connected.

The PIR sensor of the system covers only a limited area and as well as connected Webcam is focuses only to a fixed location rather than rotating to a required position. Therefore Webcam can capture images of the scene in front of it. Furthermore, user has no way to live connect to the camera or view captured images against intrusions immediately when the user is out of his/her premises.

One of the main limitations of this system is uses of a PC to connect GSM modem, Arduino board and Webcam. Because, these devices connecting program running on the PC and provide required power supply for proper functions of above devices too. Therefore, it is necessary to have continuously power ON the PC to make the system function.

6.3 Lessons Learnt

Lessons learnt from beginning to successful completion of the project can be summarized in the following points.

- How to develop a system according to the phases of software development life cycle.
- How to develop a system incrementally rather than in one big-bang release.

- How to work in a time frame and ability to achieve the target on time.

- Gained experience about the development of applications for the Android phones.

- Got knowledge about how to work with SMS technology.

- How to write programs using Visual C# to access the devices connected to the PC such as GSM Modem, Webcam, and Arduino board.

- How to reduce the lines of code (LOC) by using reusable modules.

- Obtained working experience with MySQL database.

- How to write/test microcontroller programs to control and monitor various appliances.

- Knowledge about the field of electronic had been gradually enhanced.

- Follow up coding standards like comments, indentation, variable names, function names, etc.

- Learnt how to test a system in various development stages by creating test cases and applying testing techniques.

- Learnt the process of proper documentation methods while writing this dissertation. It improved writing skills and learning methods.

6.4 Future Developments

The basic level of home appliances remotely controlling and monitoring system has been implemented within a short duration of time and a few number of persons' point of view. According to the user feedback obtained from the user evaluation questionnaire, getting expert knowledge from the industry and by increasing the time period for the system design and development, will be able to enhance the system by integrating with the following improvements.

Present system limited to most primitive functionalities such as switch ON and OFF only. Supporting operations such as increase or decrease the volume or change channels of a TV can do with the assistance of extra circuits. Also, adding an extra circuit to the appliance to check whether the flowing of current through the appliance will assure the proper operation of the appliance rather than giving only the logical levels HIGH or LOW of the connected digital pin.

Locating more than single PIR sensor on proper places will be able to cover large detecting area and placing the Webcam on a motorized stand will be able to rotate to a required position and capture images of the scene in front of it rather than focusing on to a fixed location. Moreover, by using an IP Camera instead of Webcam allows user to directly connect to its

inbuilt web server through the public IP address and remotely monitor the area covered by the camera.

Besides that, design and development of a microprocessor based circuit board to connect GSM modem, Arduino board, Webcam and upgrade program running on PC into microprocessor will allow to removes the PC from the system. The resulted embedded system will compact and can operate without user interaction.

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Appendix A: Levels of Data Flow Diagram
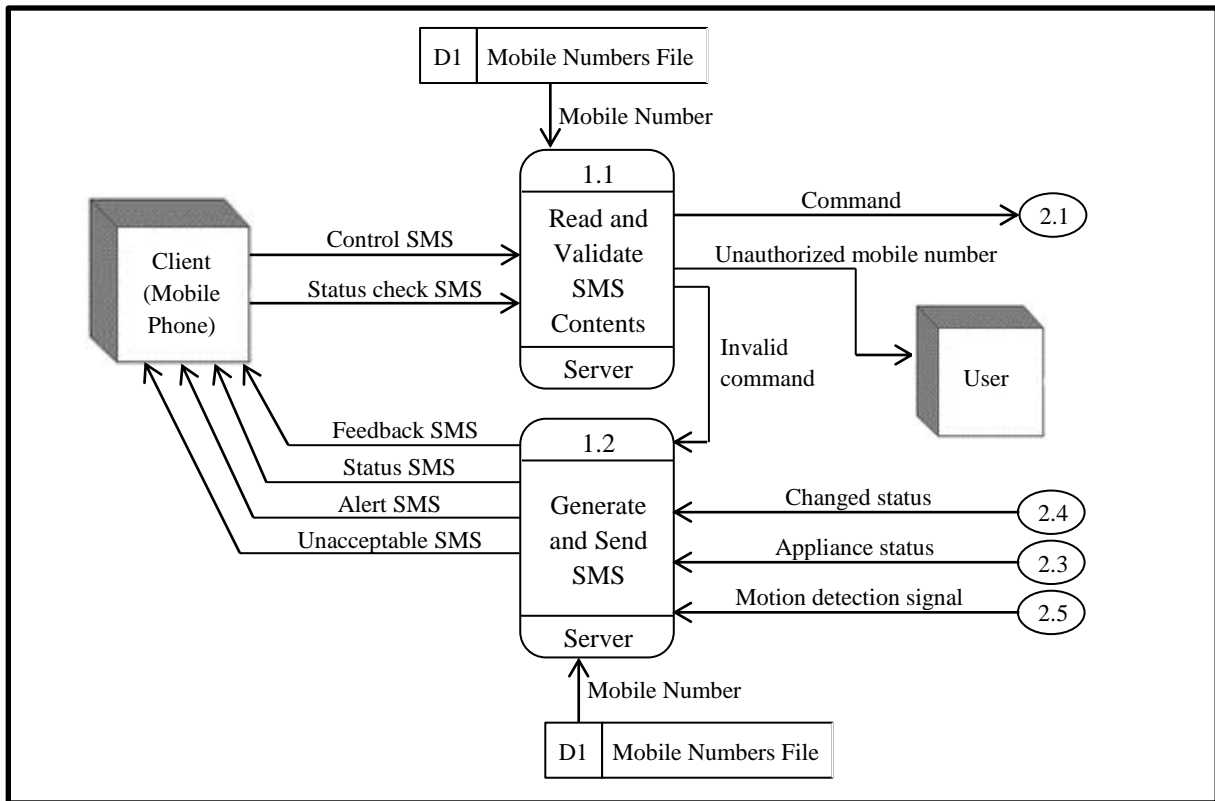
Level 2: Process 1.0 Diagram

Figure 3-4: Level 2 - Process 1.0 Diagram
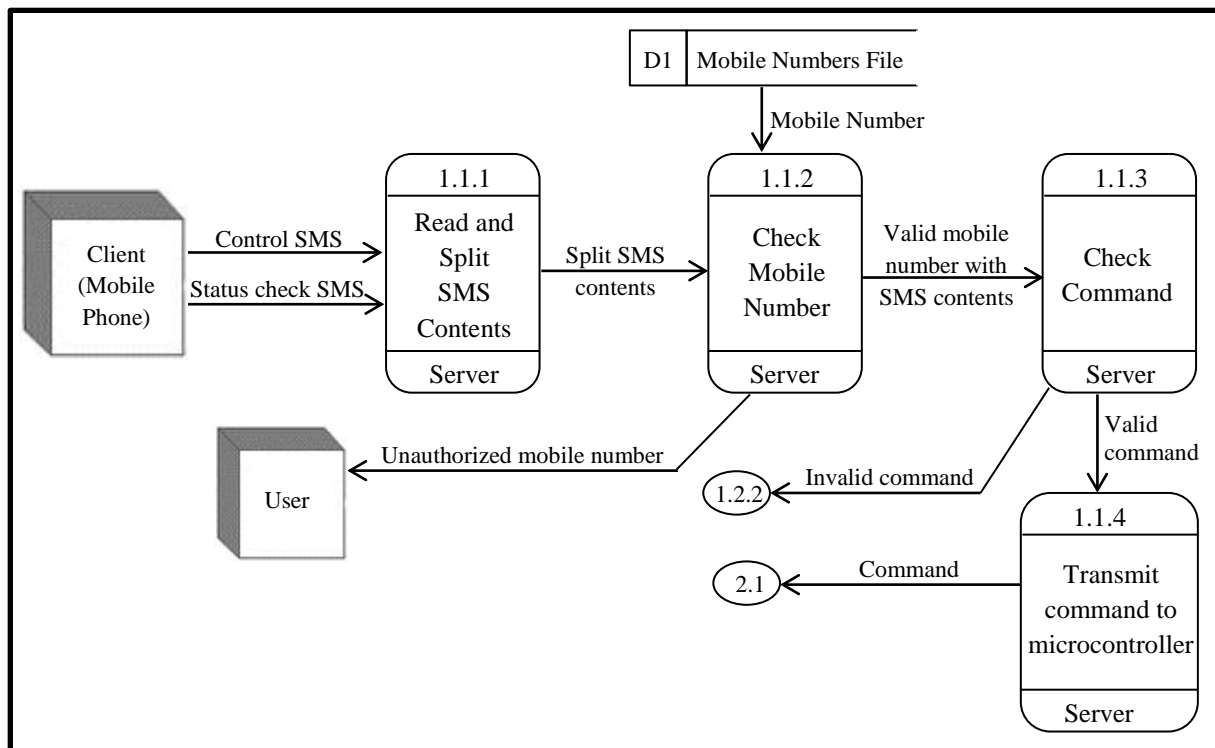
Level 3: Process 1.1 Diagram

Figure 3-5: Level 3 - Process 1.1 Diagram

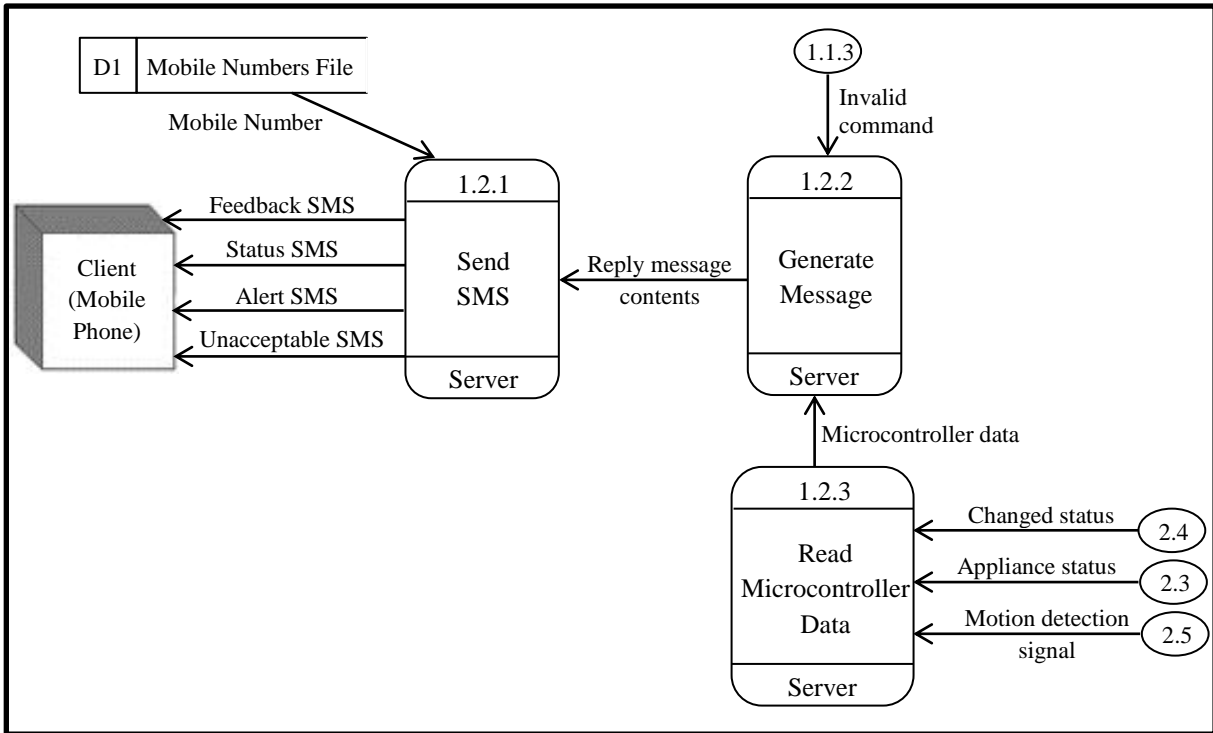**Level 3: Process 1.2 Diagram**

Figure 3-6: Level 3 - Process 1.2 Diagram
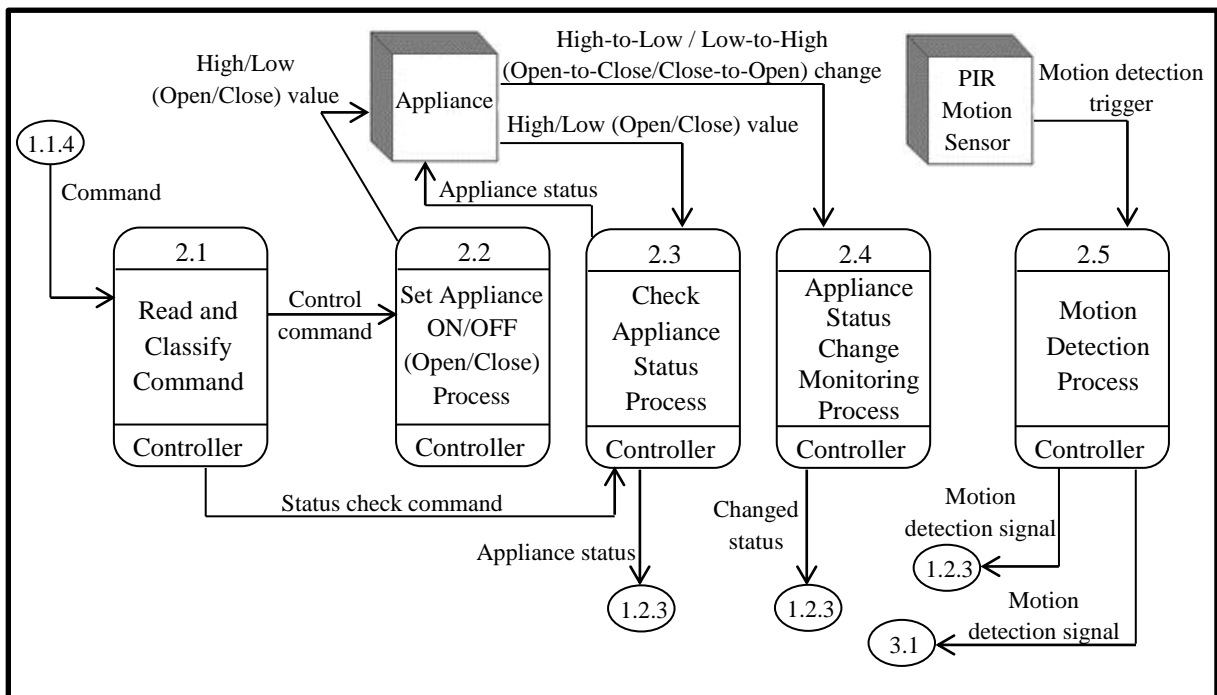
Level 2: Process 2.0 Diagram

Figure 3-7: Level 2 - Process 2.0 Diagram
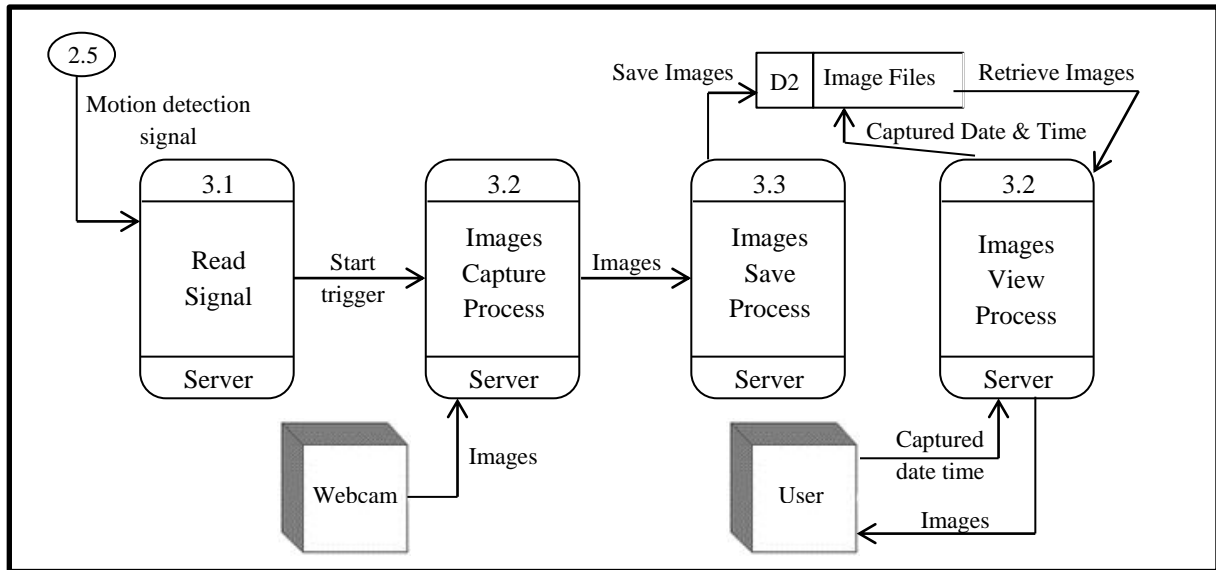
Level 2: Process 3.0 Diagram

Figure 3-8: Level 2 - Process 3.0 Diagram

Appendix B: Test Cases

Following table (Table 5-6) represents the test cases for System Main Menu

No.	Test Case	Purpose	Output	Status
System Main Menu				
01	Click "Mobile Phone Number Setting"	To check display of correct screen	For authorized users, redirects to "Mobile Phone Number Setting" screen. For unauthorized users, show message "You don't have access to Mobile Phone Number Setting" & remains in the screen.	Pass
02	Click "Webcam Setting"	To check display of correct screen	For authorized users, redirects to "Webcam Setting" screen. For unauthorized users, show message "You don't have access to Webcam Setting" & remains in the screen.	Pass
03	Click "User Login Management"	To check display of correct screen	For authorized users, redirects to "User Login Management" screen. For unauthorized users, show message "You don't have access to User Login Management" & remains in the screen.	Pass
04	Click "View Captured Images"	To check display of correct screen	For authorized users, redirects to "View Captured Images" screen. For unauthorized users, show message "You don't have access to View Captured Images" & remains in the screen.	Pass
05	Click "Controlling and Monitoring"	To check display of correct screen	For authorized users, if mobile phone number was not setup then show message "Please set mobile phone number". If it exists, redirect to "Appliances Controlling and Monitoring" screen. For unauthorized users, show message "You don't have access to Appliances Controlling and Monitoring" & remains in the screen.	Pass
06	Click "Logout"	To check successfully log out from the application	Show confirmation message "Do you want to logout from the system (y/n)?". Click "Yes" to redirects to User Login screen. Click "No" to remains in the screen.	Pass

Table 5-6: Test Cases for System Main Menu

Following table (Table 5-7) represents the test cases for Mobile Phone Number Setting

No.	Test Case	Purpose	Output	Status
Mobile Phone Number Setting				
Required Information: • MySQL Database Server is running				
01	Screen display	To confirm displaying of existing mobile phone number	If mobile phone number is exists then show it in mobile phone number field. Otherwise field displays as empty.	Pass
02	Click "Edit"	To check mobile phone number field is enabled to input	Mobile phone number field is enabled to input	Pass

03	Click "Cancel"	To check cancellation of edit mode	Cancel edit mode & display mobile phone number in field if it exists.	Pass
04	Click "Close"	To test successfully close the screen	Close the screen & redirects to System Main Menu screen.	Pass
05	Click "Save" with empty mobile phone number	To validate empty field	Show message "Please enter the Mobile Phone Number" & remains in the screen	Pass
06	Insert mobile phone number and click "Save"	To test inserting new mobile phone number	If saved successfully then show message "Mobile Phone Number inserted successfully". Otherwise show error message "Mobile Phone Number inserting error". Remains in the screen.	Pass
07	Edit mobile phone number and click "Save"	To test updating existing mobile phone number	If updated successfully then show message "Mobile Phone Number updated successfully". Otherwise show error message "Mobile Phone Number updating error". Remains in the screen.	Pass

Table 5-7: Test Cases for Mobile Phone Number Setting

Following table (Table 5-8) represents the test cases for Webcam Setting

Webcam Setting				
Required Information:				
• Webcam connected to PC via USB cable.				
No.	**Test Case**	**Purpose**	**Output**	**Status**
01	Click "Start"	To test receiving of video streams from Webcam	Showing live video streams receiving from Webcam.	Pass
02	Click "Stop"	To test stop of video streams receiving from Webcam	Stopped live video streams receiving from Webcam.	Pass
03	Click "Continue"	To test continue of video streams receiving from Webcam	Showing live video streams receiving from Webcam.	Pass
04	Click "Resolution Setting"	To check displaying of Resolution Setting dialog box	Show Resolution Setting dialog box & facilitate to change setting.	Pass
05	Click "Advanced Setting"	To check displaying of Advanced Setting dialog box	Show Advanced Setting dialog box & facilitate to change setting.	Pass
06	Click "Close"	To test successfully close the screen	Close the screen & redirects to System Main Menu screen.	Pass

Table 5-8: Test Cases for Webcam Setting

Following table (Table 5-9) represents the test cases for User Login Management

No.	Test Case	Purpose	Output	Status
	User Login Management			
01	Click "Add New User"	To check display of correct screen	Redirects to "Add New User Login" screen.	Pass
02	Click "Change User Password"	To check display of correct screen	Redirects to "Change User Login Password" screen.	Pass
03	Click "Delete User"	To check display of correct screen	Redirects to "Delete User Login" screen.	Pass
04	Click "Change User Type Privileges"	To check display of correct screen	Redirects to "Privilege Setting for Different User Types" screen.	Pass
05	Click "Close"	To test successfully close the screen	Close the screen & redirects to System Main Menu screen.	Pass

Table 5-9: Test Cases for User Login Management

Following table (Table 5-10) represents the test cases for Add New User Login

No.	Test Case	Purpose	Output	Status
	Add New User Login			
	Required Information:			
	• MySQL Database Server is running			
01	Screen display	To confirm retrieval of existing user types into User Type list	User Type list filled with existing user types.	Pass
02	Skip user name & click "Add"	To test add new user without user name	Show message "Please enter User Name" & remains in the screen.	Pass
03	Insert user name with less length than minimum & click "Add"	To check minimum no. of characters for user name	Show message "User Name required minimum 8 characters" & remains in the screen.	Pass
04	Insert special characters in user name & click "Add"	To avoid insertion of special characters for user name	Show message "User Name has invalid characters" & remains in the screen.	Pass
05	Without selecting User Type Click "Add"	To test add new user without user type	Show error message "Please select a user type" & remains in the screen.	Pass
06	Skip Password & click "Add"	To test add new user without password	Show message "Please enter Password" & remains in the screen.	Pass
07	Insert password with less length than minimum & click "Add"	To check minimum no. of characters for password	Show message "Password required minimum 8 characters" & remains in the screen	Pass
08	Insert special characters in	To avoid insertion of special characters for	Show message "Password has invalid characters" & remains in the	Pass

	password & click "Add"	password	screen.	
09	Insert different password in Confirm Password & click "Add"	To check password and confirm password are different	Show message "Password and Confirm Password are not match" & remains in the screen.	Pass
10	Insert existing user name & click "Add"	To avoid creating new user login with existing user name	Show message "User Name already exists" & remains in the screen.	Pass
11	Insert correct data in appropriate fields and click "Add"	To confirm successful insertion of user login details	If successfully added, show message "User details added successfully". Otherwise show message "User details insertion error". Remains in the screen.	Pass
12	Click "Close"	To test successfully close the screen	Close the screen & redirects to User Login Management screen.	Pass

Table 5-10: Test Cases for Add New User Login

Following table (Table 5-11) represents the test cases for Change User Login Password

Change User Login Password				
Required Information:				
• MySQL Database Server is running				
No.	**Test Case**	**Purpose**	**Output**	**Status**
01	Skip user name & click "Search"	To test search user login without entering user name	Show message "Please enter User Name" & remains in the screen.	Pass
02	Insert not existing user name & click "Search"	To test disabling of password change for not existing user	Show message "User name does not exists" & remains in the screen.	Pass
03	Insert existing user name & click "Search"	To test enabling of password change for existing user	Show message "User name exists" & remains in the screen.	Pass
04	Skip Old Password & click "Update"	To test update user password without entering old password	Show message "Please enter Old Password" & remains in the screen.	Pass
05	Skip New Password & click "Update"	To test update user password without entering new password	Show message "Please enter New Password" & remains in the screen.	Pass
06	Insert New Password with less length than minimum & click "Update"	To check minimum no. of characters for new password	Show message "New Password required minimum 8 characters" & remains in the screen.	Pass
07	Insert special characters in New	To avoid insertion of special characters for	Show message "New Password has invalid characters" & remains in the	Pass

	Password & click "Update"	new password	screen.	
08	Insert old password in the New Password & click "Update"	To check old password and new passwords are same	Show message "Old Password and New Password are same" & remains in the screen.	Pass
09	Insert different password in Confirm New Password & click "Update"	To check new password and confirm new password are different	Show message "New Password and Confirm New Password are different" & remains in the screen.	Pass
10	Insert incorrect Old Password & click "Update"	To test entered old password match with existing password	Show message "Invalid Old Password" & remains in the screen.	Pass
11	Insert correct data in appropriate fields and click "Update"	To confirm successfully updating of user password	If successfully updated, show message "Password updated successfully". Otherwise show message "Password updation error" & remains in the screen. Remains in the screen.	Pass
12	Click "Close"	To test successfully close the screen	Close the screen & redirects to User Login Management screen.	Pass

Table 5-11: Test Cases for Change User Login Password

Following table (Table 5-12) represents the test cases for Delete User Login

Delete User Login				
Required Information:				
• MySQL Database Server is running				
No.	**Test Case**	**Purpose**	**Output**	**Status**
01	Screen display	To confirm retrieval of existing user login details into the grid except current user	If no users exist other than current user, then display message "No existing users to be display". Otherwise display list of user login details in grid.	Pass
02	Click "Delete" without selecting a login record	To test deletion of user login record without selecting it	Show message "Please select the user login record to delete" & remains in the screen.	Pass
03	Select required login record & Click "Delete"	To verify successfully deletion of required record	Show confirmation message "Do you want to delete this user login (y/n)?". Click "Yes" to delete required record. If successfully deleted show message "User login deleted successfully" & display updated list. Otherwise show message "User login deletion error". Click "No" to ignore deletion.	Pass

			Remains in the screen.	
04	Click "Close"	To test successfully close the screen	Close the screen & redirects to User Login Management screen.	Pass

Table 5-12: Test Cases for Delete User Login

Following table (Table 5-13) represents the test cases for Change User Type Privileges

Change User Type Privileges				
Required Information: • MySQL Database Server is running				
No.	**Test Case**	**Purpose**	**Output**	**Status**
01	Screen display	To confirm retrieval of existing user types into User Type list	User Type list filled with existing user types.	Pass
02	Click "Get Privileges" without selecting User Type"	To test getting of user type privileges without selecting user type	Show message "Please select user type" & remains in the screen.	Pass
03	Select user type & click "Get Privileges"	To test displaying of user type privileges according to selected user type	Assigned privilege display with tick on checkbox & unassigned privilege display without tick on checkbox.	Pass
04	Click "Edit"	To check user type privileges are enable to change	Privileges of selected user type are enable to change.	Pass
05	Click "Cancel"	To check cancellation of edit mode	Cancel edit mode & display user type privileges of selected user type.	Pass
06	Edit user type privileges & click "Save"	To test updating of selected user type privileges	If updated successfully then show message "User type privileges updated successfully". Otherwise show error message "Error in user type privileges update". Remains in the screen.	Pass
07	Click "Close"	To test successfully close the screen	Close the screen & redirects to User Login Management screen.	Pass

Table 5-13: Test Cases for Change User Type Privileges

Following table (Table 5-14) represents the test cases for View Captured Images

View Captured Images				
Required Information: • MySQL Database Server is running				
No.	**Test Case**	**Purpose**	**Output**	**Status**
01	Start Date-time greater than End Date-time &	To test start and end date-time range	Show message "Start Date must be less than the End Date" &	Pass

	click "Download Images"		remains in the screen	
02	Correct Start & End Date-time range & click "Download Images"	To confirm no images exist in the given date-time range	Show message "No images to display" & remains in the screen	Pass
03	Correct Start & End Date-time range & click "Download Images"	To confirm displaying of images which are captured within given date-time range	Show first image of the collection with captured date-time. Also display total no. of images in the collection and "1" in the Current Image field.	Pass
04	Click "Next"	To check move & display the next image in the collection	Show next image with captured date-time until last image in the collection.	Pass
05	Click "Prev"	To check move & display the previous image in the collection	Show previous image with captured date-time until first image in the collection.	Pass
06	Click "Save Image File…"	To test saving of currently displaying image as a file	If no image displaying in the picture box then show message "No image to save". Otherwise display file save dialog box to save file in different image formats.	Pass
07	Click "Close"	To test successfully close the screen	Close the screen & redirects to System Main Menu screen.	Pass

Table 5-14: Test Cases for View Captured Images

Appendix C: User Evaluation Questionnaire

Following is the questionnaire form used to collect user's feedback about the system.

User Evaluation Questionnaire
SMS Based Home Appliances Controlling and Monitoring System Using Arduino PCB
The main purpose of this survey is to find out how satisfied you were with this software product. Your feedback is very valuable to make decisions about the system and to improve its quality.
Instructions: Please put a tick (√) in the box corresponding to the answer of your choice or write in the space provided. Please do not leave any questions incomplete.

1) General

   i) Level of Computer Literacy: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

   ii) Have you any experience of using this kind of system? ☐ Yes ☐ No

2) System Outcomes

Please indicate your level of agreement with the statements listed below.

   i) Do you think this system will facilitate to manage power consumption?

     ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

   ii) Does this system enable home security against intrusions?

     ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

   iii) Are you agree this system provide assistance to the elderly and disabled people those who are at home alone?

     ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

   iv) Is this system gives users a better safety against any current leakage?

     ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

   v) Easier controlling & monitoring of appliances from anywhere at any time will improve the people's lifestyle?

     ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

   vi) Is this system helpful for people who are unaware of typing SMS and mistakes occur when typing SMS?

     ☐ Strongly Agree ☐ Agree ☐ Undecided ☐ Disagree ☐ Strongly Disagree

3) System Characteristics					
What is your overall opinion of the following aspects of the system?					
Characteristics	**Excellent**	**Good**	**Average**	**Fair**	**Poor**
Easy to use and learn (Usability)	☐	☐	☐	☐	☐
Security	☐	☐	☐	☐	☐
Performance	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐
Availability	☐	☐	☐	☐	☐
Usefulness	☐	☐	☐	☐	☐
Meets Expectations	☐	☐	☐	☐	☐

4) Comments

Please comment on any positive or negative aspects that you feel to improve this system.