# CERTIFICATE OF ORIGINALITY

We the undersigned, hereby certify that this dissertation entitled “DISTANCE MANAGEMENT OF A BASE STATION” presented by NGAI ELIZABETH ASOBI, Matriculation number FE14A153 has been carried out by her in the Department of Computer Engineering, Faculty of Engineering and Technology, University of Buea under the supervision of Dr. Tsafack Pierre.

This dissertation is authentic and represents the fruits of her own research and efforts.

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# DEDICATION

I dedicate this work to God Almighty for his infinite strength and knowledge He bestowed on me during the period of my project research, also to my Father: Bisong John Bisong for his unending moral and financial support, to my fellow course mates and friends for their intellectual support all throughout the conception and design of this project.

# ACKNOWLEDGEMENT

First and foremost, we would like to thank God Almighty for reasons too many to mention, one of which is for being the source of strength. We also want to express our deep and sincere gratitude to:

* Dr. Tsafack Pierre, my academic supervisor whose support, advice and close follow-up has greatly contributed to the accomplishment of this report.
* MY FAMILY for their moral and financial support
* Prof. TANYI EMMANUEL Dean of FACULTY FO ENGINEERING AND TECHNOLOGY (FET) for his efforts to make FET a place for inquisitive and creative engineers.
* To all my friends and course mates who met me in my point of need.

# ABSTRACT

As more and more people rely on mobile communication in their daily lives, the smooth functioning of Mobile Communication Base Station is necessary to also ensure smooth functioning of the network. To do this, the BTS comprises many devices as such, the goal of this project is to develop a system capable of detecting faults occurring in these devices and generate alerts immediately and also to control and analyze the overall functioning of this system remotely. The major problems encountered in such sites are fuel theft, unauthenticated entry, temperature fluctuations, unattended smoke detections, no way to check status of power supply, battery and the workability of the generator.

The system will make use of temperature sensors to detect abnormal increase or decrease in temperature outside set threshold values, smoke sensors to detect abnormal presence of smoke, PIR sensors to detect presence of human in the site, RFID authentication system. The system uses Global System for Mobile (GSM) Short Message Service protocol to send instant messages about each activity in the cell site using a GSM modem. This information will be displayed and interpreted on a web interface running locally on a PC management office which can then be used for analyses and control.

**Keywords:** *Arduino Uno, sensors, GSM, SMS, base station.*

# CHAPTER ONE. GENERAL INTRODUCTION

## Background and context of the study

This study outlines the problems faced by network operators in managing their base station cites and subsystems across different geographical locations. As the number of people relying on mobile communications in their daily lives keep increasing, the pressure on telecom infrastructure is increased. We want telecom base stations to achieve higher performance while decreasing operational costs. This can be a real challenge, especially in rural and scarcely populated areas where we might lack a well-developed power grid and the nearest service technician is miles away. There are many actions that can be taken to improve operations and reduce costs, for example using newer energy-efficient equipment and integrated power management systems to use power more efficiently. These actions may work well when a new site is being built, but the investment may be harder to justify on existing sites as it requires replacing existing, well-functioning equipment with new.

## Problem Statement

The problem this study aims to solve is the management of the different devices that control such base stations. Controlling such devices entails controlling the parameters that control the proper functioning of such systems. This control requirements can be divided into three main parts;

* Inefficient Power Consumption/Supply management
* Uncontrolled Environmental Factors
* Technician’s Time Management
* Security

## Inefficient Power Consumption/Supply Management

Being able to detect whether the base station cite is supplied with power or not is one important aspect of monitoring because few minutes of the site being down, can amount to huge losses by the network operators. Another aspect of monitoring and control is the ability to see how much power devices at the sites are consuming so as to be able to measure the site’s Energy Efficient Ratio (EER).

## Uncontrolled Environmental Conditions

Controlling the environmental aspects such as temperature, humidity and smoke is very crucial to the functioning its devices most especially temperature. This is because variations in temperatures can affect the lifespan of batteries and other devices so maintaining the temperature set threshold is very important to increase the lifespan of batteries and devices in such sites.

## Technician’s Time Management

Since the proper maintenance and control of sites are needed to maintain smooth functioning of the site, technicians are forced to pay regular check up visits to all sites in order to make sure the devices are functioning properly. This is time wastage and cost inefficient for the network operators if the sites are actually doing well since most sites are sometimes miles away. So, being able to schedule visits only for sites which need immediate attention is a big challenge.

## 1.2.4 Security

Security has always been a crucial aspect of any system. Base station sites usually face problems of unpermitted entry, fuel theft, theft of wires. The lack of efficient ways to monitor such activities in the sites poses major security threats and lack of tracking methods to catch the thieves.

## Objectives of the Study

Here, we shall describe what we intend to accomplish with this study. This part will be divided into two; general and specific objectives.

## 1.3.1 General Objectives

The general Objectives of this study is to be able to design and implement a system that will be able to manage, control and secure a base station operation site remotely thereby cutting down cost by sending alerts and notification whenever there is a need for a particular service to the appropriate person in charge remotely.

## 1.3.2 Specific Objectives

The specific objectives is to be able to set, manage, control and secure the site through remote monitoring of parameters like temperature, smoke, energy consumption, movement across restricted areas in the site, monitor functioning of devices remotely and check for fault. This system will then send alerts if there is any unusual activity in the site through an SMS. These data gotten from the site will then be displayed on a Web Interface which then interprets the data thereby, enabling the technicians to be able to make predictions about what needs to be done and where. Appropriate sensors, Arduino, GSM module and a SIM card are used to make a system which is there just to monitor the environment and performances of devices in such sites after which, data is sent to the web for analyses.

## Proposed Methodology

There are many things that can be done to improve the operation of existing telecom sites, but the key factor to successfully be able to reduce operational costs is information. By understanding when, how and if equipment is operating, we are able to make better decisions regarding site maintenance and take actions when necessary. Here, we shall be listing the proposed method to reduce cost and better management system remotely.

## 1.4.1 Proposed solution to Power Management

For operators to be able to manage Power supply and measure energy consumption, we propose adding intelligent energy meters at strategic locations in the site to get a detailed overview of how much energy each part of the BTS is consuming. For example, with an AC meter installed directly after the mains, and DC meters which measure the consumption of the telecom load, you can easily calculate the site’s Energy Efficiency Ratio (EER). Additionally, energy meters can be added to individual equipment (the air-conditioning for example) to see how it is performing and when it is time to do maintenance. Also, getting the amount of battery charge left.

The results will help you identify what kind of energy efficiency measures to take [1].

## 1.4.2 Controlling Environmental Conditions

We propose the installation sensors such as, the LM35 which monitors changes in temperature, the gas Sensor which can monitor abnormal presence of gas or smoke in the site so as to be able to remote immediately to the management personnel whenever values go beyond set threshold.

## 1.4.3 Managing Technician’s Time

We propose and interface that will be able to send commands to the site to check for the operational functioning of certain devices remotely. This will give technicians enough time to attend to sites which needs immediate attention and forget about ones working properly. We also propose that the system be able to control the functioning of certain devices automatically without needing the help of a technician; for example, turning on the cameras of the system when entry to restricted areas detected, turning on the cooling/heating systems when temperatures rises/drops below set thresholds.

## 1.4.4 Securing the System

Motion sensors will be placed at different areas of the site to detect levels of entry so as to be analyze the different restrictions. Fuel level sensors will be used to detect abnormal decrease in fuel level. Cameras will be installed in the system which automatically comes on in case of theft detection or motion in restricted areas. Last but not the least, the system will make use of RFID authentication before granting access to restricted sites of the site in case an authorized technician visits the site for maintenance avoiding unnecessary alerts and notifications being sent to the head office.

Finally, a Web site that will be used to display information from data collected from sites at the head office and a well-structured database system which will store these values for use in predictions by graph plots.

## Significance of the study

This study signifies a breakthrough in the deployment of fully functioning Mobile Telecommunication sites in developing countries like Cameroon where speed of internet connectivity is very low especially in rural areas reasons why this study makes use of SMS for control and feedback rather than the Internet. This study also helps to give network operators with remote monitoring way ahead of competitors.

## Scope of the Study

This study was targeted to fulfilling the requirements for a fully functional Mobile telecommunication base station. However, the problems stated above are similar to proposed faces by other types of base station so this study can be applied to them as well. This study takes care of monitoring and controlling parameters like temperature, motion, fuel\_level, starting on generator remotely, detecting gas leakages or smoke, on site control (turning on fan when temperature is high, turning on alarm when theft or fire is noticed so people living around can notice) and offsite control.

## 1.7 Delimitation of the Study

The delimitation of the Study is that it makes use of GSM Short Message Service Protocol to send control data to and from site. The problem though with this protocol is that is has a maximum limit of characters it can send which makes it difficult to adapt to sites where the control parameters are many.

## Definition of Keywords and Terms

* Arduino Uno:
* GSM:
* SMS:
* BTS:
* Sensors:
* Base Station:

## Organisation of the dissertation

This dissertation will be organized as follows;

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Introduction

The literature related to the research topic has been reviewed for last twenty years in order to find out work carried out by various researchers. There are many systems for remote monitoring and control designed as commercial products or experimental research platforms. It is noticed that most of the research carried out belongs to the following categories

a. Internet based Monitoring using Servers, GPRS modems, etc. with different approaches.

b. GSM-SMS protocols using GSM module individually or in combination with Internet Technologies.

c. Monitoring using Wireless Sensor Networks.

d. Wireless Monitoring using Bluetooth, Wi-Fi, Zigbee and RF.

e. Applications have varied widely like Home Automation, Security Systems, Biomedical applications, Agriculture, Environment, Reservoir, Bridge health monitoring, etc.

## 2.1.1 Internet Based Monitoring

Internet monitoring is one of the common approaches for remote monitoring. Many researchers have worked in field of Internet based remote monitoring. (Alkar and Buhur, 2005) implemented Internet based wireless flexible solution where home appliances are connected to slave node. The slave nodes communicate with master node through RF and master node has serial RS232 link with PC server. The nodes are based on PIC 16F877 µc. PC server is formed of a user interface component, the database and the web server components. An Internet page has been setup running on a Web server. The user interface and the Internet front end are connected to a backend data base server. The control of devices is established and their condition is monitored through the Internet. (Al-Khateeb et al., 2009) used X10 controller interfaced through serial port to PC server for control of devices. The Common Gateway Interface (CGI) is used to interface between the browser and the X10 protocol via http connection. The server executes CGI programs in order to satisfy a particular request from the browser, which expresses its request using the http.

## 2.1.2 GSM-SMS Based Monitoring

With the wide spread use of cellular networks, this approach is also popular when small amount of data is to be transferred through the network. Extensive work has been carried out by researchers using this approach especially in medical field. (Chen Peijiang and Jiang Xuehua, 2008) describe a remote monitoring system based on SMS of GSM. The system includes two parts which are the monitoring center and the remote monitoring station. The monitoring center consists of a computer and a TC35 GSM communication module. The computer and TC35 are connected by RS232. The remote monitoring station includes a TC35 GSM communication module, a MSP430F149 MCU, a display unit, various sensors, data gathering and processing unit. (Alheraish, 2004) implemented home security system by means of GSM cellular communication network using microcontroller 89X52 and Sony Ericsson GM-47 GSM module. This system enables far end user through SMS facility to monitor the state of home door, provide password facility for key based door lock and control home lighting system. (Van Der Werff et al., 2005) proposed a mobile-based home automation system that consists of a mobile phone with Java capabilities, a cellular modem, and a home server. The home appliances are controlled by the home server, which operates according to the user commands received from the mobile phone via the cellular modem. In the proposed system the home server is built upon an SMS/GPRS (Short Message Service/General Packet Radio Service) mobile cell module Sony Ericsson GT48 and a microcontroller Atmel AVR 169, allowing a user to control and monitor any variables related to the home by using any java capable cell phone.

## 2.1.3 Remote Monitoring using Wireless Sensor Networks (WSN), Bluetooth, WiFi, Zigbee technologies:

Many Wireless Technologies like RF, Wi-Fi, Bluetooth and Zigbee have been developed and remote monitoring systems using these technologies are popular due to flexibility, low operating charges, etc. Today Wireless Sensor Network are used into an increasing number of commercial solutions, aimed at implementing distributed monitoring and control system in a great number of different application areas. (Wijetunge et al., 2008) designed a general-purpose controlling module designed with the capability of controlling and sensing up to five devices simultaneously. The communication between the controlling module and the remote server is done using Bluetooth technology. The server can communicate with many such modules simultaneously. The controller is based on ATMega64 microcontroller and Bluetooth communication TDK Blu2i (Class 1) module which provides a serial interface for data communication. The designed controller was deployed in a home automation application for a selected set of electrical appliances. (Kanma et al., 2003) proposed a home appliance control system over Bluetooth with a cellular phone, which enables remote-control, fault-diagnosis and software-update for home appliances through Java applications on a cellular phone. The system consists of home appliances, a cellular phone and Bluetooth communication adapters for the appliances. The communication adapter hardware consists of a 20MHz 16bit CPU, SRAM and a Bluetooth module. The communication adapter board is connected to the home appliance and to the cellular phone through serial ports. The appliances can communicate with the cellular phone control terminal via Bluetooth SPP

## 2.2 Major Concepts on Research Topic

In this section, we shall briefly state and explain the concepts behind the keywords used in this research.

## 2.2.1 Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P used for programming/controlling external devices. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

## 2.2.2 Sensors

In the broadest definition, a sensor is a device, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics, whether as simple as a light or as complex as a computer. Examples of sensors used in this study are; temperature sensor, gas/smoke sensor, fluid level sensor, proximity sensor.

## 2.2.3 Global System for Mobile Communication (GSM)

GSM (Global System for Mobile communications) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation digital cellular networks used by mobile devices such as tablets. It was first deployed in Finland in December 1991[2]. As of 2014, it has become the global standard for mobile communications – with over 90% market share, operating in over 193 countries and territories [4].

## 2.2.4 Short Messaging Service (SMS)

SMS (short message service) is a text messaging service component of most telephone, internet, and mobile-device systems [5]. It uses standardized communication protocols to enable mobile devices to exchange short text messages. An intermediary service can facilitate a text-to-voice conversion to be sent to landlines [6]. SMS was the most widely used data application, with an estimated 3.5 billion active users, or about 80% of all mobile subscribers, at the end of 2010 [5].

## 2.2.5 Base Station (BS)

Base station (or base radio station) is – according to the International Telecommunication Union’s (ITU) Radio Regulations (RR) [7] – a "land station in the land mobile services "

## 2.3 Related Works

The distance management of a base station has been a crucial aspect in the telecommunication sector for the control and maintenance of telecom sites in order to meet up with high demand. As such, many works have come up so far to address these challenges faced – some of which have been commercialized.

2.3.1

## 2.4 Partial Conclusion

From the above findings, it is certain that distance management of a telecom base station plays a vital role in improving the quality of service of such networks.

# CHAPTER THREE: ANALYSIS AND DESIGN

## 3.1 Introduction

In this chapter we shall see a detailed view of the design and implementation of a distance management of a base station system. We shall design from the collection of data, transfer, analysis and control processes.

## 3.2 Proposed Methodology

The method we proposed to enable distance management of a base station is a GSM messaging control system which can be able to get data to and from the base station to be used for control remotely. Sensors will be placed at the base station which will be able to sense changes in the surrounding and send alarms to the remote system if there is any fault in the station through SMS. A local web server will be built at the remote office capable of getting information sent from base station sites and store in a database, display and interpret the information through a web interface so that control can be done.

## 3.3 System Design

In the system Design, we ensure proper communication between the base station and the remote head office in control of the site. In this section we shall be looking at how the request for data is being done, how the data is transferred, when and how alarms are sent and how control is being done for the achievement of our objectives. This part is made up of the structural design which tells us how the components are connected with each other and the communication between this.

## 3.3.1 Structural Design

## 3.3.2 Communication Flow

## 3.4 Global Architecture of the Solution

Here we shall generalize the entire system into one functional unit

## 3.5 Description of the Resolution process

Here, we shall generalize the functionality of the system to achieve our said goals.

## 3.6 Partial Conclusion

With this proposed solution, it can be seen that the system design accomplishes our objectives which is to be able to mange a distance base station.

# CHAPTER FOUR: IMPLEMENTATION/REALIZATION AND PRESENTATION OF RESULTS

## 4.1 Introduction

This chapter presents the working system designed above and ensures that it meets up with the desired objectives. It also brings out the engineering application and significance of the system.

## 4.2 **Tools and Materials Used**

The tools and materials used in this work include proteus simulation tool, Arduino IDE, XAMPP web server, GSM module, Arduino Uno board, bread board, jumper wires, a resistor, bulb, smoke sensor, temperature sensor, motion sensor, fan, buzzer, liquid level sensor, liquid crystal display, I2C, SIM cards, an MTN 3G Modem, transistor, free wheeling diode, leds, Arduino serial cable, relay module, bulb holder, wires, head plug. The uses of the following tools and materials in this project are described below.

1. **Proteus Simulation Tool**

The Proteus Design Suite is a proprietary software tool suite used primarily for [electronic design automation](https://en.wikipedia.org/wiki/Electronic_design_automation). The software is used mainly by electronic [design engineers](https://en.wikipedia.org/wiki/Design_engineer) and technicians to create [schematics](https://en.wikipedia.org/wiki/Schematic) and electronic prints for manufacturing [printed circuit boards](https://en.wikipedia.org/wiki/Printed_circuit_board). Thus, this simulation tool was used to create schematic design for the implementation and manufacturing of the hardware part of the project described above.

1. **Arduino IDE**

The Arduino IDE is a cross platform application written in java programming language use for writing and uploading programs Arduino. This IDE was used to write and upload the program to put the site under monitoring and control.

1. **XAMPP Web Server**

XAMPP stands for Cross-Platform (X), Apache (A), MariaDB (M), PHP (P) and Perl (P). It is a simple, lightweight Apache distribution that makes it extremely easy for developers to create a local web server for testing and deployment purposes. This study made use of the XAMPP functionalities to implement a local web server that can be used to display information collected base station sites. PHP: Hypertext Processor (PHP), is a server-side scripting language used for web development integrated in XAMPP and was used to program the script that interacts the database and the web front end. It queries the database for information concerning the current condition of the site. PhpMyAdmin is a free and open source administration tool for MySQL and MariaDB also integrated into the XAMPP server which was used in this study as a tool to create database for the storage of sites data using the MySQL database language.

1. **GSM module (SIM900)**

The SIM900 described in chapter 2, was used for the sending and receiving of messages at the base station sites.

1. **Arduino Uno**

The Arduino Uno (ATmega328p) board described in chapter 2, was used as the microcontroller to control the various devices at the base station.

1. **Bread board**

It is a construction base for prototyping of electronic and it was used in this project to construct the prototype system for the study.

1. **Jumper Wires and Wires**

Jumper wires are [electrical wire](https://en.wikipedia.org/wiki/Electrical_wire), or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a [breadboard](https://en.wikipedia.org/wiki/Breadboard) or other prototype or test circuit, internally or with other equipment or components, without soldering [8]. These jumper wires were used to connect the components on the bread board.

1. **Resistor, fan, transistor and freewheeling diode**

A resistor is a [passive](https://en.wikipedia.org/wiki/Passivity_(engineering)) [two-terminal](https://en.wikipedia.org/wiki/Terminal_(electronics)) [electrical component](https://en.wikipedia.org/wiki/Electronic_component) that implements [electrical resistance](https://en.wikipedia.org/wiki/Electrical_resistance) as a circuit element and it was used in my project to limit current to the base of the transistor . A transistor is a [semiconductor device](https://en.wikipedia.org/wiki/Semiconductor_device) used to [amplify](https://en.wikipedia.org/wiki/Electronic_amplifier) or [switch](https://en.wikipedia.org/wiki/Switch) [electronic](https://en.wikipedia.org/wiki/Electronics) signals and [electrical power](https://en.wikipedia.org/wiki/Electrical_power) and it used in my project as a switch to enable the fan to come on base on the signal from the Arduino. A freewheelingdiode is a [diode](https://en.wikipedia.org/wiki/Diode) connected across an [inductor](https://en.wikipedia.org/wiki/Inductor) used to eliminate flyback, which is the sudden [voltage spike](https://en.wikipedia.org/wiki/Voltage_spike) seen across an [inductive](https://en.wikipedia.org/wiki/Inductance) [load](https://en.wikipedia.org/wiki/Electrical_load) when its supply current is suddenly reduced or interrupted. It is used in circuits in which inductive loads are controlled by [switches](https://en.wikipedia.org/wiki/Switch), and in [switching power supplies](https://en.wikipedia.org/wiki/Switching_power_supply) and [inverters](https://en.wikipedia.org/wiki/Power_inverter). And it is was used in my project to prevent sudden voltage surge from the inductive load (fan) when powered off.

1. **Buzzer**

A buzzer is an audio signaling device and was used in this project to raise an alarm when temperature and/or smoke values go beyond certain values so that if there are people living around the site, they can easily escape in time in case of fire breakouts.

1. **Smoke sensor and temperature Sensor**

The smoke sensor detects the level of gas or smoke in the surrounding while the temperature sensor detects the temperature of the surrounding. These two sensors where used in this project to get the smoke/gas and temperature levels of the base stations for use in arduino.

1. **Fuel level sensor and motion sensor**

The fuel level sensor and motion sensor as described in chapter two are used in this project to get the level of fuel left and detect the presence of humans at the site respectively.

1. **Relay module, head plug, bulb holder, bulb**

A **relay** is an electrically operated switch of mains voltage. It means that it can be turned on or off, letting the current go through or not and it was used in this project to turn on and off a bulb used to simulate the genset using Arduino.

1. **Liquid Crystal Display**

Liquid Crystal Display as described in chapter 2, was used in this project to display the actions taking place at the base stations though it is not really necessary since there is no person to be constantly checking to see what is happening. We will use it here just to illustrate the synchronization between the base station and the head office.

1. **I2C**

Inter-Integrated Circuit was used to reduce the number of pins interfaced to the Arduino to 8 to 2 thereby leaving enough space for important sensors to be controlled.

1. **Huawei 3g modem**

Huawei 3g modem as described in chapter 2, was used in this project to send and receive text messages at the head office.

1. **SIM Cards**

**SIM** cards plugged in the GSM module and Huawei 3g modem to enable the establishment of a GSM network used for the sending and receiving of SMS.

## 4.3 Description Of The Implementation Process

In this section, we are going to give a detailed implementation of the process flow. Implementing GSM based monitoring and control alarm system will be described in two parts; the implementation at the site for data collection and monitoring and the implementation done at the head office for interpretation and control management. The base station site is mostly made up of the circuitry to implement the monitoring, data collection and alarm system while the head office has a webserver, database and web interface for interpreting, storing and displaying the results of the data collected from the sites. I will describe the implementation into three phases; the monitoring and data collecting system, the remote web server and the communication between the two.

## 4.3.1 Monitoring and data collecting system

This system is implemented at the base station and its main purpose is to constantly wait for fault to occur so it can notify or wait for a request to send data or modify parameter thresholds. Below is a detailed explanation of how this is achieved.

* The ground (GND) and supply (5V) pins of Arduino Uno was tapped to a bread board using wires so as to easily supply all the components required by the system without running short of pins.
* The LM35 has three pins (supply, ground and control pin). The supply pin is connected to the 5V supply created on the bread board and the GND pin was also connected to the GND. The input pin is connected to an analogue input pin (pin A0) of Arduino to read the temperatures at any given time. The analogue pin is used because the temperature can take many values (varies with time).
* The smoke sensor also has 3 pins, the supply pin is connected to the 5V supply source and the GND pin is connected to the GND source from Arduino. The input pin is connected to analogue pin 1 of Arduino (A1) for continuous reading of smoke levels in the surrounding.
* The liquid level sensor has 3 pins, the supply pin is connected to the 5V source and the GND pin is connected to the GND source from Arduino on the bread board using wires. The input pin was connected to analogue pin 3 of Arduino (A3) for constant reading of the fuel level.
* The PIR sensor has three pins, the supply pin is connected to 5V and the GND to the GND of Arduino whereas, the control pin is connected to the digital pin 12 of Arduino (D12) since it detects just two cases (if there is a human being or not).
* The buzzer has two pins, the GND pin is connected to GND on the bread board and the output pin is connected to the digital pin 13 (D13) of Arduino using wires on the bread board. This connection allows the for the buzzer to be turned on/off in case of emergency alarms automatically.
* The NPN transistor has 3 pins (emitter, base, collector), the emitter is connected to GND on the bread board, a 10kΩ resistor is connected the base a transistor and the 5V source is applied to this base through the resistor to limit the current going into it using digital pin 11 of Arduino (D6). A freewheeling diode is connected between the collector and the and the fan input pin in forward bias to prevent sudden voltage surges. The GND pin of the fan is connected to the GND source from Arduino on the bread board using wires. The fan can now be turned on/off by Arduino when need arises.
* A relay module has 3 pins, the input pin is connected to digital pin 6 of Arduino (6), the supply pin is connected to the 5V source on the bread board, the GND pin is connected to the GND. The relay is now connected to the bulb and supply using the NO (normally open) and COM points of the relay. This connected enables the Arduino to turn on/off bulb automatically when need arises.
* The 8 parallel pins of the 16x2 LCD is connected to the 8 parallel of the I2C and the 4 serial pins of the I2C which are; GND, VCC, SCL and SDA are connected to GND, 5V, A5 and A4 respectively. This enables Arduino to display the readings or actions going on in the site at base station system.
* A sim card was inserted into SIM900 and the which was then connect to pins 7 and 8 of Arduino to be used as receiver and transmitter pins respectively. Pins 7 and 8 of Arduino

## 4.3.2 Remote interpretation and control system

## 4.3.3 Communication protocol

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