

FIRE FIGHTING SYSTEM



By

GROUP BSE 17-40

EMBEDDED SYSTEM

DEPARTMENT OF NETWORKS

SCHOOL OF COMPUTING AND INFORMATICS TECHNOLOGY

**A Project Report Submitted to the School of Computing and Informatics Technology in
Partial Fulfillment of the Requirements for the Award of the Degree of Bachelors of
Science in Software Engineering of Makerere University.**

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Declaration

We, group BSE 17-40, hereby declare that the work presented is original and has never been submitted for an award to any university or institution of higher learning. We can confirm that where we have done consultations either from published material or the works of others, it has been attributed in this report.

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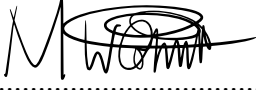
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Dedication

As a result of our work, we hereby dedicate it to all the people who helped us achieve its results successfully, our families have been of tremendous support to us financially, spiritually and otherwise, Mr. Mwotil Alex the project supervisor who without hesitation took time to share his knowledge on the various information technology fields making it possible for us to complete our project.

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Abstract

In the world today, firefighting is one of first priorities to any country or government for its survival. Fire outbreak is one of the biggest setbacks due to the enormous losses associated with it, the losses can be property or lives or monetary. In well developed countries, for example the United States, China and several European countries, etc. there exist advanced mechanisms of firefighting like, AFT portable water mist and CAFS systems. These give fire fighters a bigger advantage in the fight against fire.

However in low developed countries like Uganda and many African countries, without the above mentioned firefighting mechanisms, firefighting is very difficult and a very big challenge to these countries. Given the fact that they have gotten poor infrastructure i.e. Poor road networks for the movement of the fire brigade trucks to places that have caught fire, poor communication means of network, without advanced firefighting tools fire accidents remain a big problem to many places of these countries.

Firefighting system is an embedded system with GSM capabilities that uses sensors like the smoke detectors and fire sensors to detect fire, activate an alarm and also set off the water sprinklers of the building and then send a message to the nearby fire brigade department and other people responsible like the local authorities to rapidly respond, the message contains the location of the building, the time the fire started, how to switch off the system and an option to forward the message to different people. The system sends a message every after six hours to responsible people to counter reliability. The system automatically goes off when the temperature reduces to 'normal'.

Table of Contents

Declaration	1
Approval	2
Dedication	3
Acknowledgements	4
Abstract	5
Table of Contents	6
List of Figures	9
List of Tables	10
Abbreviations/Acronyms	11
Chapter 1	12
1 Introduction	12
1.1 Background	12
1.2 Problem Statement	13
1.3 Main Objective	13
1.3.1 Objectives	13
1.4 Scope	14
1.4.1 Subject/Theoretical	14
1.4.2 Geographical Scope	14
1.5 Significance	14
1.5.1 Significance	14
Chapter 2	16
2 Literature Review	16
2.1 Introduction	16
2.2 Classification of fires	17
2.3 Firefighting systems in existence	17
2.3.1 Fire Sprinklers	17
2.3.2 Fire extinguishers	18
2.3.3 Fire alarm pull station	19
2.3.4 Alerts	19
2.3.5 Fire Hydrant Pump Systems	20
2.3.6 M Fire Alarm systems	20
2.3.7 L Fire Alarm Systems	20
2.3.8 P Fire Alarm Systems	21
2.4 General weakness and gaps of the various systems	21

2.5 Conclusion	21
Chapter 3	22
3.0 Methodology	22
3.1 Introduction	22
3.1.1 Requirements Elicitation techniques	23
3.1.2 Reviewing Existing Documents	23
3.1.3 Interviews	23
3.1.4. Questionnaires	24
3.2 Requirement analysis techniques and tools	24
3.2.1 Interviews	24
3.2.2. Scenarios	24
3.2.3 Tools	25
Chapter 4	27
4 System Design and implementation	28
4.1 System Design	28
4.2 System Architecture	28
4.3 Decomposition Description	29
4.3.1 Input module	29
4.3.2 Output module	29
4.4 Design Constraints	30
4.5 Design Methodology	31
4.6 High Level Design	32
4.7 Conceptual design	32
4.8 Sequence Diagram	33
4.9 System Implementation	34
4.9.1 Implementation (coding and compilation)	34
4.9.2 Anomalies:	34
4.9.3 Utilities for validation and testing	34
4.9.4 Pseudo codes for the different functions of the system	34
Chapter 5	42
5 Presentation and Discussion of Results	42
5.1 Inspection and performance.	42
5.2 Test plan and performance	42
5.2.1 Test objectives	43
5.3 Precautions	43

5.3.1 Anomalous conditions	43
5.3.2 Precautionary steps taken.	43
5.3.3 Limitations and safety	43
Chapter 6	44
6.0 Conclusion, Recommendations and Future Works	44
6.1 Recommendations and future works	44
6.2 Lessons Learned	44
6.3 Conclusion	44
References	46
Sample questions used in the questionnaire	48

List of Figures

Figure 4.1.1 Architectural Design	29
Figure 4.1.4.1 High level design	32
Figure 4.1.4.2 Conceptual or Logical Design	33
Figure 4.2.1 components of the system	37
Figure 4.2.2 A screen shot showing messages sent when fire is being detected by the system	38
Figure 4.2.3 screen shot showing a call being made by the system	39
Figure 4.2.4 showing a screen shot when there is no fire being detected by the system	40

List of Tables

Table 1: Data that could be collected

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Table 2: Shows challenges and lessons learned.44

Table 3: Budget

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Abbreviations/Acronyms

V&V	Verification and Validation
IT	Information Technology
LED	Light Emitting Diode
LCD	Liquid Crystal Display
MTTF	Mean Time to Failure
SLDC	System Development Life Cycle
TCP	Transport Control Protocol
IEEE	Institute of Electrical and Electronics Engineers
POFOD	Probability of Failure on Demand
USB	Universal Serial Bus
GSM	Global System for Mobiles
MCU	Microcontroller Unit

Chapter 1

1 Introduction

1.1 Background

The Uganda fire brigade under the Uganda police force is responsible for providing fire control services for example quenching fire, educating the public about fire safety and how to handle some minor fire outbreak situations all over the country. Each district is entitled to have at least one department responsible for fire emergency handling. Mainly most buildings in Uganda are mandatory to have a fire extinguisher which is considered to be a primary means of fighting fire however it's of less significance in times of bigger fires hence the need for intervention of the Uganda Fire Brigade department. Currently the fire departments of building use a mechanism whereby if there is an emergency in a building a warning alarm is turn on for people in the building to vacate and the responsible people call the fire brigade. However this mechanism has proven to be less reliable in the essence of time since there has to be someone to call the fire department to come [1], in case there is no one at the time when the fire starts or in case there is no one who has gotten the numbers the fire can engulf the whole building.

However, technologies have to try and provide efficient methods in the fight against fire. Notably mobile applications [2] and embedded systems have been the leading technology employed in this field. These have led to great improvement in the field in terms of efficiency and handling emergency cases. Fire accidents go on to contribute a percentage of death rates in Uganda for every 100,000 people who die in Uganda 17.98 of them die just because of fire accidents [3] by 2014 but this value is expected to have increase because no good measures have so far been take.

Fire emergency calls received were 936 out of which 702 were actual calls handled, 173 incidents of fire emergency calls were handled before the arrival of Fire brigade and 61 false calls were responded to. Residential structures continue to have the biggest number of fires over 34 %, followed by commercial structures at 16% among others [4].

Electrical short circuits remain the single most identified cause of fire out breaks in Uganda due to habits like overloading power supplies, poor wiring, using poor quality electrical materials, structures not protected from power upsurges and fluctuations along with outright theft of power. During the period under review, 18,368 crashes were reported out of which 14.2% were fatal, 48.3% were serious and 37.5 % were minor in nature. There was a 7.6% decrease in the number of accidents reported in 2013 from 19,870 in 2012 to 18,368 in 2013 [4] Fatal accidents increased slightly by 0.2%, serious accidents reduced by 1.7% and minor accidents by 16.3%. There was a decrease of 4.1% in the number of casualties from crashes on Ugandan roads in 2013 in the period under review [4]. The total number of vehicles involved in crashes was 27,648. This is 10% less

than the vehicles that were involved in 2012. 283,114 traffic offenders were fined under the express penalty scheme for the various traffic offences [4].

Emergency of embedded systems provided a way of fight against fire in real time. The system in existence uses a smoke detector which then sounds an alarm then the building is evacuated after the responsible people call the fire department to come and put off the fire

1.2 Problem Statement

In the world today, firefighting is one of first priorities to any country or government for its survival, buildings' fire outbreak is one of the biggest setbacks due to the enormous losses associated with it, the losses can be property or lives or monetary [5]. In well developed countries, for example the United States, China and several European countries, etc. there exist advanced mechanisms of firefighting like, AFT portable water mist and CAFS systems. These give fire fighters a bigger advantage in the fight against fire.

In low developed countries like Uganda and many African countries, without the above mentioned firefighting mechanisms, firefighting is still challenge to these countries. Given the fact that there are still very many poor infrastructure i.e. Poor road networks for the movement of the fire brigade trucks to places that have caught fire, poor communication means of network, without advanced firefighting tools fire accidents remain a big problem to many places of these countries.

Given the fact that fire accidents need rapid responses an embedded system with GSM capabilities can be great tool at solving this problem. There is wide spread of mobile devices among Ugandans including the fire fighters, an automated notification to some of the fire fighters around the scene can be of higher advantage and other people responsible.

1.3 Main Objective

To develop an embedded system that is able to alert the owner of the building in case of a fire, put it off and also provide safety routes for the users of the system to escape.

1.3.1 Objectives

- i. To study the current firefighting systems in uganda and collect the different requirements for it
- ii. To synchronous the alarm system with the mobile number of the owner
- iii. To design and implement the fire alarm system.
- iv. To test and validate the system

- v. To deploy and maintain the system

1.4 Scope

1.4.1 Subject/Theoretical

The system was intended to tackle the epidemic of fire outbreaks in Uganda that have become rampant in most stored buildings in Uganda like commercial ones and those used by the schools and the banks through use of an embedded firefighting system that is automated in way that it's in position to detect the fire sound an alarm, trigger the sprinklers, shows the emergency exits on the building and automatically turns off the main power of the building in which its installed

1.4.2 Geographical Scope

The study was carried out and limited to organizations that are located in urban center's mainly the big towns of Uganda and other public places .the research was mainly done only to a few limited places that have become victims of the rampant fire outbreaks in Uganda especially the schools and the stored commercial buildings

1.5 Significance

1.5.1 Significance

The firefighting system implementation and use could have positive implications to different stake holders as enumerated below;

1. Users of the system

- i. To provide a reliable system that's is in position to automatically control fire outbreaks in stored building's especially schools and markets
- ii. To help users of the system be alerted in times when there is an outbreak of fire through a call or a text message.

2. The government of Uganda

- i. To help government have a greater understanding of epidemic of fire accidents hence ensuring that they make informed decisions on how to deal with the problem.
- ii. To help the government decide on which system is suitable for the different buildings in Uganda.

- iii. To help the government collect enough data about the different fire outbreaks in Uganda

3. Academia

- i. The findings of the project are to be used as a basis for further research by different scholars.
- ii. The development of the system is to enable the students to utilize and put in practice the enormous skills and knowledge required to solve an existing problem.

Chapter 2

2 Literature Review

2.1 Introduction

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products [6]. Contains flames and gases, a flame is a mixture of reacting gases and solids emitting visible, infrared, and sometimes ultraviolet light, the frequency spectrum of which depends on the chemical composition of the burning material and intermediate reaction products [6].

The flame is the visible portion of the fire [7]. If hot enough, the gases may become ionized to produce plasma. Depending on the substances alight, and any impurities outside, the color of the flame and the fire's intensity will be different. Fire needs three elements to ignite. These three elements are: Oxygen: When Oxygen in the air combines with flammable vapors given off by Fuels they create a form of heat at a molecular level. Then, a source of ignition (a match or spark, say) can cause it to combust. Without enough Oxygen, ignition cannot happen. In the opposite way, if there is too much Oxygen then the vapors won't be concentrated enough to ignite. The ratio of vapor to Oxygen is known as the 'explosive' or 'flammable' limit and is different for each gas or vapor.

Heat: Combustion occurs when flammable vapors mix with air (Oxygen) and are ignited by a spark or flame. Solids give off flammable vapor's by being heated. Certain solids such as paper or flour appear to ignite almost instantly [7]. This is because they give off vapors and reach a flammable temperature almost immediately. In fact, fine dusts dispersed in the air can

Explode because they give off vapors and ignite so quickly it appears to happen instantly.

Other solids like timber take longer to ignite because they are denser and so don't give off

flammable vapors so easily. Liquids are a bit different to solids. They are a lot runnier for a start

But, where solids need to be heated to give off flammable vapors, some liquids give off vapors even in cold weather. Fuel: Fuels can take almost any form: Solids like wood, fabric, rubber and plastic.

Liquids such as petrol, oil, cooking oil or even nail varnish remover.

Gases like propane, butane and 'natural' gas. Different fuels burn at different rates and with different intensities.

Fire Fighting, techniques and equipment used to extinguish fires and limit the damage caused by them. Firefighting consists of removing one or more of the three elements essential to combustion-fuel, heat, and oxygen-or of interrupting the combustion chain reaction [8].

The Uganda Police Force received a total of 936 Fire emergency calls out of which 702 were actual calls handled 173 incidents of fire emergency calls were handled before the arrival of Fire brigade and 61 false calls were responded to. Most of the fires were registered at Kampala Headquarters (562), followed by Rwizi (84), Kiira (47), Elgon (37) and Masaka (33) among other fire stations [7].

The number of people injured in the fire incidents increased from 28 in 2012 to 56 in 2013 while those who died in the incidents increased from 22 in 2012 to 62 in 2013.

Residential structures continue to have the biggest number of fires over 34 %, followed by commercial structures at 16% among others [7].

2.2 Classification of fires

The characteristics of fires and the effectiveness of extinguishing agents differ with the fuels involved. While particular extinguishing agents are very effective on fires involving certain fuels, they may be much less effective or even hazardous for use on other types of fires. Take for example, the use of a portable water extinguisher [8]. Water is a good extinguishing medium and is very effective on deep seated fires, such as burning wood or rubbish. However, a firefighter would not want to use a portable water extinguisher on a fire involving a “live” electrical panel or switchboard due to the conductivity of the water and the possible shock that could result. Considering the different types of fuels that may be involved in a fire, the different types of extinguishing agents available and the different mechanisms which the various agents use to extinguish a fire, it is important to be able to identify the type of fire on which a particular medium will be effective [8]. The job of selecting the proper extinguishing agent has been made easier by the classification of fires into four types, or classes, lettered “A” through “D”, and based upon the fuels involved. Within each class are fires involving those materials with similar burning properties and requiring similar extinguishing agents. Thus, knowledge of these classes is essential to efficient fire-fighting operations, as well as familiarity with the burning characteristics of materials that may be found aboard a vessel [8].

2.3 Firefighting systems in existence

2.3.1 Fire Sprinklers

Fire Sprinklers were invented in the United Kingdom by Major Harrison in 1864. But like so many good things invented in the UK it was left to be developed abroad by Henry Parmelee in the USA, who wanted to protect his piano factory. Automatic sprinkler systems are used more than any other fixed fire protection system and over 40 million sprinklers are fitted world-wide each year. Sprinkler systems have been proven in use for well over 100 years. Possibly the oldest in Britain was fitted in 1812 at the Theatre Royal Drury Lane and updated form is still in use today [9] [10]. A fire sprinkler system are a network of fixed water pipes supplied by two water sources with sprinkler heads fitted at recommended distances apart. Water can be supplied from a tank via pumps or from the town mains, providing the flow are sufficient and fill the pipes [9] [10]. Detector heads

are nozzles that direct a jet of water on to a deflector plate which defuses over a large area. The water is held back by a glass bulb or soldered strut which holds a plug in place. When heat is applied from a fire below, the glass bulb will burst, due to expansion of the liquid in the bulb, or the solder will melt, which then releases the plug and water flows through the sprinkler head [9]. The fire sprinklers though work fine have some weaknesses for example they lack a mode of communication with higher institutions responsible for fire [11].

2.3.2 Fire extinguishers

A fire extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situations. It is not intended for use on an out-of-control fire, such as one which has reached the ceiling, endangers the user to say , no escape route, smoke, explosion hazard, etc.), or otherwise requires the expertise of a fire department [12]. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire [12]. Fire extinguishers all work in much the same fashion, holding their contents under pressure and releasing them through a nozzle or horn when the operating lever is squeezed. The fire extinguishing agent inside works by removing one or more of the three things a fire needs to burn; oxygen, heat and fuel. [13] By removing the supply of oxygen, reducing the heat or reducing the heat around the fuel, a single fire extinguisher can extinguish a small fire in a matter of seconds [13]. When you squeeze the lever on the top of a non-gaseous fire extinguisher, you both open a valve to the nozzle and also release a highly pressurized supply of gas stored at the top of the extinguisher. This gas escapes and pushes out the extinguishing agent from the cylinder through the nozzle. In CO₂ fire extinguishers, the gas is held under tremendous pressure so it liquefies. When you squeeze the lever and release the pressure, the CO₂ rapidly expands into a gas again [13]. The fire extinguisher works in the following conditions: you know that the extinguisher is suitable for use on the flammable materials involved in the fire; you have considered whether electricity is possibly involved and, if so, that the available extinguishing agent is non-conducting; you can extinguish the fire quickly; you are not putting your safety at risk by staying in the vicinity of the fire; and all other persons have been evacuated from the area [14]. The fire extinguisher has some weakness which include the following; It causes irritation on contact with skin; It causes irritation and discomfort on contact with eyes; and It causes breathing discomfort on inhalation [15]. The other weakness of these fire extinguishers is that the handle limited classes of fire for example foam extinguishers are suitable for class A and Class B [13], ABC powder extinguishers are suitable for class A, class B and class C [16]. The fire extinguisher needs an operator to be readily available to use it in case there is a fire outbreak.

2.3.3 Fire alarm pull station

A fire alarm pull station is an active fire protection device, usually wall-mounted, that, when activated, initiates an alarm on a fire alarm system. In its simplest form, the user activates the alarm by pulling the handle down, which completes a circuit and locks the handle in the activated position, sending an alarm to the fire alarm control panel. After operation, some fire alarm pull stations must be restored to the ready position using a special tool or key in order to deactivate the alarm sequence and return the system to normal [16]. Primitive manual stations, requiring only a single action or hand motion to activate, can be subject to unwanted activation by jarring or accidental contact. Early strategies to cope with this problem included requiring the operator to break a pane of glass to release an internal spring-operated mechanism. Manual pull stations that require two hand motions, such as lift up and pull down, or push in and pull down, have since replaced the break-glass and single-action models in many modern installations[16].

2.3.4 Alerts

Alerts are used to control fire in case of an outbreak, when an alarm is triggered, there are a number of different methods for notifying those in the building of danger [17], the fire alerts may be in form of: bells, powered by a 12- or 24-volt DC current, bells are only designed for areas where they can be clearly distinguished from similar sounds. A school, for example, would not use this type of notification as it would be too close to the bells that signal a change in classes [17]; horns, far more common than a bell, this type of alarm provides a louder and far more distinct style of alert. Found in almost every office building and industrial facility in the world, horns come in a variety of shapes and sizes, including surface-mounted, flush-mounted, and semi-flush mounted, not to mention trumpet style [17], they provide notification through either continuous vibration or electronic signal; sirens, one of the most effective levels of alert is provided by sirens, though they are almost exclusively relegated to emergency notification. In general, sirens are often mounted to the exterior of buildings or used within loud environments such as machine shops or other facilities that run noisy machinery [17], these systems are not of use to people with disabilities such as the deaf; Strobe lights Strobes emit a high intensity flash of light in short durations that signals alarm. In some cases, the flashes are emitted in sequence to guide people to the nearest exit. Strobe lights are incorporated into fire alarm systems for a couple of different reasons, the first of which is to get attention. In large manufacturing facilities or areas where employees wear hearing protection, an audible alarm may not be enough to notify everyone of danger. The quick successive burst of a strobe light quickly grabs attention in almost any setting. The second reason they're used is to direct people during low-visibility situations, a smoke-filled room being a common example [17], one of

the weakness of strobe lights is they don't sent automatic signals to the fire department and they may not be of use to people with disabilities such as the blind. Strobe lights are available in a wide range of intensities and as a wall- or ceiling-mounted unit. It's worth noting that if you have a large area, you will be required to either have a greater quantity of lights interspersed throughout the floor plan or fewer lights that emit higher intensity flashes [17].

2.3.5 Fire Hydrant Pump Systems

Fire hydrant pump systems are high pressure water pumps designed to increase the firefighting capacity of a building by boosting the pressure in the hydrant service when mains is not enough, or when tank fed. They can also be used in water transfer and irrigation applications , they are installed in buildings to help firefighters quickly attack the fire. Essentially, a hydrant system is a water reticulation system used to transport water in order to limit the amount of hose that firefighters have to lay; thus speeding up the firefighting process. Fire hydrants are for the sole use of trained firefighters (which includes factory firefighting teams). Because of the high pressures available serious injury can occur if untrained persons attempt to operate the equipment connected to such installations [18] Fire hydrant systems sometimes include ancillary parts essential to their effective operation such as pumps, tanks and fire service booster connections. These systems must be maintained and regularly tested if they are to be effective when needed [18].The placement of such equipment needs to closely interface with fire service operational procedure; simply complying with deemed to satisfy code provisions is a potential recipe for disaster. For any advice regarding these systems, old or new, please ask the intended users; contact the Community Safety Department [18].

2.3.6 M Fire Alarm systems

These comprise Manual Call Points where recommended and raise the Alarm throughout the building, usually found on escape routes staircases et cetera. There is no Automatic Fire Detection built in and is operated by someone raising the alarm [19]. The major weakness of this system is that it depends on existence of a nearby individual during the fire incidence

2.3.7 L Fire Alarm Systems

These are concerned primarily with preserving life, and enabling all occupants other than those immediately affected by the fire, to make good their escape from the building. There are several categories within the L system identified as L1 through to L5 (lesser). The sub categories denote the type of Automatic sensors, sirens and beacons to be fitted and where [19].

As these systems are designed primarily to evacuate the building and prevent loss of life/injury then the system may not automatically call for the brigade and protection of property is dealt with by:

2.3.8 P Fire Alarm Systems

These denote an Automatic Fire Detection System installed to take on the additional task on not only preserving life but protecting the building and contents as well when the building is quite and unoccupied. The system should automatically dial out to the Brigade as a matter of course. Again there are various sub categories from P1 to P5, where the type of protection from the sensors used may be varied [19].

2.4 General weakness and gaps of the various systems

- i. Lack of Anti-RF interference design, easy to cause false alarm or omit alarm. From my experience on testing majority of wireless security system from other supplier, some of products may cause false alarm when using cell phone with the distance of one meter between alarm systems but in our fire alarm system, the alarm will only go on in case of detection of fire or detection of smoke which makes it reliable.
- ii. Confidential problem, most of Chinese made wireless alarm systems adopt 2262 remote control chip, 3 to the 8th power (6561 unique addresses), with the high ratio of duplicate addresses. Also this addresses likely to duplicate via scan method, with high security risk. Few products are using learning code and rolling code to increase the confidentiality of wireless transmission.
- iii. Alarm Delay, for reduce the power consumption, almost of wireless detectors adopts alarm delay function, that means after one time of trigger, the detector will not be triggered among 2-4 minutes, intruder only need to interfere the sensor, then got enough time to damage the alarm system.

2.5 Conclusion

In summary, a number of attempts have been made to address the challenge of firefighting in Uganda. Based on our review of the different attempts, it is clear that much effort is still required to develop a reliable, secure and cost effective firefighting systems.

Chapter 3

3.0 Methodology

3.1 Introduction

This section describes the step by step process followed to achieve the project's specific objectives. The study involved both qualitative and quantitative methods. This is because the research required people's views and opinions, and analysis of documents:

The data was collected in different ways including interviews with the different stakeholders for

example the alarm system home owners , the police and firefighters, surveys were used to study the way the population would like the system to be.

3.1.1 Requirements Elicitation techniques

This involved different methods that were used in collecting and analyzing information about the system that we developed in order to acquire the necessary user requirements. During this phase we were able to investigate the problems that the people were facing in locating places where they could receive services. Methods we used included: Questionnaires, Reviewing existing documents, and interviews.

3.1.2 Reviewing Existing Documents

We reviewed the existing literature ranging from relevant text books, dissertations, magazines and the internet in order to gather as much data as possible about the research subject in question. This assisted us in developing a well-documented and perfectly understood system that guided us in learning about the procedures, regulations and standards.

The reasons for using this technique was that there was no need of time commitment.

The cons is that the day to day working differed from documented procedures

3.1.3 Interviews

This involved holding face to face interactions with some of the particular system stakeholders such as companies that are going to be integrated with the system. Interviews were carried out by a group of selected group members.

The objective was to collect firsthand information about the system that was developed, encouraged people to respond due to the direct interaction with them which also made the exercise more pleasurable, verified facts, and identified requirements of the system

The short comings with using interviews are that; time consuming and getting time to arrange the interviews without letters from the university

3.1.4. Questionnaires

This is a well-established technique for collecting and analyzing demographic data and users' opinions for users in different localities.

The advantage with this technique was that it was distributed to a large number of people at a lower cost hence a wide general opinion and they also helped to clarify and deepen understanding.

The weaknesses with this technique are; the response rate is low, responses could not be what you wanted

3.2 Requirement analysis techniques and tools

The findings were discussed to enable us get a variety of perspectives on the data. The aim of this is to begin structuring and recording descriptions of requirements. This involved the different techniques and tools that we used to assess and analyze the collected data for the proper development of the proposed system.

In our effort to analyze requirements, we used Qualitative methods of research and analysis to provide added value in identifying and exploring intangible factors such as cultural expectations, gender roles, ethnic and religious implications and individual feelings about the project.

The techniques we used included

3.2.1 Interviews

Vital information was drawn from the results of the interviews which aided in coming up with the system specification, the interviews were mainly done at the Uganda house in Kampala since it was the latest victim of fire outbreak at the time the research was undertaken. In the interviews the interviewees were asked to state what might have been the root cause of fire, the existing methods that were available at the time the fire engulfed the building, how long did it take for them to put it off and whether the users of the building had knowledge of how to deal with fire emergencies.

3.2.2. Scenarios

A scenario is an informal narrative description that describes human activities or tasks in a story that allows exploration and discussion of contexts, needs, and requirements. It does not explicitly describe the use of software or other technological support to achieve a task. Using the vocabulary and phrasing of users means that the scenarios can be understood by the stakeholders, and they are able to participate fully in the development process, scenarios like the previous fire outbreaks of Owino market were considered and used in the research

3.2.3 Tools

The different tools used have been chosen depending on the following factors;

- i. **Available** meant that the tool is immediately ready for use and could help us in the development process of analysis and design environments.
- ii. **Robust** demanded that the tool is runs without major bugs, as well as easy to maintain and upgrade.

- iii. **Understandable** implies that the tool is easy to learn and we understand the role of the tool in requirements engineering.
- iv. **Scalable** means the requirements engineering tool can handle projects of different sizes.
- v. **Expandable** tool allows easy addition of new functionality to support new techniques and new methods.

The different tools that we shall use with reference to the above characteristics

Text editor

A text editor usually has the program and the data of the program located in the same computer and that program takes responsibility to create, display, save, and change the data.

The reasons for the choice are that; it is simple, easy to use, and relatively low cost, requirements documented in textual format can be easily delivered to stakeholders for review and also facilitates user involvement.

Strengths of qualitative research

The main strengths of qualitative data collection that, it provides;

- i. rich and detailed information about the intended application users
- ii. perspectives of specific social and cultural contexts (i.e. the human voice of the disaster)
- iii. inclusion of a diverse and representative cross section of different persons
- iv. in depth analysis of the user problems
- v. a data collection process which requires limited numbers of respondents
- vi. a data collection process which can be carried out with limited resources.

Weaknesses of qualitative research

Weaknesses inherent in qualitative data are that it:

- i. results in data which is not objectively verifiable
- ii. requires a labor intensive analysis process (categorization, recoding, etc.)
- iii. needs skilled interviewers to successfully carry out the primary data collection activities.

3.3 System Design Techniques and tools

We used Unified Modeling Language where we developed use cases, high level diagrams, and conceptual diagrams since it is a notation that was going to be used to build an object oriented system. We assigned responsibilities to classes of objects, showed how objects interact and what classes did.

Use cases

Our use cases, stories were written to describe the related domain process, showing the actors and how they will be interacting with the system. These describe how a system will be used to fulfill a particular.

3.4 system Implementation

- i. For implementation in terms of code, we used Arduino Integrated Development Environment (IDE). This provides an environment for writing, debugging, compiling the source code and uploading it to the hardware.
- ii. Proteus. This was used as a development tool to assemble the system components and simulating the system.
- iii. We used smoke sensor to determine the threshold frequency of the smoke beyond which it should be detected.
- iv. GSM module. We used a GSM sim900 to send messages to the mobile user indicating the presence and absence of methane gas produced by E-coli bacteria in water.
- v. A number of selected jumper wires to enable us connect the components to the Arduino micro-controller.
- vi. We used two motors one to represent the actuator and the other to represent the elevator
- vii. We sued a buzzer for illustrating a motor

3.4.1 Anomalies

- i. We experienced freezing of the Arduino IDE when opening up more than one instance of the application. This occurs when the serial COM port is busy.
- ii. The bsmoke sensor took long to detect the smoke

3.5 System Testing and Validation

The system was tested using active testing, a testing technique, where the user introduces test data and analyses the result. During active testing, a mental model of the software under test is built which continues to grow and refine as the interaction with the software continues.

Active Testing is done at the end of each and every action performed on the application under test, there is need to check if the model/application fulfills the client's needs. If not, the application needs to be adapted, continuous engagement in the testing process helps to come up with new ideas, test cases, test data to fulfill. At the same time, there is need to note down things, which will be turned on later or to follow up with the concerned team on them, eventually finding and pinpointing

problems in the software. Hence, any application under test needs active testing which involves testers who spot the defects [20].

Chapter 4

4 System Design and implementation

4.1 System Design

Firefighting system is an embedded system with GSM capabilities that uses sensors like the smoke detectors and fire sensors to detect fire, activate an alarm and also set off the fire sprinklers of the building and then send a message to the nearby fire brigade department and other people responsible like the local authorities to rapidly respond, the message contains the location of the building, the time the fire started, how to switch off the system and an option to forward the

message to different people. The system sends a message every after six hours to responsible people to counter reliability

It is mainly composed of three modules namely;-

I. System processing unit

This module is used to manage and control all the activities of the firefighting system it receives information from the input module and act accordingly

II. Input Component

This module is composed of the various sensors that are used on the system for example the smoke detectors which starts the whole mechanism of the system

III. Output module

This module is composed of actuators that are the fire sprinklers, the fire alarm and the GSM it's with in this module that a response is taken after getting information from the input devices and also the power of the building the system is contained.

4.2 System Architecture

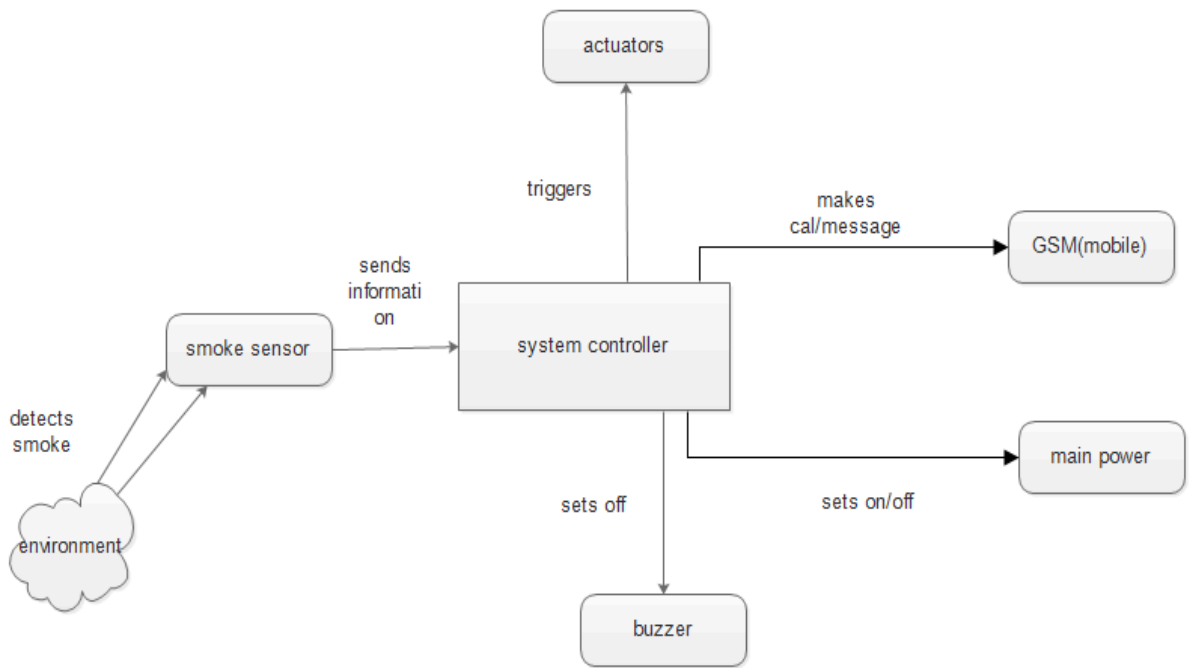
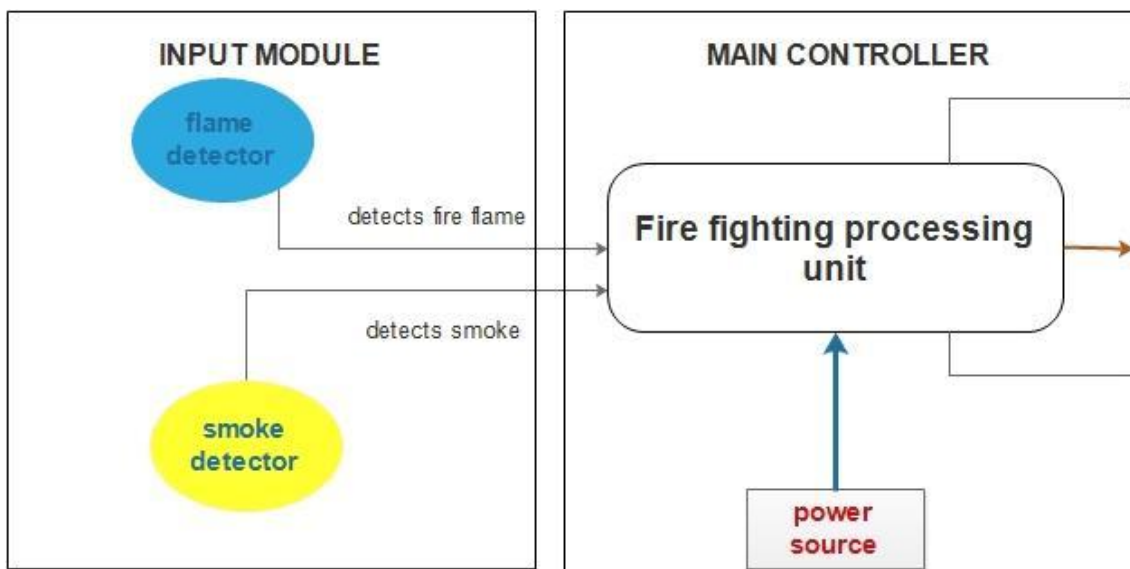


Figure 4.1.1 system architecture

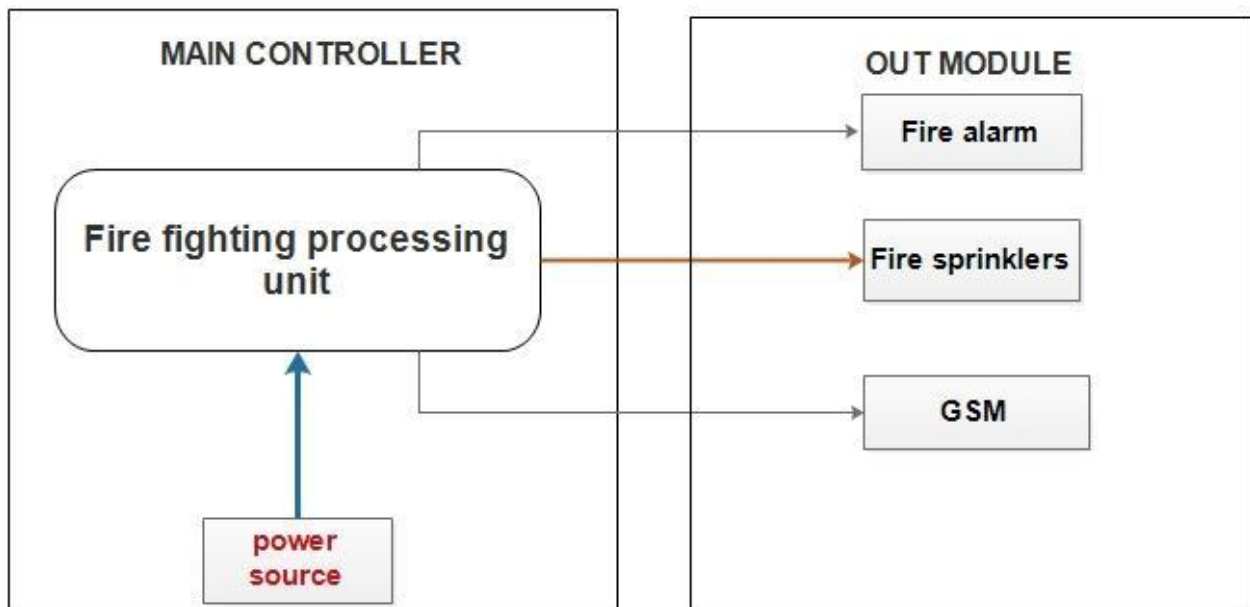
4.3 Decomposition Description

4.3.1 Input module



3.2.1 Input module

4.3.2 Output module



3.2.2 Output module

4.4 Design Constraints

The reliability of the system entirely depends on the good communication network for proper messaging and making of calls other constraints include independent reliable power and water supply.

Assumptions

- i. The system uses an external source to power it on
- ii. The system does not receive any information from the users, rather it always sends information to its users after a given interval of time.
- iii. The system assumes that it will always be available in all the condition, and the system can neither automatically switch off nor switch on itself.
- iv. The fire threshold will have a smoke level enough to be detected by the system in case of any fire incidence.
- v. Any smoke detected by the system is caused by fire not any other kind of smoke source.
- vi. There is always at least one of the users of the system who can monitor any event that goes on with the system.
- vii. The system is only applicable in condition where the flames of fire are causing smoke, in conditions of smokeless fire, the system may not work well.

Limitations

- i. Smoke/flare sensors are not in position to differentiate between smokes from tobacco smokers to that of real fire, the system alarm could be set off on unnecessary occasions.
- ii. The system is not in position to be manually switched off from a distant control, the operator has to physically switch it off.

4.5 Design Methodology

Scrum development method of agile methodology was used in the design and the implementation of the system. Initially we submitted our proposal (which included the name of our project, what it was meant to do and to whom it was supposed to deliver the services specified) which was reviewed by our supervisor several times and concluded that it was conclusive to the requirements then requirements specification document for the proposed system was formulated and was reviewed again by the supervisor who gave us the green light to go ahead with it the design document of the system which was produced basing on the SRS that was formulated earlier. After confirmation of all the specifications

The first sprint was done with in the three weeks it involved the acquisition of devices testing of the devices and the initial coding of the system started ,the milestones after the sprint were delivered to the supervisor for review .several changes were recommended by the supervisor then a second sprint was started it involved in several system testing and validation then again after two weeks the iteration was delivered to the supervisor for more reviews then last sprint was started that involved system testing, verification, validation and quality testing then it was brought back to the supervisor for review and for presentation.

4.6 High Level Design

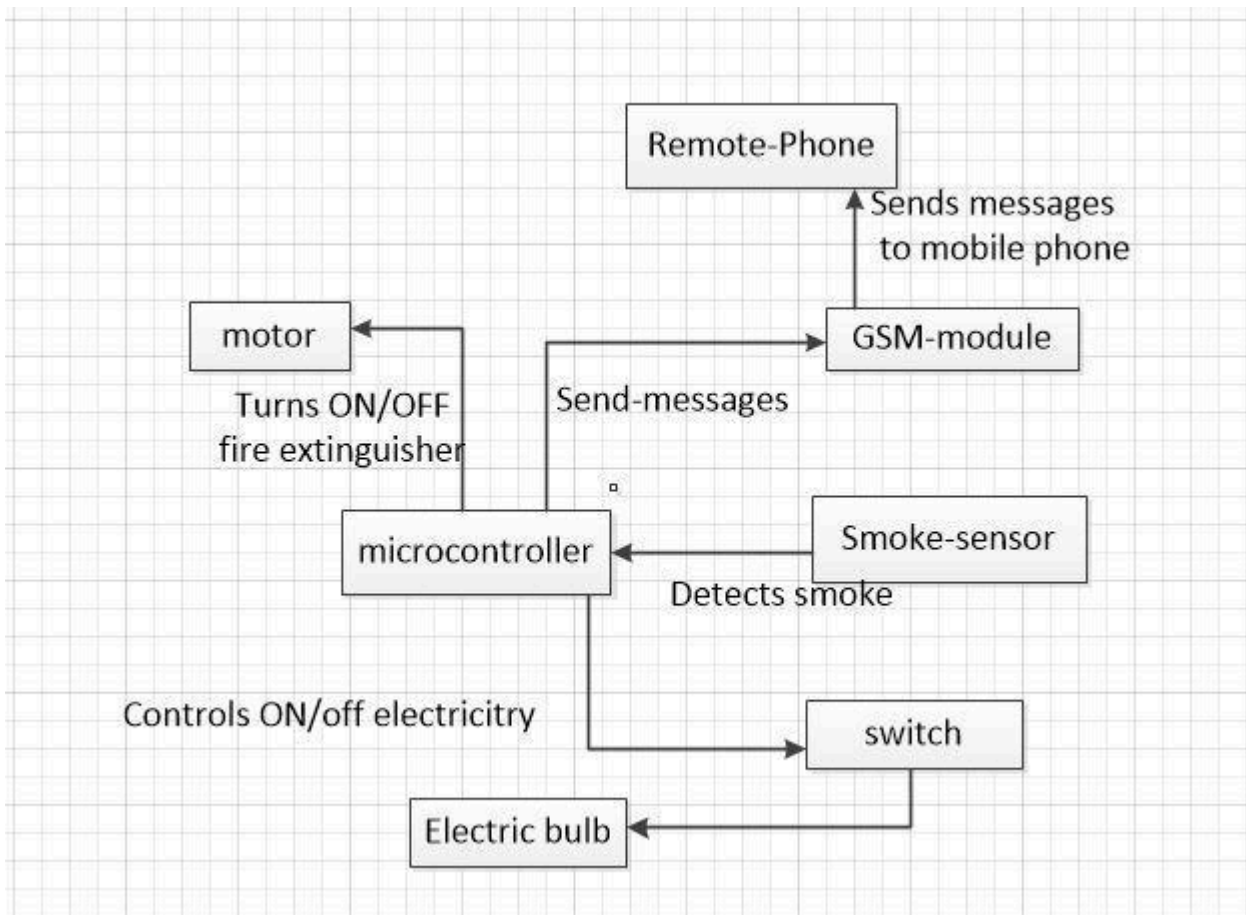
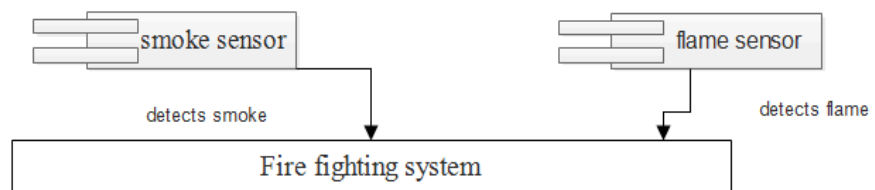


Figure 4.1.4.1 High level design

4.7 Conceptual design

IN PUT



OUT PUT

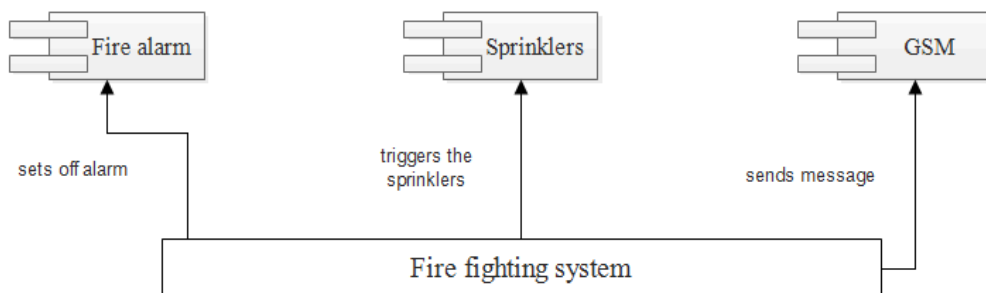


Figure 4.1.4.2 Conceptual Design

The system architecture is composed of mainly three modules the input, output and the main controller there are basically two sensors at the input module that is the smoke and the flame sensors which ignite the main controller to trigger the fire sprinklers and fire alarm also GSM module is set off to send and receive messages to the users phone all these are part of the output modules

4.8 Sequence Diagram

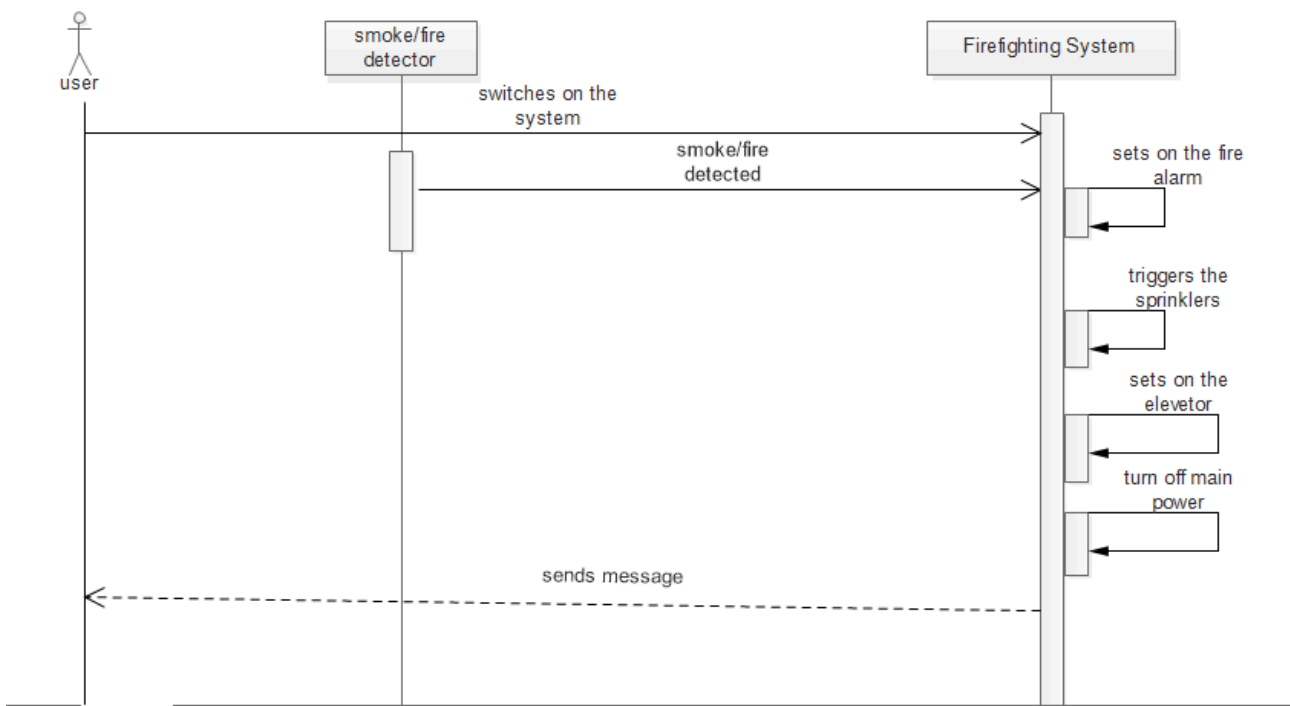


Figure 4.1.4.3 Sequential diagram

The user switches on the system through powering it on, an external power source is used on the system, when smoke is detected that is above the threshold level the system switches off the main power of the building in which it is installed in then it triggers the buzzer and the motors (sprinklers and elevators) and a message is sent to the user then after five minutes the system calls the user

4.9 System Implementation

4.9.1 Implementation (coding and compilation)

- viii. For implementation in terms of code, we used Arduino Integrated Development Environment (IDE). This provides an environment for writing, debugging, compiling the source code and uploading it to the hardware.
- ix. Proteus. This was used as a development tool to assemble the system components and simulating the system.
- x. We used smoke sensor to determine the threshold frequency of the smoke beyond which it should be detected.
- xi. GSM module. We used a GSM sim900 to send messages to the mobile user indicating the presence and absence of methane gas produced by E-coli bacteria in water.
- xii. A number of selected jumper wires to enable us connect the components to the Arduino micro-controller.
- xiii. We used two motors one to represent the actuator and the other to represent the elevator
- xiv. We used a buzzer for illustrating a motor

4.9.2 Anomalies:

- iii. We experienced freezing of the Arduino IDE when opening up more than one instance of the application. This occurs when the serial COM port is busy.
- iv. The smoke sensor took long to detect the smoke

4.9.3 Utilities for validation and testing

- i. The utilities, which were implemented to assist in validation, testing and specification of the test environment include;
- ii. Arduino IDE- this was used to test the code to make sure that it has no errors.
- iii. Proteus – this was used for simulation of the system. This tool has library components like Arduino, GSM module and gas sensor that were corresponding to the system.

4.9.4 Pseudo codes for the different functions of the system

4.9.4.1 Register user functionality

Get user's details,
Store the user's details.

4.9.4.2 Send location functionality (sendLoction)

If alarm is on

 Get number of nearest fire department,

 Get location of the place,

 Send location details of the place.

End if.

4.9.4.3 Sense fire functionality (sense Fire ())

If fire on is true

 Trigger alarm on (Trigger Alarm ())

 Trigger sprinkler on (Trigger Sprinkler ())

 Trigger gsm on (Triggers ())

End if

Fire On is false.

4.9.4.4 Trigger alarm functionality (Trigger Alarm)

Alarm is off,

Change alarm to on.

4.9.4.5 Trigger sprinkler functionally (Trigger Sprinkler ())

Sprinkler is off,

Turn on sprinkler.

4.9.4.6 Trigger gsm functionality (Triggers ())

Gsm is off,

Turn on GSM.

4.9.4.7 Alarm ring functionality (Ring ())

For Alarm on

 If trigger Alarm is true

 Turn Alarm on

 End if

End for

4.9.4.8 Sprinkler fire functionality (sprinkle ())

If Trigger Sprinkler is on

 Turn on sprinkler

End if

4.9.4.9 Send simple message (send Message)

Name of the place

Phone number of the place

If Triggers is true

 Send Name of the place, Phone of the place

End if

4.9.4.10 make a call (make call)

Name of the place

Phone number of the place

If Triggers is true

 Send Name of the place, Phone of the place

End if

The initial state of the system, the figure below is a representation of the Firefighting System, showing all the devices connected to the system, the other figures show sms messaging on user's phone

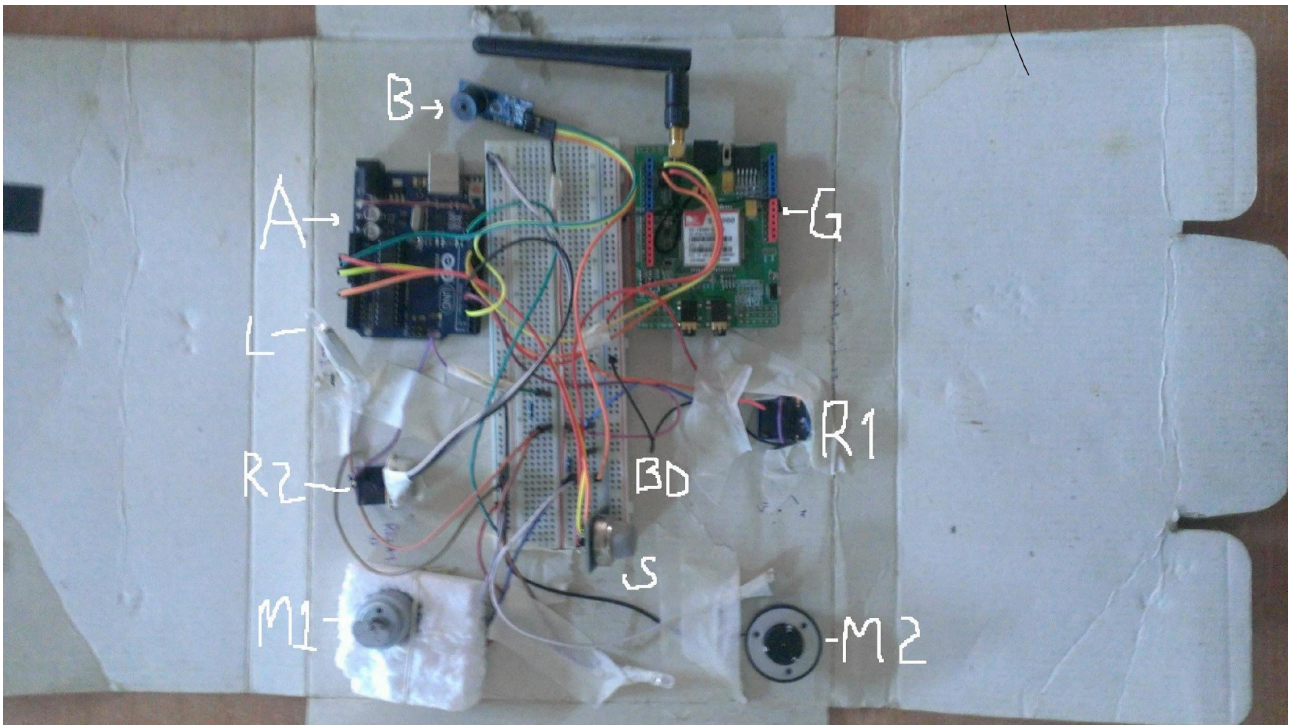


Figure 4.2.1 components of the system

System components explained in detail

A- Arduino(micro controller); its responsible for taking all the necessary actions of the system it determines which action to take place at a given time

B- Buzzer; it's the alarm of the system

G-GSM; it's for sending messages and making calls

L-lamp; it illustrates the main of the building that the system is installed

M2-motor; it shows the actuators of the building, which are the fire sprinklers

M1-motor; it illustrates the elevator of the building

BD-breadboard; it's used for giving more support for connection of the different devices on the micro controller

R1&R2-relay switches; they are all used for the control of motors and

S- Smoke sensor, it's used to detect the presence of smoke in the environment

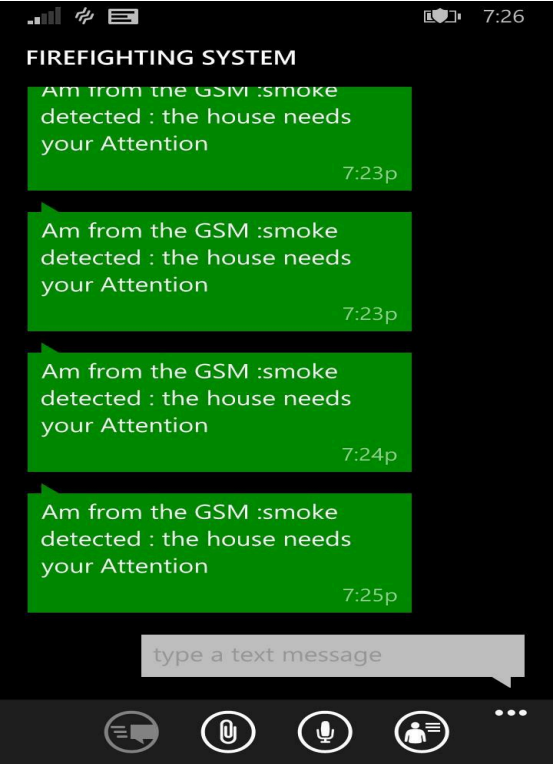


Figure 4.2.2 A screen shot showing messages sent when fire is being detected by the system

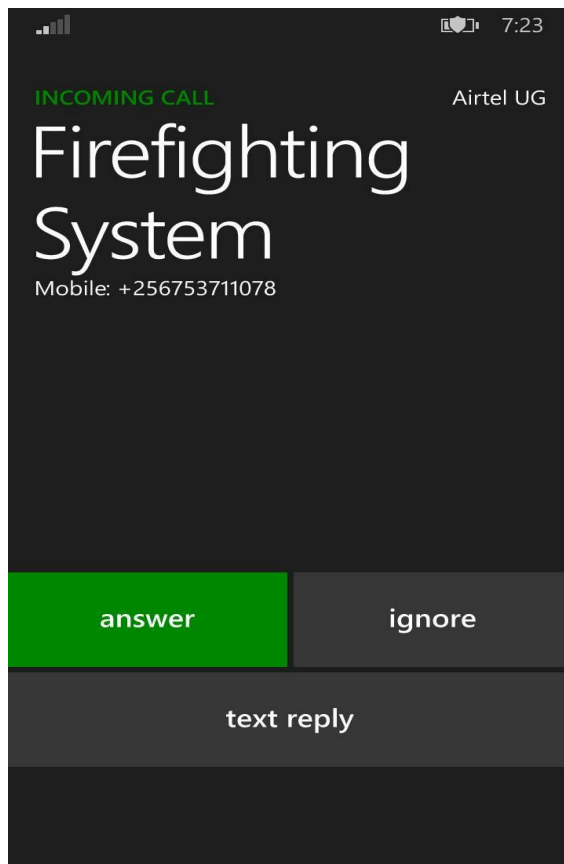


Figure 4.2.3 Screen shot showing a call being made by the system

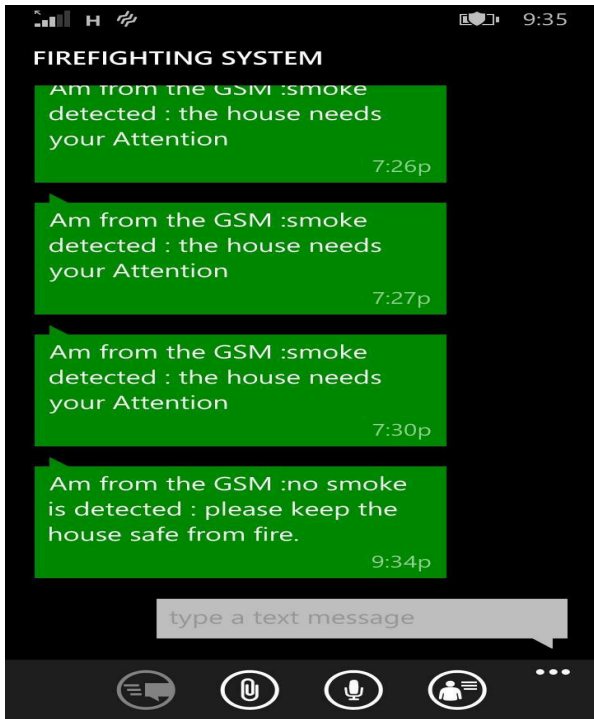


Figure 4.2.4 showing a screen shot when there is no fire being detected by the system

Table below shows data that could be collected

DATA	ATTRIBUTE	DESCRRIPTION	TYPE
GSM module	Mobile phone screen	It's for sending an alert about the occurrence of fire.	String
Fire sensor	Flame detection	This will be used to detect the presence of fire.	Int
Smoke sensor	Smoke detection	This will be used to detect the presence of smoke	Int
Motor	Sprinklers	This will be used to represent the turn on and off of sprinklers.	Int
LED Lights	Fire alarms	This will be used to show the occurrence of fire through an alarm	Int
System's status	LCD screen enable	Shows all the previous activities that happened to the system from a given period of time	String

Table 1: Data that could be collected

Chapter 5

5 Presentation and Discussion of Results

5.1 Inspection and performance.

For the inspection part, good programming practice, change control reviews and reports were inspected and approved.

5.2 Test plan and performance

Testing was done for the different requirements of the system or the functions to be provided by the system. It included the following;

What to test	What to expect	How to do the testing
Gas detection	Analog values displayed on the serial monitor	Testing was done by exposing the sensor onto smoke to determine the threshold value.
Motor rotation	The two motors should be able to rotate	Testing was done when the threshold gas level exceeded the normal level that was set
Lights on/off	The lights are supposed to go on and off	Testing was done by lowering the gas level to ensure that the lights go on and also tested to go off every time the threshold is increased
Calling the responsible user	The mobile user is expected to receive a call when a smoke exceeds the normal threshold	Testing was done by the GSM module which uses the GSM network.
Sending SMS notifications to the mobile user.	The mobile user is expected to receive a notification SMS on his or her mobile phone before and a after the gas has been detected.	Testing was done by the GSM module which uses the GSM network.

Table 4.2 showing the test plan and performance.

5.2.1 Test objectives

The following were the objectives for carrying out the testing;

- i. Finding defects and bugs which may have been created while developing the software.
- ii. To make sure that the end product met the user requirements.

5.3 Precautions

5.3.1 Anomalous conditions

The gas sensor had some delays in detecting the different gas level and also the SIM card used in the firefighting system was sometimes slow due to network and technical problems. This may delay a call or the display of results information of a message on the mobile user's phone.

5.3.2 Precautionary steps taken.

The Arduino software is made to avoid freezing and data loss risks by securing the host computer with anti-virus software to avoid data corruption and also ensuring that the host computer to the system is supplied with sufficient RAM to facilitate the processes.

5.3.3 Limitations and safety

- i. Power supply limitations: The system requires constant power supply and it uses PC battery as its power supply.
- ii. Network availability: The system needs good network coverage for it to send an SMS and also make calls to the mobile phone yet there is a possibility of network loss in some places.
- iii. Payment of the SMS: The system must have a SIM card that has airtime on it for it to send an SMS.

Chapter 6

6.0 Conclusion, Recommendations and Future Works

6.1 Recommendations and future works

This document was describing the implementation of firefighting system. We identified that the work done both during analysis and implementation of the system is by no means complete. We therefore recommend that the future versions of firefighting system should have databases for keeping the information about the different times when the fire cases erupted to ensure that the firefighting organizations can determine how to curb the fires and make certain guidelines

6.2 Lessons Learned

Challenges	<ul style="list-style-type: none">• The biggest challenge was beating the strict deadlines set for project milestone delivery.• The challenge of acquiring the different devices like the sensors most of the devices were very expensive and hard to find.
Lessons learned	<ul style="list-style-type: none">• We have been able to learn and acquire much more knowledge about the embedded system world works• We have been able to embrace the power of teamwork and the strength in interpersonal communication.

Table 2: Shows challenges and lessons learned.

6.3 Conclusion

This project was a continued research solution to many that are in existence in Uganda about how to curb fire emergencies but we mainly focused on reliability of the system, we viewed this project as a journey where we learnt many lessons and gained some insight into the subject that we tried to address in this report. Therefore, the development and implementation has been a great experience

of research and improvement of our skills in problem solving through use of the different techniques of information technology. Due to the limited time we were unable to produce a much better version of the system but we are confident that in the future a much better system with various features can be developed.

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Sample questions used in the questionnaire

1 What are the several means you use to communicate in case of a fire outbreak in your area?

.....
.....
.....

2 Briefly talk about the application that you are familiar with and how frequently do you frequently use it?

.....
.....
.....

3 How do you find the application? (mention in Qn2 above)

.....
.....
.....

4 Do you find any problems using this application? (Tick the appropriate box)

Yes No

4 (b). If yes, list them

.....
.....
.....
.....

5 How would you like these problems to be solved?

