

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

MOBILE APPLICATION TECHNOLOGIES IN
FOOD SUPPLY CHAIN

BY

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**A Dissertation submitted to the University of Zambia in partial
fulfilment of the requirements for the award of the degree in Masters
of Engineering in ICT Regulation, Policy and Management**

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DECLARATION

I, the undersigned, declare that this has not previously been submitted in candidature for any degree. The dissertation is the result of my own work and investigations, except where otherwise stated. Other sources are acknowledged by giving explicit references. A complete list of references is appended.

Signature:

Date:

CERTIFICATE OF APPROVAL

This document prepared by is approved as fulfilling the requirements for the award of the degree of Masters of Engineering in of the University of Zambia

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DEDICATION

I dedicate this research to my loving wife, Gorret Chayuma Phiri for her untiring support, together with my children, Zilose, Stella, Almakio, Gloria Arianna and especially my daughter Deborah Tadala Phiri, who was born during the time I was writing this document. And not forgetting aunt Chrisbel Chileshe and the entire family for their support.

GLOSSARY

Abbreviation	Description
AMPS	Advanced Mobile Phone System
ASD	Adaptive Software Development
BREW	Binary Runtime Environment for Wireless
CDMA	Code Division Multiple Access
FOMA	Freedom of Mobile multimedia Access
GPRS	General Packets radio Systems
GPS	General Packet Radio Services
GSM	Global System for Mobile Communication
HTTP	Hyper Text Transfer Protocol
ICT	Information and Communication Technology
iDEN	Integrated Digital Enhanced Networks
LTE	Long Technology Evolution
RFID	Radio Frequency Identification
SDLC	System Development Life Cycle
SMS	Short Message Service
TDMA	Time Division Multiple Access
UML	Unified Modelling Language
URL	Uniform Resource Location
WML	Wireless Mark-up Language
WSN	Wireless Sensor Network
WSN	Wireless Sensor Network
www	World Wide Web
ZNFU	Zambia National Farmers Union

ABSTRACT

The use of ICTs by way of developing mobile applications can go a long way in improving the small scale farmers and traders' participation in trade. A mobile application that can be used by cooperatives to link traders and farmers, can reduce the need to travel in order to gather the agricultural commodities from rural areas, which can result in reduced exposure to road traffic accidents, loss of cash, lives and commodities. On the whole, reducing the cost of doing business and thus making peasant agriculture profitable. A survey was carried out at Soweto market in Lusaka and Libuyu market in Livingstone, where small scale traders and farmers were targeted. Questionnaires were distributed and oral interviews are carried out. It was found that 35.25% of the total number of respondents obtained their food commodities from outside their locality. This is one of the reason to establish the Food Supply Chain. The risks of not establishing a Food Supply Chain were seen from the results of the survey. These included risks associated with travel, where 30.5% of the respondents lost food commodities, and 91.6% traveled with large sums of cash. It was also found that 50.4% of the respondents use mobile money facilities and 75.25% use mobile phones when trading. The data show that the development of a mobile application was viable and would yield desirable results. A mobile application, called Smart Trader System was developed using a server which was connected to a modem. This system interacts with the mobile phone for the traders via SMS. The system was developed using NetBeans Integrated Development Environment, MySQL database and java development kit for windows. It has been implemented and tested. This application will go a long way to reducing the cost of doing business among the farmers and traders, who may be remotely located.

Keywords: Mobile Application, Smart trader System, Traders, Farmers, SMS.

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CHAPTER ONE:

INTRODUCTION TO THE RESEARCH

1.1 Introduction

Information and Communication Technologies (ICTs) have taken centre stage in our day to day lives. They have found use in education, health [1], agriculture [2], [3], commerce [4], [5] and trade. The need to harness information that has to be shared in order to improve the livelihood of mankind cannot be over emphasised [6]. Innovations have come up that are solving real life problems [7], [8], such as mobile money, which is a solution to sharing of money with parties in remote areas, at an instant, without the need to travel. Cashless transactions are now possible and all this is owed to ICT enabled innovations. Some of these innovations have also created some issues, and they include sociological [9], [10], technological and legal issues. Policy and regulation is very important in the innovative use of ICTs as some solutions may be injurious to others [6]. On the whole, the application of ICTs can be limited to one's ingenuity and hence innovations [11], [12] should be encouraged.

Traceability [13] is very important in the Food supply Chains system as it used to track food products and is used for food safety [14], [15] activities. The use of ICTs in Food traceability system enhances the efficiency and effective execution of these activities, in order to expedite the handling of implicated food products [16]. ICT technologies that are used in the food supply chains include radio frequency identification tags (RFIDs), wireless sensor networks (WSN) and bar codes. There are, also, a number of applications and software agents [17] that have been developed to work with the food supply chains systems, for the purposes of data and information

processing and storage.

This study looks at the food supply chain in Zambia, in particular with regard to the small scale farmer and the small scale traders. And in turn, at the development of an ICT solution that will enable small scale traders and small scale farmer to trade cost effectively. This solution will enable the food supply chain in Zambia which is undefined. It can be said to be undefined because, the traders as not assured of the availability of the food commodities at the place and time of need. As a result, there are food shortages which result in heavy price fluctuations at the market places. This solution is meant to mitigate the costs and risks that are associate with the safety of money, property and lives of the traders, who spend a lot of time on travel [18], [19]. The system will enhance traceability in the food supply chain as all actors will need to be registered in order to participate in trade using the system. The actors being the corporative (who are the owners of the application), trader and the farmer.

1.2 Motivation and Significance of the Study

The food supply chain in Zambia has undefined processes that hinder the growth of the small scale traders and farmer' participation in trade and commerce. These traders operate from markets such as Soweto market in Lusaka and Libuyu market in Livingstone. They travel long distances around Zambia to source the food commodities which include rice, tomatoes and beans. Mostly, they travel without any guarantees that they will find what they want and in correct quantities.

The aim of this study is to find ways of improving the food supply chain in Zambia in order to enable small scale farmer/trader participation, through the use of ICTs in order to reduce the cost of doing business and avoiding unnecessary exposure to risks that come as a result of traveling.

The significance of the study is as follows:

- a. It will help the small scale traders to run and develop their businesses cost effectively due to the reduction in expenses such as travel and the transportation of their merchandise.

- b. Zambia has a very high prevalence of road accidents, whereby in 2014 there were 32, 392 road accidents, which translated in an increase of 3,274 from 2013 [20]. This study will increase awareness in the risk of being involved in road accidents especially on long distance routes.
- c. It will stimulate the creation of value chains that will foster quality control and assurance. Delivery, stock availability, price stability will be assured and will be in place.
- d. It will form the basis for development of mobile apps for small scale traders in as far as policy and regulation formulation is concerned, both the private and public business sector will be involved.
- e. Small scale traders will use the outcome of this study to review the performance of their businesses.
- f. The study will assist in setting standards that will be used to meet the food supply chain industry's objectives.
- g. The results of this study will support government efforts in poverty alleviation in the region as it will reduce the cost of doing business
- h. The results of this study will be of benefit to the researchers and academicians as it will provide basis for further research.

1.3 Scope

The research was conducted in Lusaka, the capital city of Zambia and in Livingstone, the tourist capital of Zambia. A baseline study was done at the major markets, namely Soweto market in Lusaka and Libuyu market in Livingstone. The result of this research is to develop a mobile application that will be used by small scale traders and small scale farmers to purchase food commodities from small scale farmers in remote places. The mobile application will be developed for handheld mobile devices and will use short message service (SMS). SMS is offered on both standard and smartphones. Standard phones are popular among people who live in both rural and urban areas of whom most are small scale trader or small scale farmers. The mobile

application will be interfacing with the owner of the system, in this case, a cooperative who will manage the trading, arrange for transport, insurance, money transfers and exchange of commodities. All these activities will be done without the need, for neither the traders nor the farmers, to travel great distances.

1.4 Problem Statement

The cost of doing business, in Zambia, for the small scale trader and farmer is very high. This is so because of risks and high cost which both the small scale trader and farmer are exposed to, when they engage in trade. The farmers grow food commodities that are at risk of not being bought due to heavy competition from commercial farmers who enjoy the economics of scale and mass production. These farmers are very far from markets and do not have access to loans and banking facilities. In spite of all these drawbacks, they produce organic food which is usually free of pesticides and synthetic fertilizers, and highly sought after by markets in the developed countries. On the other hand, small scale traders travel great distances in order to gather the food commodities. These traders are exposed to risks associated with the poor transport infrastructure such as bad roads, lack of bridges and lack of access to aviation transport. Zambia has one of the highest road traffic accidents in the world [19]. Most of these accidents involve traders who are usually on their business travel. Traders in commodities such as fresh and dry fish, use dugout canoes which occasionally capsize on rivers, lakes and swamps. All these risks involve loss of lives and commodities. The other risk that the traders are exposed to is loss of cash. This is so because of lack of banking infrastructure in some remote trading places. This situation forces the traders to travel with cash on themselves. The trader is exposed to the possibility of being mugged, robbed, or swindled out of their hard earned income. Further the trader has to spend a lot of time travelling and gathering of the commodities as compared to their core business, which is trading. This research therefore seeks to use an ICT solution, in form of a mobile application that

will reduce the cost and risks of doing business between the small scale farmers and small scale traders.

1.5 Aim

The main aim of this study is to find ways of improving the food supply chain in Zambia that will enable small scale farmer/trader participation, through the use of ICTs in order to reduce the cost of doing business and avoiding unnecessary exposure to risks that come as a result of traveling.

1.6 Objectives

The specific objectives that will enable the achievement this objective are as follows:

- 1) To determine the current status of the food supply chain in Zambia pertaining to small scale farmer/trader participation.
- 2) To determine the level of utilisation of ICTs among traders in the food supply chain
- 3) To develop a mobile application in the food supply chain.

1.7 Research Questions

The small scale traders find it difficult to source the food commodities in a cost effective manner.

Research questions that the study sought to answer were:

1. Is it possible to source food commodities in Zambia using ICTs?
2. How can we determine the levels of utilization of ICT among the traders in the food supply chain?
3. Is it possible to develop a mobile application for use in the food supply Chain?

1.8 Research Contributions

This research focuses on the development of a mobile application which will be used by a cooperative in order to gather the farm produce and sell it to the traders without the need for either parties to travel great distances. These works have been published in the international Journal of Innovative Research in Science, Engineering and Technology¹.

(IJIRSET)¹. See the list of publications in the appendix for the research articles published from this work.

1.9 Organization of the Thesis

The work done in this thesis is organised into six chapters. Chapter 1 is the introduction to the research. In this chapter, a brief overview of the work in this thesis is given. The problem statement, aims and motivation of this thesis, are also given. This chapter concludes by the giving an outline of the thesis. Chapter 2 looks at the background theory and related works. This chapter begins by providing a comprehensive review and the background theory of food supply chain systems. The important aspects of the food supply chain are also covered. Finally, the proposed prototype of the ICT solution in form of a mobile application that will be used in the food supply chain with the corresponding related works in the above themes are discussed. Chapter 3 looks at the methodology of how the survey was carried out. This is a baseline study which was carried out at Soweto market in Lusaka and Lubuyu market in Livingstone.

¹**Ariel Henry Phiri**, Gift Lyoko, Jackson Phiri, “The Use of SMS Mobile Phone Technology to Improve the Food Supply Chain in Zambia”, International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Volume 4, Issue No. 12, pp, 12412-12418, 2015.

It was based on this study that the smart Trader system was developed. The chapter also looks at the Implementation of the mobile application that was e called the smart trader system. This is where the system design is discussed in detail. The functional and non-functional requirements were defined. The use case diagrams and use case text methodologies were used to analyse the system in order to identify, clarify and organise the system requirements. Chapter 4 looks at the results of the baseline study and the system Implementation. The mobile application prototype was tested and performed successfully. Chapter 5 discusses the implementation and results in relation to the objectives of this study and the conclusion.

1.10 Summary

This chapter looked at the basic introduction of the work in this dissertation. It begun by looking at the basic concept of food supply chain model and development of the mobile application with its core technologies in this implementation. The motivation, significance and scope of the work in this study were then outlined. Finally the problem statement was outlined, together with the aims, the research contributions and the chapter closed with the outline of the thesis.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature is reviewed, in order to give the background theory and the works related to this study. It begins by reviewing the information and communication technologies (ICT) and how they have been viewed as enabler of various fields. The innovative use of ICTs, especially mobile and web technologies have been covered in this study because they are important to the development of mobile application that used to address some challenges in our society. The review of the mobile and web technologies is relevant to this study as to provides the background of the mobile communication. The chapter also looks at the food supply chain and its facets that include food availability, food safety, food security and food traceability. This is followed by the several kinds of applications of ICTs the food Supply Chain and the corresponding solutions to these provided in the current literature. This chapter concludes by looking at the analysis and related works to the use of ICTs and SMS based solutions. Further the Zambia National Farmers Union (ZNFU) SMS Information System which is one of the examples of the applications in the food supply chain in Zambia.

The food supply chain is very important in the world food industry. Food has to be available at the place of need and in edible state. As a result, the food industry has become highly regulated and involves government Policy [21] and regulation. At global level, the food policy is expressed with reference to human rights [22], [23]. Thus the food supply chain is concerned with food availability [24], [25], food safety [26], food security [27] and food traceability.

2.2 Review of the Literature

2.2.1 Information and Communication Technologies (ICTs)

Information and Communication Technologies (ICTs) are referred to as a range of technologies that incorporate the use of information technology devices such as computers and communication technologies such as telecommunication networks and mobile and fixed line phones [28]. The technologies and their convergence with conventional media that is

growing all the time.

ICTs are viewed as enablers of the agricultural, medical, trade, educational, food sectors which make dynamic and real-time global level exchange of data, information and knowledge quick, interactive and easy throughout the supply chains [29].

The effective deployment of ICTs can lead to improved agricultural competitiveness through cuts in production and transaction costs, that raises production efficiencies and farm incomes, conserving natural resources, and by providing more information, choice and value to stakeholders. ICTs have changed the outlook of agriculture in many third world countries. In these countries, most agricultural activities, are now established on the use of web-linked interactive databases that provide information on weather, natural resources, credit, quantities of products demanded and government programmes, as well as technical knowledge [6].

Information has become a fourth critical factor of production in developed country agriculture [30]. The first three being land, labour and capital. This change has happened in the context of high literacy rates, well-developed infrastructure for telecommunications, roads, electricity, transportation and markets, sufficient scope for value addition to processed foods, and easy access to ICTs in an enabling policy environment. In third world countries including India, these conditions partially apply. Neglecting ICTs in agricultural development planning can have serious negative consequences for the rural economy in this era of world globalization. Understanding and implementing ICTs in developing country agriculture depends on recognizing that knowledge is an increasingly significant factor of production and that ICTs can accelerate agricultural development by facilitating knowledge management.

The technologies that has enabled the innovative use of ICTs are chiefly Mobile and Web Technologies. These technologies, have made it possible for people in the world to exchange information at the speed of light regardless of location and distance between them.

2.2.2 Mobile Technologies

Mobile technologies may be referred to as technology that can be carried around. This can be said to be the use of devices that are able to move freely or easily between places, occupations or social classes.

Mobile wireless or cellular phone is a portable, handheld communication appliance, or device that is connected to a network wirelessly in order to enable people make calls, send text messages and use applications. These devices are designed to meet the expectations of

different people. In order to achieve this, different manufacturers make different devices that meet different customer profiles. The manufacturers of mobile devices include RIM, Samsung, Nokia, BenQ, Motorola, LG, Sony Ericsson to mention but a few.

Mobile devices include standard phones, feature phones, smartphones, tablets, laptops and PDAs or handheld computers.

The standard phones are low cost phone and usually run on proprietary or series 40 operating system (OS). Series 40 or S40 is proprietary to Nokia, although it is also used on some of the Vertu line of luxury phones. JAVA and BREW is the mostly used applications on these phones.

The smart phones are priced slightly higher than the standard phones. The commonly used operating systems include the S60 from Nokia, Windows Mobile and Linux. These devices use any application that may be compatible. The PDAs or handheld are quite pricy. The commonly used operating systems include PalmOS and PocketPC. They also use any application that may be compatible.

a. Mobile development Ecosystem

The mobile development ecosystem can be defined as a spectrum of solutions that range from purely mobile web applications to purely native applications [31]. In between, there are a variety of solutions that either lean more heavily on the WebView (the same technology, more or less, that powers the mobile web browser) or more toward a native user interface (UI) and native libraries.

Below is a simple diagram to illustrate this spectrum of solutions and where each is placed:



Figure 1: Spectrum of Solutions [31]

As can be seen, from Figure 1, the hybrid and hybrid/native categories lean more toward the mobile web, while JavaScript native and cross-compiled lean more toward native. The mobile development ecosystem also involves working with solutions pertaining to certification, mobile operator, mobile UI, mobile OS, platform, language, packaging, deployment, data bearer, Air interface, publishing, among other things.

b. Why mobile

A mobile device may be defined as mobile because of some of the characteristics that it may poses which may include being a one handed device. It being small in size enables it to be

portable as long as it is light. A Mobile phone has its down side such as, having limitations on its input like the keypad, which might be too small and inconvenient. It also does not have a good processing power nor battery life. However, a mobile phone is a truly ubiquitous device, because it can be equipped with rich sensors such as, GPS, altimeter, compass, cameras, etc.

c. Mobile phone capabilities

The mobile phones have evolved and acquired capabilities that have enhanced their performance over time. In the 1990s, mobile phones were basically operating voice, and were equipped with a speaker, microphone, ring tones and monochrome screens. They worked on the GSM (platform. In the mid-1990s, the TDMA (Time Division Multiple Access) platform came in and the phones acquired the Bluetooth, text, and colour screens. In 2000s, the CDMS platform was introduced and the mobile phone acquired the capabilities to handle images, cameras, PTT, GPS and WAP technologies. Other features such as RFID were incorporated on the mobile phone including the capability to handle GPRS, UMTS and EDGE. After 2007, the mobile evolved to handle Wi-Fi, NFC and WiMAX including the W-CDMA network platform.

d. Evolution of Mobile Generations

There have been different generations of mobile devices associated with the electronic and telecommunication evolution in time. The First generation (1G) were analog devices, the Second generation (2G) devices were digital, and the Third generation (3G) allowed for voice, data and advanced services [32].

- **Early mobile phones**

The mobile phone technology stated as far back as in 1946, which marked the Zero Generation (0G). The 0G pioneered the mobile phone industry from 1946 to 1980, was characterised by phones that were mounted in cars, trucks or carried in brief cases, they were bulky and not really portable as the technology was limited to thermionic valves [33]. Owing to this, these mobile phone were very expensive as compared to the landline. They only used voice.

- **1G 1980 to date**

First generation cellular networks came into being in the 1980 and are still in use today [34]. They use analog technologies namely AMPS (Advance Mobile Phones System) [35] and Data Tac that support mobile phones such as the Blackberry 850, which was the first in its family. The 1G mostly supports voice call communication and limited data communication.

- **2G 1990s to date**

The Second generation cellular networks which are still in service today were initiated in the 1990s. These are digital systems. They support voice and SMS using Circuit switched data techniques [36]. They ride on the GSM, iDEN, CDMA and TDMA Telecommunication network standards. GSM which stands for Global System for Mobile Communication, is the most popular standard for mobile phones worldwide used by 2.2 billion people on over 210 Networks.

GPRS stands for the General Packet Radio Services. It is a mobile data service for use on GSM networks and is part of the 2.5G standards family. iDEN stands for Integrated Digital Enhanced Network. This is a second generation (2G) mobile telecommunications standard which was developed by Motorola. It is mainly used by US Operators, namely Sprint-Nextel and Boost. Code Division Multiple Access is abbreviated as CDMA is a second generation (2G) standard for Mobile phones. It originates from the USA. It is operated by Sprint and Verizon of USA.

- **2.5G 1990s to date**

The 2.5G was more of a Marketing term which supported GPRS, HSCSD, and WiDEN technologies, including the EDGE, CDMA2000, 1 x-RTT. This technology has been in use since the 1990s [37].

- **3G 2004 to date**

Third Generation cellular networks also known as 3G is a mobile telecommunication standard that came into being in 2004 and is operational to date. It supports Broadband data video and voice, streaming. This is on the W-CDMA (UMTS, FOMA), 1xEV-DO platforms [38].

- **4G the future**

The 4G which stands for 4th Generation, is also known as the LTE (Long Technology Evolution). It is a mobile telecommunication standard that came into being in 2014 and is operational to date. It operates a High speed broadband for data and visual centric information. It allows for data transmission at 100Mbps while moving and 1Gbps while standing still [39].

e. State of the industry

The Operators, the technology, platform, network and the number of subscribers in the United States of America are show in Table 1. It also shows the location and openness, which is the ease of development of the systems.

Table 1: State of the Industry in the United States [40]

Service	Cingular	Verizon	Sprint	T-Mobile
Subscribers	61m	59.1m	53.1m	25m
Technology	GSM	CDMA	CDMA/iDEN	GSM
Platform	J2ME	BREW	J2ME	JSME
Openness	Open	Semi-walled	Open	Semi-walled
Network	2.5G/3G	2.5G/3G	2.5G/3G	2.5G/3G
Location	TDOA	A-GPS	A-GPS	TDOA(no access)

f. Mobile Development options

The Comparison of the web in 1997 and the mobile apps in 2007 is shown as in the Table 2.

Table 2: A comparison of the Web and the mobile Application [41]

1997	2007
Netscape Vs Microsoft	Symbian Vs Flash Lite vs Java ME vs Python vs BREW vs .NET vs WAP vs Palm
Proprietary feature vs standards <blank> vs <marquee>	Platform feature / standards OEM APIs (java)
Free environment	\$\$ environment ((contracts)
Free development tools	Mostly free development tools (except for BREW)
Clear development / deployment process	Convolutd development &painful deployment process

In 1997, during the Internet browser age, there were only two companies that were in competition and that was Netscape and Microsoft [41] There was little competition between features and standards, and the environment was free and so were the development tools. There was a clear development and deployment process of applications. This is not the case as at 2007 as for the Mobile applications are concerned. There is a lot of competition among platforms where one has to choose between platform feature and standard OEM APIs such as Java. The environment is no longer free as contracts have to be made between development parties. Although most of the development tools are free, one need to pay for BREW. Mobile applications have a convolute development and painful deployment process.

- **Java ME / J2**

Java ME which was formerly known as Java2 platform, micro Edition or J2ME, is a collection of Java API for developing software on resource constrained devices such as PDAs, cell phones and other customer appliances. Java can be sourced from Sun systems on the following url; <http://java.sun.com> [42]. It is at this site that one can download SDK, tools and have access to community resources for development. Another source for Java is the Manufacturer of devices who produce SDKs, community and device emulator.

- **Flash Lite**

Flash Lite is a development platform which was created by Macromedia, based on their hugely successful Flash web application platform [43]. It operates on devices that Flash player cannot. The V1.1 is the most widely deployed but limited and the V2.x has an improved experience. Flash lite is not an operating system but a technology for developing mobile applications that runs on a mobile operation system.

- **Symbian**

Symbian Operating System based on original PDAs from Psion. It has the largest installed base and has a multiple version customised for different manufacturers. It uses the C++ Language [44].

The user Interface Quartz (UIQ) software platform is the version that supports Sony Ericsson while Series 60 supports the Nokia, which are Symbian based phones. Another platform for Symbian and Linux Operating Systems is the MOAP [45] which stands for Mobile phone Oriented Application Platform. MOAP was developed by DoCoMo [46], so that it can be used commonly by multiple mobile terminal vendors and software vendors, when developing mobile terminal software. This arose following the introduction of the Freedom of Mobile multimedia Access (FOMA) terminals in 2001.

- **BREW**

Binary Runtime Environment for Wireless (BREW) is a proprietary mobile device platform developed by Qualcomm [47]. Development language is C with C++ interfaces. Certification and development process is expensive.

Table 3: Overview Features of each Platform [50]

Platform	Overview
Java ME	Second best rich, best overall development
Flash Lite	Good for graphics- heavy application in supported markets
Symbian	Strong support from Nokia, best access to hardware
.NET	PocketPC + Windows mobile devices
BREW	The only option for CDMA networks
Python	Great for quick prototypes, still immature
WAP	Largest overall reach, lightweight functionality

- **WAP**

Wireless Application Protocol which is abbreviated as WAP [48], was originally used to describe lightweight protocol which used Wireless Markup language (WML) [49]. Currently, WAP is used to refer to mobile web, which uses XHTML MP/Basic + CSS.

As can be seen in Table 3, the overview feature are of each platform is highlighted [50]. Java ME platform offers the best richest applications and the best overall development mobile application.

As can be in Table 4. the platform and language that can be used is shows. The performance of the platform including the learn curve that is required for one to use the platform, is also shown. The need for an emulator of type is indicted and the popularity of the platform is also indicted. As an example, the Python platform uses the python language whose X-platform is free, has a gentle learning curve and an add-in emulator. It is available to Nokia only.

Table 4: Platforms and Languages [50]

Platform	Language	X-Platform	Learning curve	Emulator	Availability
Java ME	Java	Average	Average	Free	~1.5bn
Flash Lite	AS	Excellent	Average	With IDE	77-115m
Symbian	C++	Average	Steep	Free	120m
.NET	C#, C++, VB.NET	WM	Steep	IDE	4.5m
BREW	C++	CDMA Only	Steep	Simulator	???
Python	Python	Free	Gentle	Add-on	Nokia only
WAP / Mobile Web	XHTML, WML	Free	Gentle	Free	2bm+

Popularity of the platform and its functionality is shown in Table 5. As can be seen, the JAVA ME platform supports 2D and 3D. It has many widgets and uses visual form builder. Its functionality is varied by handset. It has no caller identification but has high resolution. Phone access is varied by handsets and has optional APIs. It has an extensive developer community.

Table 5: Platform, GUI, and Functionality and Developer community [51]

Platform	GUI	Functionality	Phone data access	Developer community
Java ME	2D/3D. Many widgets. Visual form builder	Varies by handset, no callID, high resolution pictures	Varies by handset, Optional APIs	Extensive
Flash Lite	2D/3D. Many widgets. Visual IDE	Partial through API	None	Extensive
Symbian	2D/3D. Many widgets. Visual form builder	No restriction	Simulator	Extensive
.NET	2D/3D. Many widgets. Visual form builder	Limited audio	Full	MSDN
BREW	2D/3D. Many widgets. uiOne	Operator dependant	Full	Limited
Python	2D graphics. some widgets	Partial through API	partial	Small but growing
WAP/ Mobile Web	Basic forms. inconsistencies	Limited to browser	None	Extensive

Java VM

A typical Java ME stack configurations specifies the minimum java technology that can be expected for certain devices and also include language, virtue machine feature, core libraries [52]. It also has a profile layer, which defines APIs and specifications for a particular device or market, such a MIDP, FP. It also has a profile for MIDlets and optional packages which include additional functionality that is only supported by certain devices- e.g. Bluetooth API, Location API. Figure 2. Shows the typical Java VM stack.

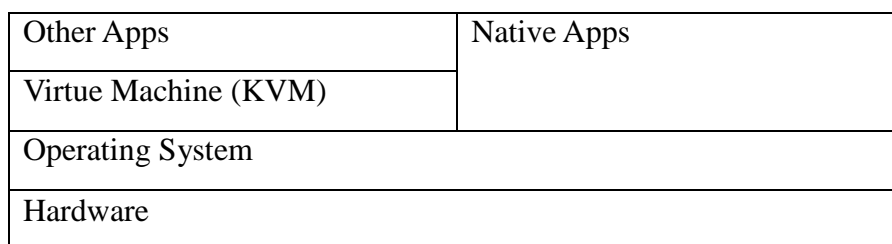


Figure 2: A Typical Java VM stack [53]

g. Applications

Applications that have been developed for mobile devices cover Games such as Pang and the Sims2. Web browsers such as Opera Mini and GCalSync are some of the popular applications on the mobiles. As for the social applications on the mobiles, BEDD, Flirtomatic and Loopt

are some of the most popular. Application development have included mapping where Google Maps, mGmaps, WayFinder and uLocate have been developed for navigation use. For the RSS (really simple syndication) [54] has been developed so that the author of web content can be syndicating their content automatically on their mobile devices. Widsets and MobileGlu are some applications that were developed to tap into the RSS on mobiles. The photo applications for mobles include Mobup, Shozu and Zonetag. As for art, Balldropping is one of the pioneer applications

h. Python for Series 60

Python programming Language was created by Guido van Rossum in 1990. It is an interpreted, object oriented programming language which is very powerful with a terse syntax. It is structured in modules, classes, exceptions and has dynamic typing. Python for Series60 is an Open source scripting language ported by Nokia and is only used on the Nokia series 60 smart phones. Python wrappers around low level APIs because it has easy access to native OS features [55].

- **Comparison of Java with Python**

The syntax structure of Java and python are compared as shown in Table 6.

Table 6: Comparison with Java and Python

Java	Python
Statically typed String blah="";	Dynamically (“duck”) typed Blah="string" Blah =1
Verbose	Concise
Public class hello world { Public static void main (String [] args) { System.out.println(“Hello, world!”); } }	Print “Hello World”

As can be seen from Table 7. Java ME is widely supported by manufacturers of mobile phones than the Python S60 that support Symbian series60

Table 7: Comparison of Java ME with Python S60

Java ME	Python S60
Freshly open source	Open source
Broad manufacturer support	Symbian series60
Complex, multiple APIs (High Level, low level), confusing exception model, run in sandbox	Extremely terse. No checked exceptions. Uses Python standard library. Simpler APIs, C++ wrapper

The comparison of Java ME with Python S60 is shown in Table 7.

i. Compatibilities of PyS60

The capabilities of PyS60 are that it has a Graphical User Interface (GUI) which consists of menu, Forms, list boxes, input fields, dialogs, Notes [56]. It has Graphics that support color, font and style attributes. It also has direct-screen drawings, which allows for the display of images and icons. It has Key-down and key –up events capabilities. Python S60 supports sockets such as TCP/IP, Bluetooth (RFCOMM, PBEX). It supports Messaging (SMS) and accessing the inbox. Networking features such as HTTP, FTP are supported. PyS60 also allows access to file system, file reading, XML, RSS, access to camera, telephone, access to calendar, contacts, sysinfo, Location (Cell-id), Content handling, this download and open videos, etc. Further Python extensions can be written in C++. Package scripts into standalone applications, using SIS files is supported

j. WAP and WAP 2.0

At the end of the 1990s WAP was created and the Data services bearers namely CSD (circuit switched data/dialup)/CDPD became available. The Data connection speeds on the CSD was 9.6kbs and CDPD was 14.4kbs. WAP is the Light weight protocol that was needed to transfer data because it has a gateway that translates pages into a form suitable for mobiles, for instance the Wireless markup language (WML) and Handheld Device Markup language (HDML).

The WAP 2.0 was released in 2002 and has Data service bearers available on GPRS at 54Kbps. Development of the 3G networks lead to enhancement of languages and platforms such as WAP 2.0 and XHTML-MP (Mobile Profile) [57], which were released by the WAP forum. As a result, smarter phones can be used with faster data on 3G Networks. WAP GW can be used with WAP 2.0 as a standard proxy server. On the other hand, WAP GW is largely for legacy device support (WAP1.1 devices)

- **A Comparison of WML with XHTML**

The wireless Markup Language (WML) [58] used to be controlled by the WAP forum which is now defunct. However, the XHTML –MP is controlled by the W3C (World Wide Web Consortium) [59] and the OMA [60], [61]. As can be seen from Table 8, XHTML-MP is more versatile as compared to the WML.

Table 8: Comparison of WML with XHTML [62] [63]

	WML 1.x	XHTML-MP
Standards Body	WAP forum (defunct)	W3C + OMA
Content displaying	Content + layout in same document. Tailored separately for different devices.	Content + layout separate. Can be rendered separately
Content Encoding	Binary	No encoding required
Document Layout Control	Basic	Advanced layout with CSS
Colour control support	Only colour images, no colour control for fonts. Background, borders etc.	Full support for CSS, fonts, background, borders
Data Bearer	WAP	Wireless profile-TCP/IP

- **Comparison of Java with WAP**

A Wireless Application Protocol (WAP) is the default standard that is used for

Table 9: Comparison of Java with WAP [42]

Java	WAP
Complex syntax, powerful language	Simple syntax, not so powerful
Download apps	Use built in browser (no download necessary)
<pre> Public class HelloWorld { Public static void main (String [] args) { System.out.println("Hello, world!"); } } </pre>	<p>Hello, WAP</p>

communication used by the world wide web (WWW) on wireless devices. Wireless Markup

Language (WML) and the WML scripting language are used for WAP application software development. As shown in Table 9, the fundamental differences between Java and WAP are shown. Because of the small size of the display, limited bandwidth, security aspects and different session management techniques, a developer has to trade carefully between using WML and the Java or C# which are languages that are used on the server side. This is so because the server has more computing capacity than a mobile wireless device [42].

2.2.3 Web Technologies

These are technologies that are used to exchange information on the computer networks such as the internet. The internet is a network of computers that cover the world and the World Wide Web (WWW) is a service that operates over the internet. All devices on the network need to communicate with each other on the same or other networks, and this is achieved through the web technologies. These technologies ensure that messages are exchanged between the senders and the recipients and accordingly, feedback and acknowledgement receipts or communication failure are reported. There are a number of examples of Web technologies and they include markup languages, programming languages and technologies, Web servers and server technologies, databases and business applications.

a) Markup languages

Markup languages are designed for definition, presentation and processing of text. The code for both the style and layout within a file is defined by the language. Examples of the markup languages include HTTP, CSS, XML, CGI and HTML. All computers clients and servers on the WWW use markup languages.

b) Programming languages and technologies

The programming languages and technologies are used to build applications for the web. Some of the commonly used languages are C#, Perl, java and Visual Basic .Net

c) Web servers and server technologies

The Web server and server technologies facilitate the handling of requests that are generated by different users on the network [64]. This is so because different users have to share the same resources and communicate with each another. The webserver is responsible for accepting requests for content that is defined in the Uniform Resource Location (URL). A URL is an address of the web page. It designates a unique address for a file that is accessible on the internet [65].

The most popular Web server software include the Apache, which is an open source webserver and supports Windows, UNIX and Mac Operation Systems. Windows also has a proprietary web server called Microsoft IIS, which runs on Microsoft Windows platforms only.

The server executes a program to generate a web content as requested on the URL. Then the HTTP request details are passed over to the program by the server. The programs return the web content or an error code. The Apache server uses the Common Gate way Interface (CGI) while the Microsoft IIS uses the Active Server Pages (ASP).

d) The Browser and Server Communication via HTTP

The Hypertext Transfer Protocol (HTTP) is a standard protocol for transferring web content where the server listens on port 80 waiting for connections. Figure 3, shows the brief of how the protocol works.

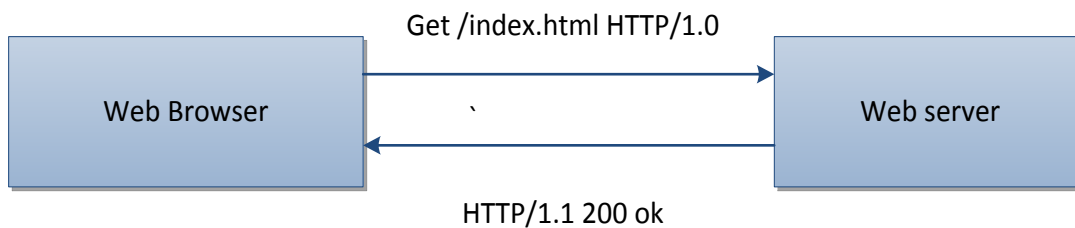


Figure 3: Hypertext Transfer Protocol

Then the web browser connects to the server, and sends a request. Finally, the server responds with an error code or the web content.

e) Browsing the web using the Client server model

The Client server model uses networked interactions between a client (the web browser) and the server (the web server). The Dynamic content is generated on the server side.

The merits of generating the content on the server side is programs cannot be executed on the low powered client computers. Mostly likely is that the data that may be required by the client will be present on the server. And finally client is likely to have restricted program functionality due to security reasons. The drawn back of the server side is that the server need lots of processing power especially when there are many clients that may be connected at that time. Finally, a lot of information and data may need to be passed back and forth.

f) Databases

A database is an organised collection of data or a collection of schemas, tables, queries,

reports views and other objects. Databases are web technologies that store information and other crucial data on a computer network, in order for the users to access. Some of these include MySQL, Microsoft SQL, Oracle, Sybase and SAP, these database technologies have to be accessible on demand hence the need for them to be on the World Wide Web (WWW) [66].

g) Business applications

Business applications are application that are tailored to perform specific tasks on the network. Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Business Intelligence (BI) and are some of the business applications that can be used to manage and handle all data flow in the company or organisation [67]. It deals with security and data redundancy.

On the whole, web technologies offer a platform on which effective communication takes place, among different users and devices on a computer network. This in turn brings about the much needed efficiency that yield profits in an organisation.

2.3 Technology used in the food supply chain

This section will explore some of the technologies that are used in the Food Traceability and Food Supply Chain. These include the RFID, Bar code and the WSN.

2.3.1 RFID Technology

Today, the use of Technology in Food traceability has gained reputation and promotion, as opposed to the traditional ways of manually processing, because it has made traceability become faster and more accurate [68]. Some of the advancements is in the use of RFID technology which incorporate the use of data logger capabilities and integrated sensors [28]. This has provided a new dimension to the application of RFID technology in the food supply chain.

In the last ten years, RFID has developed as a leader in the development of traceability systems in the food supply chain and their implementations are growing at a speedy pace. The implementation of RFID technology in food traceability systems have become more reliable and proficient since RFID allows for advanced reading rate than traditional barcodes [69]. Since RF Technology can recognise products without any physical contact, this technology is able to deliver effective information sharing with efficient customization and handling.

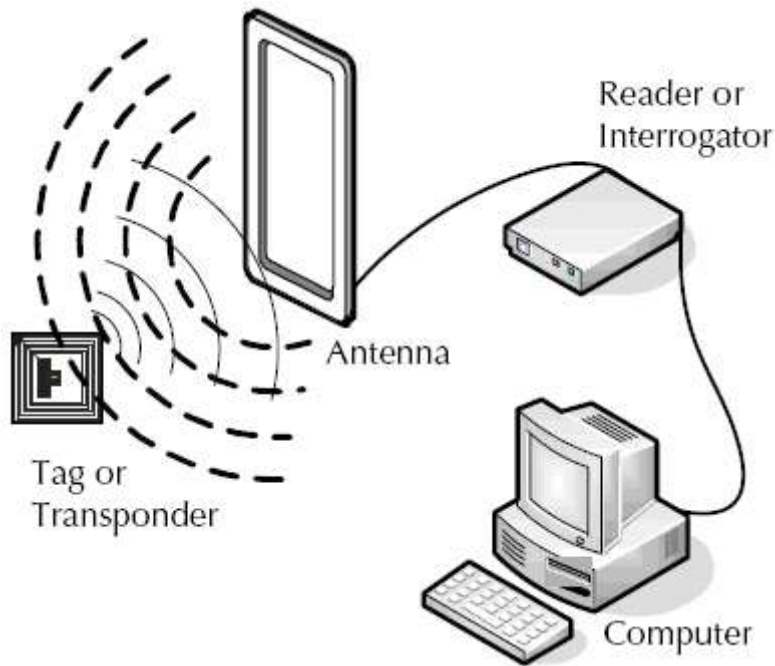


Figure 4 The reader and Tag of the RFID system [69]

a) A typical Radio Frequency identity (RFID) system

The technology which has proved to be effective is the Radio Frequency identity (RFID). A typical RFID system comprises tags and readers, application software, computing hardware, and middleware. This technology can be categorised, as shown in Figure 4, into the following sub-categories:

- i. **Tags and aerials:** An RFID tag comprises an integrated circuit with memory, which is basically a microprocessor chip. The aerials are the channels for the communication of data between the tag and the reader. This area focuses on RFID chips and tag aerials.
- ii. **Reader:** An RFID reader is a device that can read data from and write data to compatible RFID tags. To ensure the compatibility of the communication, the tag and reader must work at the same specified working frequency and comply with specific regulations and protocols.
- iii. **Communication infrastructure:** This category includes relevant communication criteria and protocols, safe- guards, and network connectivity issues.

b) RFID applications.

RFID is a developing technology that has been successfully applied in supply chain management, manufacturing, and logistics, but its range of application extends far beyond these areas. The various industry areas of application include, animal detection, building management, enterprise feedback control, food safety warranties, Health, Library services, Logistics and supply chain management, Museums, Retailing, Manufacturing and Casinos.

2.3.2 Bar Codes Systems

Barcode is a marking that has series of parallel lines that have different thickness and are printed on the product. An example of a linear or one dimension (1-D) bar code is as shown on figure 5.

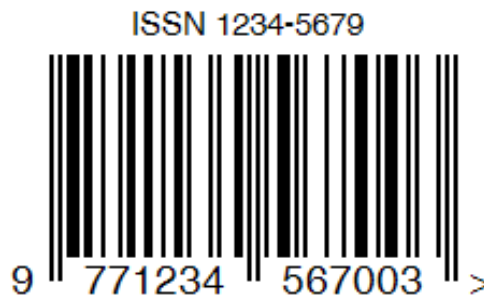


Figure 5: One dimensional Bar Code [70]



Figure 6: Two dimensional (2-D) barcode [71]

The other presentation of a barcode is a symbol consisting of rectangles, dots, hexagons and other geometric patterns in two dimensions (2D). This mark represents a code of information

and is machine read using an optical reader. Figure 6, show the picture of the 2D bar code.

In order to effectively manage the use of the barcode, different countries and products have specific barcode categories, which are used to uniquely identify a product and other details, including its origin. There are specific barcodes that are used in the Food Supply Chain. The Barcode technology has the inadequate capacity of processing powerful data because it dependent on the laser-scanning device to read and process data in a close distance [3]. Owing to this drawback, it may not be effective for use on livestock such as cattle and other huge objects.

2.3.3 Wireless sensor Networks

The wireless sensor network (WSN) generally utilizes the conjoining of the stationary sensor nodes (stationary node) which collect the environmental sensor data in a fixed location and the mobile sensor nodes (mobile node) that travel around the sensing field, thereby forming the WSNs. A WSN can be presented as shown in Figure 7.

In these networks, the stationary nodes concurrently perform the two functions of obtaining the environmental data and acting as a location reference/communication proxy (access point) with numerous mobile nodes.

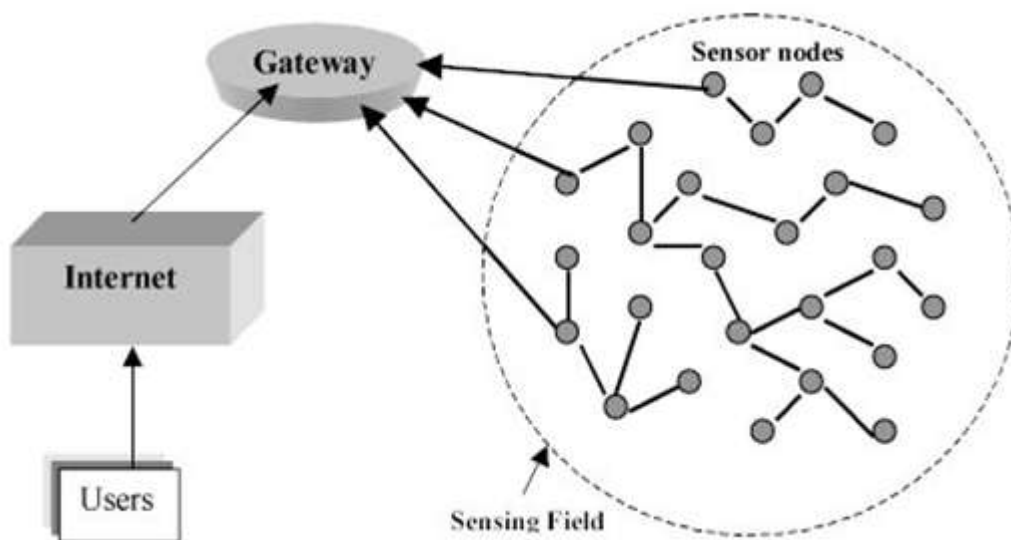


Figure 7: Wireless Sensor Network [72]

The bidirectional mobile asset tracking service is one of the well-known applications of this network and is applicable to the settings such as warehouse, hospital, etc.

2.3.4 Mobile Technologies in use today

The technology that is portable is referred to as mobile technology. The Mobile technologies include communication technologies that are used on mobile devices especially laptops, smartphone, tablet, netbooks, GPS devices, wireless credit/debit card payment terminals etc. These devices are used to exchange information among other users in remote locations because they use wireless communication technologies such as Wi-Fi, Bluetooth, GPRS, GSM, 3-G and 4-G. VPN and dial-up services are also used to connect to enable mobile computing. These technologies have enabled commerce and trade to be conducted between parties that may be geographically separated.

Generally, the mobile computing has made people to work more inside and outside their offices because of the portability of the computing devices that are available today. These devices have enabled people to multitask, in that, they are able to work anywhere while doing other things. People are able to work in parks, on the bus, train or even in the restaurant. The cost of the mobile computing devices has really dropped and they are affordable to many people these days.

a) E-commerce

E-commerce refers to electronic commerce or rather trading that is achieved through electronic means, using networked computers or the internet. This has turned the world into a global village as people interact all the time without distance and time being a barrier. E-commerce can also be define as buying and selling goods and services online such as e-books, software, streaming media, retail services, banking, DVD-by-mail, flower delivery, food ordering, pharmacy and travel [73]. It can also include marketplace services such as advertising, auctions, comparison shopping, social commerce, trading communities and wallet.

E-commerce has brought about other business to evolve thus creating other business that are solutions to problem that are associated with the traditional way of doing things. For instance, the delivery of parcels has been hampered by traffic congestion and this has given rise to parcels to be dropped at some points, say shopping malls, in some lockers that are available for rent [74] [75].

b) M-commerce

Mobile commerce also known as m-commerce can be said to be trading using wireless communication devices such mobile cellular phones. It covers payment, ticketing, customer service, call centre help desk and live support software. It also covers e-procurement which

incorporates purchase-to-pay.

c) Online Auction

An auction is the selling of goods or service through a public bid. There is not negotiation of prices but the price is arrived at by the highest bidder. Usually a seller will ask for offers and the buyers successively offer prices in order to beat their fellow buyers and the highest bidder gets the offer.

The advent of the internet has increased and made bidding convenient, in that, more people can participate in an auction without having the need to physically attend the auction sale. Auctions are taking place every day and at any time because of the internet which is supporting massive participation of bidders from around the world. An example of this is eBay where Auction are conducted over the internet and are called e-auctions [76]. They, however, have had challenges as there have been a number of frauds that have been committed that affect the e-auctions [77] [78] [79].

d) Cloud Computing Technology

The technology that is used, in the Food supply chain, is usually based on the server

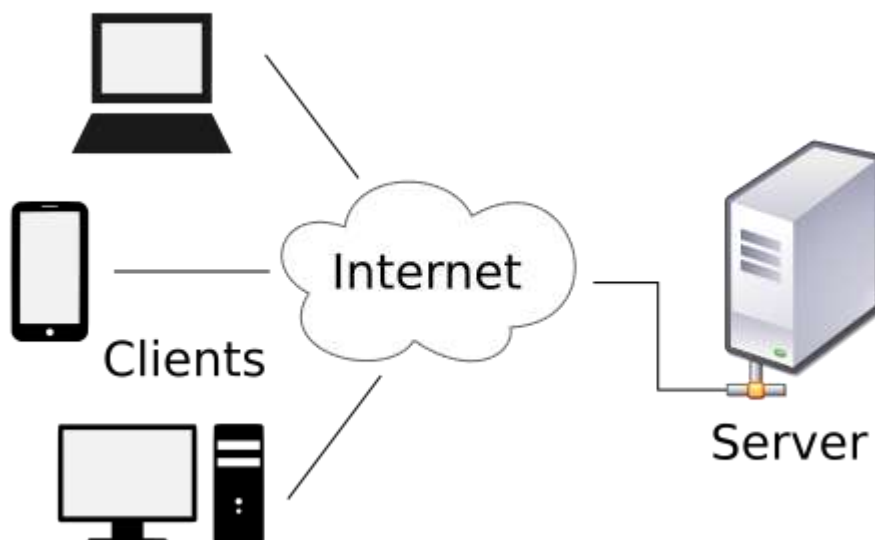


Figure 8: Client Server architecture [80]

client model where the client is the mobile devices which are remotely located relative to the server, while the Server equipment is located at the site of Mobile Network Operators or in the Cloud or other corporate premises. As shown in the figure 8, the server is connected to the clients over the internet. This is a server client relationship.

- **Server**

A server is a computer that provide share resources to the clients. It is required to interact with the client devices for a particular application to work [81]. The servers that are used for mobile applications have huge resources which include the requirement for reliability, availability and security.

- **Client**

The client is usually an end-user of a computer system [82]. The client devices feed on the resources that are provided by servers which are machines that have huge resources or computing capabilities that are available for sharing.

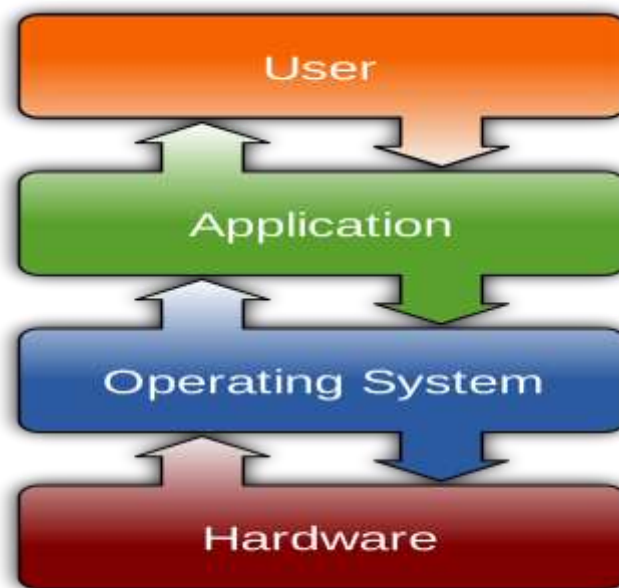


Figure 9: The operating System of a computer

The Client devices are low cost computer equipment that may have limited computing power which may be enhanced by connecting to a server. Mobile devices including smartphones, tablet and laptop computers, work with an Operating System that is able to support the hardware and the applications. The operation system makes it possible to for a user to be productive because it connects the computer hardware to the application software, as shown in Figure 9.

e) **Client Mobile Operating System**

There are a number of operating system, as was discussed in Section 2.2.2, that are used on the client mobile devices and these include, IOS, Windows, Android and many others. Outlined below are some description of the commonly used ones.

- **IOS**

Apple Inc., developed a mobile operating system called IOS [83]. It is distributed for Apple hardware devices. The operating system is proprietary to apple Inc. and runs only on Apple devices [84]. It has the capability of running a variety of mobile applications and these can be download from the apple store at a fee. IOS also includes another platform for entertainment called iTunes where a number of movies and music can be downloaded at a fee. The OS supports connectivity to the internet and configuration of email service, be it from the cloud or a company premises. It also supports mobile applications development.

- **Android**

The other mobile operating system that is based on the Linux kernel is the Android. It was developed by Google and it is open source [85]. It runs on a variety of mobile devices. It has brought the functionality of an office to the handheld mobile devices. The OS supports word processors, spreadsheet, and google store for uploading of additional mobile applications [86].

- **Windows**

The operating system which was developed by Microsoft for pocket PCs and smartphone was called the windows mobile [87]. This is a family of mobile operating systems which included, windows CE, pocket PC 2000, Pocket PC 2002, Windows Mobile 2003, Windows Mobile 2003, Windows Mobile 2003 CE, Windows Mobile 5, Windows Mobile 6, Windows Mobile 6.1 and Windows Mobile 6.5, etc. These generations of Windows OS have enabled the smartphone that run on this OS to deliver the capabilities that have satisfied the subscribers in that, they have been able to work outside their offices with the mobile devices [88].

- **Blackberry**

BlackBerry Ltd developed a proprietary mobile operating system called Blackberry OS [89]. This OS supports the use of the BlackBerry Smartphone to run a variety of applications which include email, calendars, address book. It also run proprietary mobile applications [90].

2.3.5 Security

Mobile and web technologies have been prone to a number of online frauds that have led to addressing the issues of security in a number of ways. In order to increase the credibility of e-commerce systems, there has been need to develop security measure that prevent some online criminal activities. E-auction sites such as eBay have been targeted as they lead in this segment of e-commerce [77] [91][76].

2.3.6 Food Supply Chain

The food supply chain can be defined as the activities that are performed on food from harvest at the farm, up to the time it is consumed at the table. These activities include, processing and distribution among other things. The food supply chain involves the aspects of food availability, food safety, food security and food traceability.

Food availability can be defined as adequate amounts of food of proper quality, delivered through the domestic production or imports, including food aid [24]. It is important that food is available at the point of need on demand because food supports life and without it mankind will cease to exist.

Food Safety is the basis of food regulation as it aims at safeguarding the health of the Consumer [92]. In order for food to be exported to other countries, measures are put in place for it to be traced and safely disposed of or sent back to its origin if it is found wanting. In order to do this efficiently, ICTs are commonly used. These include bar codes [93], RFID [94] and WSN [95] technologies.

Food Security [96] can be said to exist when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life [22].

2.3.7 Food traceability policy and regulation

This section covers the some aspects of food traceability in the food supply chain on policy and regulation. In order to meet the requirements of the society, the application of ICT has not only made this possible but easier and efficient.

Food traceability has become vital because it facilitates the removal of food from the market when need arises. This requirement may be due to food safety and food quality reasons [97]. Traceability allows the operators of the food supply chain to have accurate and targeted information relating to food products which have been implicated.

It is not easy to achieve traceability through the end-to-end supply chain because there are a lot of players involved who have to gain access to accurate and reliable data in order to make a trace which will yield desired results on time. These players including producers, authorities, retailers and consumers need to be able to trace and authenticate food products and raw materials that are used in food production, in order to comply with policy, regulation and legislation, so that the food safety and food quality requirements are met. In order to

attain a fast and effective response to incidents, the tracing of all food components that are offered from farm to the point of consumption, should have accurate real time data which should reduce food safety risks.

Traceability is defined as the 'ability to trace the history, application or location of the entity by means of recorded identifications', according to Codex Alimentarius Commission (1999) [92], Regulation EC (European Commission) No. 178/2002 [98], defines traceability as the: 'ability to trace and follow a food, feed, food-producing animal or substance intended to be, expected to be incorporated into a food or feed, through all stages of production, processing or distribution' (European commission 2002). The handling of the consecutive links between batches and logistic units throughout the food supply chain can be called as traceability.

Traceability has fostered the policy requirement at Global level. Global food safety policies are being framed and stipulated by governments and authorities all over the world, with particular occurrence in the United States of America (USA) and the European Commission (EU), as a result of a number of food incidences and scandals[99]. Traceability is required in all stages of the food supply chain as dictated by The EU regulation which has been applicable since 2005. This regulation covers all food and feed including business operators. A Business operator is required by law to register and keep information which include; (i) name, address of supplier, nature of products which were supplied to him, (ii) name, address of customer, nature of products which were delivered to that and (iii) date of transaction/delivery. The other information that is advised to be recorded is the volume or quantity, batch numbers and description of products. Unless specific provision for further traceability are stipulated, the requirement for traceability is limited to ensuring that businesses are at least able to identify the immediate supplier of a product as well as the subsequent recipient of a product [100].

The Bioterrorism Act 2002, in the USA, just like the EU regulation, dictates the one up/one down traceability for each link in the food supply chain. Each company in the supply chain is required through this regulation to keep information about the suppliers of their products and the details of the ones they supply to. This includes the details of the delivery agents along the way.

The principles and specifies the basic requirement for the design and implementation of a food and traceability system, which focuses on the one-step-up/ one-step-down are stipulated in the ISO (International Standards Organisation) ISO/DIS 22005.

2.3.8 Forces for Food Traceability

Many factors are known to influence the development and implementation of the food traceability system (FTS) and they include, regulatory [101], food safety and quality, social, economic and technological concerns

a) Regulation concerns

Laws are being enacted, all over the world, in order to address the food safety and quality concerns and resolve ownership disputes. The important reason for food companies to implement the FTS in order to fulfil the regulatory issues and to stay in business. Many food retailers are motivated to invest in FTS so as not to lose customer confidence.

The General Food law (GFL) has been put in place by the European Union, and is one of the mandatory Food laws, today [102]. Traceability data can either be mandatory or optional. Optional data can include supplier's name, contact information, receipt date, country of origin, date of pack, trade unit, transportation vehicle ID, Logistics service provider ID, buyer's name and dispatch list. Mandatory data may include lot number, product ID, product description, supplier ID, quantity, unit of measure and buyer ID.

The introduction of FTS in Asia has been on voluntary basis, particularly in China and Japan. The retail traceability program was mandatory in the EU and Japan, while it was voluntary in the USA as at 2008. Owing to this, the USA has been left behind in as far as the development and implementation of the traceability systems. Accordingly, only 12.5% of the investigated food products could be processed by facilities that could provide Lot specific information and could be traced through the food supply chain.

b) Safety and quality concerns

Due to food crises that were as a result of contaminated food, and animal diseases in the 1990s and 2000s, food traceability has become very important [103]. The food quality and safety crises caused significant crises in economic and market relationship at national and international levels, where for instance, the EU banned food products from China because of high levels of residue veterinary medicines, pesticides, and heavy metals were detected [104]. This could have affected the trade of China, one of the leading exporter of aquatic products.

c) Social concerns

Food companies are motivated to implement the food traceability systems [105] because of increased awareness of society about their health issues, increased confidence of consumers in their food and the changing lifestyle among other issues. The social and political security is strengthened when food crises management is improved by concerned agents who build

capacity to safeguard Food safety. It is therefore important for firms that are involved in Food traceability, to provide enough information that the consumers need to know such as a variety of the food attribute, animal welfare, country of origin and information on genetic engineering issues.

d) Economic concerns

Because the efficient full chain traceability systems are capital and resource insensitive, economic benefits of the food traceability system are not perceived as a strong driver [68].

e) Technological concerns

The cost of technology that may be associated with the food traceability systems are high due to the complexity of devices and systems that may be put in place [106]. However, there is new and cheaper technology that is motivating firms to develop full-fledged food traceability that are integrating information at all stages of the supply chain. The advent of nanotechnology has stimulated the development of devices, which are cheap and can be used in the Food traceability industry.

- **Benefits of traceability**

The Food Traceability System offers a number of benefits to the food supply Chain and they include, the increase in customer satisfaction, improvement in food crises management [107].

i. Increase in Customer Satisfaction

Consumers are always demanding for high quality of goods and services, and the demand for good food is not an exception. The satisfaction of the Consumer has seen the increase in the consumer confidence in the food available and how much information there is on the same, in order for consumers to make choices. The Food Traceability systems can be used to organize or analyze product information and communicate to consumers and other stakeholders. Food safety incidents can erode consumer confidence when mishandled by the media. As such, the need for a well-developed Food traceability system is vital to promoting consumer trust in food in the markets [13].

ii. Improvement in food crises management

With respect to Food safety and quality, food traceability in the food supply chain can help to reduce the production and distribution of poor quality or contaminated foods. It can also reduce the food recall activities and thus asserting the liability in case of food safety failure by spotting the indication of carelessness or neglect in the production practices.

The improvement in the performance of the food recall activities will improve food crises management.

2.4 Related Works

2.4.1 Use of SMS

This section looks at some related works in the use of ICTs in everyday life in the world. It also highlights the consequences of not securing the food supply chain, which has resulted in the development of Policy and regulation. Measures have been put in place to enable traceability of condemned food.

A number of innovations involving the use of ICTs, that are used to solve real life problems, are being used all over the world today [7]. These include systems that are covered in the field of commerce and trade, m-commerce, m-health and m-agriculture. Popular e-commerce platforms include eBay, amazon, which are online shopping platforms and can be accessed from anywhere in the world, using the internet.

In Africa, internet connectivity is still underdeveloped and is expensive in areas where it can be accessed [108]. Other platforms that are less expensive are used. These are the GSM and GPRS platform that are offered by the mobile telecommunication providers. On this platform, the short message service (SMS) is used as alternative to voice as it is cheaper [109]. The SMS platform is being used in m-health, M-commerce, m-agriculture to enable communication among people, especially, in remote areas [110], [111]. The standard phones are very popular among users in Africa, because they are cheap, have longer talk time and are quite robust as compared to feature and smartphones.

In Kenya, a mobile application called M-Pesa [110] is used as an e-cash platform which enable exchange of cash among people who may not have access to a bank. People are able to exchange e-cash using their mobile phones on the SMS platform. There is a provision to redeem cash at a kiosk that offers M-Pesa services. M-Pesa has grown to cover the whole of East Africa

RapidSMS is a free and open sources system that was developed to leverage the mobile technologies [110]. The system has an administration office that is operated by a medical centre. This medical centre exchange information with field workers using SMS on their mobile phone. Rapid SMS is currently being used to provide m-health services to mothers and children in Malawi, Zambia and Kenya. It is also being used in India [112].

Commcare, is a free open source service that is used in Tanzania and is based on Javarosa

[113] which targets community health workers who make door to door calls to patients in their communities [114]. Commcare helps the health workers of their program or assignment of that particular time. The mobile phone is used for the exchange of information.

In South Africa, Project Masiluleke utilises a free-to-end user SMS based service [115]. Praekelt Foundation developed it to prompt HIV positive patients to make follow-up visits to the health clinic, amend appointments, change addresses and make lost follow ups. The AIDS counselling is also offered on this platform. Using mobile phones means that 90% of the population can be reached by this initiative. This initiative has the potential of being rolled out on a massive scale, because phones are pervasive in the whole world, unlike the traditional forms of media such as TV, Internet and radio [116].

In India, Reuters Market Light (RML) offers agricultural information to farmers since 2007. The information is sent to the farmers using SMS on their mobile phones. The information that is sent is personalised based on the stage of the crop cycle. The weather forecast and local market prices together with international commodities information is also provided by RML. One key feature of this service is that the information is personalised and can be accessed by a farmer in his own local language [117]. This service has helped the farmers to plan their activities pertaining to planting, harvesting and hiring of labour when the weather is right. The service has also help them sell their commodities at better prices on international markets. This has made the farmers make good profits [118].

Zambia has seen a number of SMS base systems being used in various sectors. The mobile operators offer SMS services to their subscribers. These operators include Airtel [119], MTN [120] and Zamtel. The other SMS provider that offer bulk SMS is a private company called SMS Solutions. In the banking sector, all the banks that operate in Zambia including Barclays Bank [121], Standard chartered Bank [122], Stanbic Bank [123], IndoZambia Bank [124], Eco Bank, First National Bank and Zambia National Commercial Bank operate SMS, where customers get information, pertaining to the transactions on their accounts, on their mobile phones. In the health sector, SMS is being used for m-health to send reminders to patients [125] and delivery of laboratory results [126] to the clinics. In Agriculture, the Zambia Farmers Union is using an SMS mobile application to link farmers and traders in all districts in Zambia [127]. These applications only provide contact information of the farmer and location and indicative price of the agricultural produce. The other transactions are done outside this platform. This system does not arrange transport nor does it guarantee a contact. It also does not arrange payment.

2.4.2 Food Policy

The Food Supply Chain must make available information pertaining to the variety of the food attributes, animal welfare, country of origin, and genetic engineering related issues, to the consumer and other concerned parties. It is for this reason that effective and efficient food traceability systems are important, so that food issues such food scares, which have haunted mankind for long time, can be prevented or addressed. Public health risks [92] that are caused by food crises have profound impact that culminate into economic crises which result in both indirect and direct costs. The indirect costs are due to the cost of recall because of the market value and reputation loss could result in the total bankruptcy of a brand name. The risk of food contamination can affect the FSC negatively as was the case, in Japan in 2011, when radioactive materials were released from damaged nuclear plants [128]. Intensive food control measure has been put in place between Japan and other countries in order to ensure food safety.

2.5 Summary

In this chapter, a comprehensive overview of the background theory behind the technology that is used for mobile communication, has been given. In particular, the mobile technology and the web technology has been discussed. The policy and regulation aspects that concern the food supply chain has also been covered. Application of ICTs and SMS, in particular, in the field of health, education, commerce and agriculture have been discussed. Further, some examples of the related works to the use of SMS has been discussed as well. The food supply chain and its important aspects of traceability, security, safety and availability, have been covered and so has the food policy

CHAPTER THREE:

METHODOLOGY

3.1 Introduction

In this chapter, the study that was conducted to justify the development of ICT solution to problems that are encountered by the small scale traders and farmers, is looked at. In order to develop the mobile application, a survey was conducted to establish the current status of the food supply chain in Zambia pertaining to small scale farmer and trader participation and to establish the levels of utilization of ICTS among them. It was conducted at Soweto market in Lusaka and Libuyu Market in Livingstone. Lusaka, the capital City of Zambia and Livingstone being Zambia's tourist Capital were chosen for the survey. The questionnaires were designed to establish the sources of food commodities relative to where they are sold to the consumers. The appreciation of the use of ICTs such as mobile phone through the use of Voice and data. The use of data was deduced from the use of mobile money. The questionnaires also covered the aspect of exposure to risks related to travel, cash transaction and securing of commodities.

Later, the Development and implementation of the mobile application, which is the proposed solution to reduce the cost of doing business by the small scale traders and farmers, was looked at. It also looks at the methodology that were used for the software development process, function and non-functional requirements, process maps, implementation of languages and the configuration of equipment. The ICT solution, called Smart Trader, was developed using the agile method. All the modules of the Smart Trader were developed separately and linked together during presentation and testing, then changes were made when need arose.

3.2 Baseline Study

Zambia is situated in Central Southern Africa and shares borders with Zimbabwe, Botswana, Namibia, Angola, DRC, Tanzania, Malawi and Mozambique. It is divided into 10 provinces, as shown in Figure 10. and has a population of 15million people [129]. Zambia covers an area of 752,612 Km² and is highly urbanized with a population density of 100 people per square kilometer in Lusaka. Lusaka has a population of at least 2.8million people [130].



Figure 10 Map of Zambia [131]

The baseline study was conducted in Lusaka and Livingstone. Soweto market in Lusaka was chosen because it is visited by traders from all the towns of Zambia including traders from the neighboring countries. A variety of agriculture commodities are traded in this market. Livingstone was chosen because it is a border town which is visited by a lot of tourists from all over the world, who come to see the Victoria Fall and visit a number of national parks which are located in Zambia, Zimbabwe, Namibia and Botswana.

3.2.1 Data Collection

The study that was conducted at Soweto market was targeted at the small scale and informal parts of the market. This is the part is managed by party cadres, and the traders really struggle in order to make profit. The main objective of this study is enable the small scale trader/farmer participation in the food supply chain. This is unlike the parts of the market that have been covered in the research AgWater Solution Project [132], [133]. Beside, AgWater Solution project concentrated on the formal traders at Soweto market. The sample design and actual sampling was conducted and is as presented in Table 10.

Table 10: Sample Design and Sampling

Type of Frame	Sampling Technique and Justification	Population Element
	Used non probability sampling techniques as follows	
Primary frame	Judgement sampling – On consideration that being the largest of the City markets, trade in traders characteristics would be clearly notable, and being in an urban setup motivation toward food commodities trading would be conspicuous	Traders who operate from Soweto market in Lusaka and Libuyu market in Livingstone
Secondary frame	Convenient sampling – to manage time limitations and resources constraints, markets were selected based on proximity to workstation in Lusaka and Livingstone.	Two markets were selected in Zambia and there were : 1. Soweto market in Lusaka 2. Libuyu market in Livingstone
Tertiary Frame	Probability systematic sampling – chosen to eliminate any element of bias.	120 respondents comprising 60 from each of the two markets were selected, on the bases of every k_{th} respondent, where $-k$ is a number of respondents/60

There were at least six hundred fifty 650 respondents, and One hundred and twenty (120) were targeted for the survey. The total population of (650) respondents participated in the survey, representing 18.5% sample size

3.2.2 Research Approach

Data was collected from the targeted population using a combination of methods, which

included interviews and questionnaires. Two markets were selected in Zambia, namely Soweto market in Lusaka, and Libuyu market in Livingstone. Appendix B contains the questionnaires and other relevant document that were used in this research. The data collection commenced in April 2015 and end in May 2015. The questionnaires had questions that were used to meet the Objectives of the study which were highlighted in Chapter 1.

3.2.3 Development of the mobile application

This section describes the system development life cycle that was used to develop the application. A systems development life cycle (SDLC) is an outline that is used describe the stages of developing an information system. These software development systems models include the waterfall model, rapid application development model, the spiral model, the incremental model and the prototype model. These life cycle models are also known as predictive life cycles because the latitude of the projects can be clearly expressed and the schedule and the cost can precisely be predicted. A lot of time is used by the project team, to clarify the requirements of the entire system and then producing a design. For an extended period, users are often unable to see any real results in terms of the working software.

On the other hand, the Adaptive Software development (ASD) life cycle models, which are the opposite of the Predictive life cycle models, assume that software development follows an adaptive approach because the requirements cannot be clearly expressed early in the life cycle. Unlike the predictive approaches, the adaptive approach offers more freedom to create components that provide functionality that is specified by the business group, using a freer form approach.

- **Agile methods**

The software development industry has embraced agile methods and rapidly moving away from the traditional software development methods because they are flexible and deliver paybacks such as handling change requests, productivity gains and business alignment in a timely manner [134]. The agile method also present advantages such as accelerated time to market, increase in quality and productivity.

Agile System Development Life Cycle (SDLC) model is an amalgamation of iterative and incremental process models with emphasis on process adaptability and customer satisfaction by speedy conveyance of functioning software product. Agile Methods are made up of small

incremental blocks of the product. These blocks are grouped into iterations, whose duration is short, say one to three weeks long. Every iteration encompasses cross functional teams working concurrently on different areas like planning, requirements analysis, design, coding, unit testing, and acceptance testing, as shown in Figure 11. At the end of the iteration, a working product is presented to the customer or stakeholders for the much needed feedback. In the agile method, tasks are divided into small time frames in which to deliver specific features for a release. When Iterative approach is taken, a working software build is delivered after each iteration. Each build is incremental in terms of features, and the final build holds all the features required by the customer.

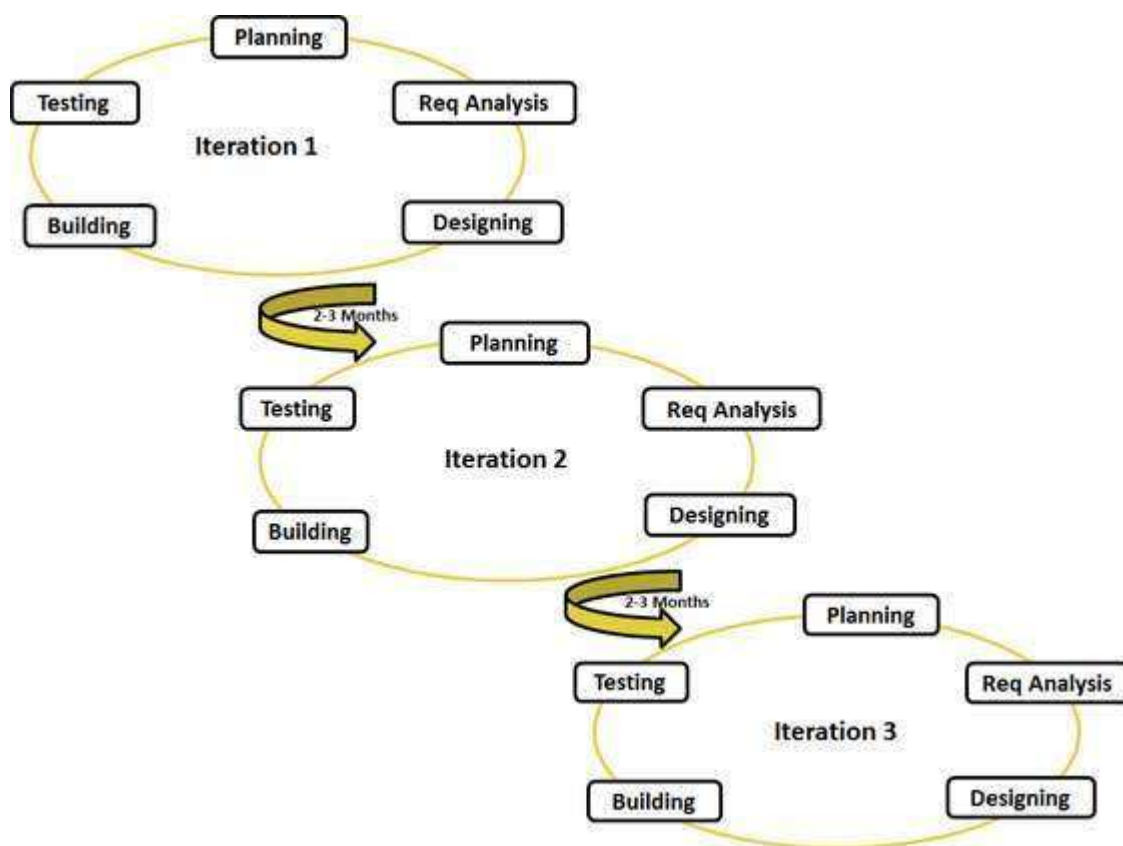


Figure 11: Graphical Illustration of Agile Model

The thought process of the Agile method started early in the software development and became popular with time due to its flexibility and adaptability. The Agile Manifesto principles includes the following benefits:

- I. **Individuals and interactions** – agile development fosters self-organization and motivation and these are as important, as are interactions that come due to co-location and pair programming.

- II. **Working software** – Agile methods involves showing a Demo working software to the client. This is considered to be the best means of communicating with the customer, in order to make sure that their requirement have been understood. This is more effective than just presenting documentation.
- III. **Customer collaboration** – It is usually difficult for the client to clearly present their requirements to the programmer due to various factors. It important that there is continuous interaction with the customer in order to get proper product requirements.
- IV. **Responding to change** – One of the important features of the agile development is getting quick responses to changes and continuous development.

Agile is centred on the adaptive software development methods as opposed to the traditional SDLC models which are based on the predictive approach such as like waterfall model. In the traditional SDLC models, Predictive teams usually work with exhaustive planning and have a complete forecast of the exact tasks and features to be delivered during the product life cycle. Predictive methods completely rely on the requirement analysis and planning done at the start of the cycle. Adjustments that are to be made have to be scrutinised through a stringent change control management and prioritization process.

Adaptive approach is used in agile method, where detailed planning is not critical, but for clarity in future tasks in regard to what features need to be developed, is required. Feature driven development is required and the team adapts to the changing product requirements dynamically. The product is tested repeatedly, through the release iterations, thus, reducing the risk of any catastrophe in future.

Customer interaction is the pillar of agile methodology. Open communication with minimum documentation is an important feature of an agile development environment. The agile teams collaborate closely with each other and are usually located in the same geographical location.

In this study the agile method was used to develop the application and the system analysis was conducted as described in the next sections.

3.2.4 System Design

A system analysis was done in order to determine the requirements of the system. The Smart

Trader system requirements document was generated. Functional and non-functional requirements were developed. In order to develop the requirements, the use case diagram and use case text were developed.

The Smart Trader System is a mobile application which has been developed and is based on the short message service (SMS) platform. It has three main actors and these are the system administrator, the trader and the farmer. The cooperative owns and manages the system, through its system administrator while the trader and the farmer interact with the system without physical contact.

Both the trader and the farmer have to be enrolled on the system by the cooperative. The cooperative has two type of users and these are Administrator and standard user. The role of the administrator is to manage the whole system while the standard user can only manage the farmers.

a. Functional Requirements

Functional requirements describe what the system should do such as things that can be captured in use cases and things that can be analyzed by drawing sequence diagrams and state charts. Functional requirements will probably trace to individual chunks of a program.

Functional requirements are the properties or function of the System. Smart Trader supports three users, namely; Administrator, User and Trader. User has limited administrative tasks. The following are the functional requirements of Smart Trader.

- **TRADER**

- 1) **Buy:** Traders must be able to buy products from Smart Trader Using SMS.
- 2) **Check Balance:** The Trader must be able to check the balance of the his/her account
- 3) **Inquire:** The trader must be able to inquire about Smart Trader
- 4) **Search Product Category:** The Trader must be able to search the product categories from Smart trader and then buy
- 5) **Search Products:** The Trader must be able to search products offered by Smart trader and the buy

- **ADMINISTRATOR**

- 1) **Add Administrator and Users:** The administrator must be able to add other administrators and users

- 2) **Edit Administrator and Users:** The administrator must be able to edit administrators and Users information
- 3) **View Administrator and Users:** The administrator must be able to view administrators and Users
- 4) **Delete Administrator and Users:** The administrator must be able to delete administrators and Users
- 5) **Search Administrator and Users:** The administrator must be able to search for administrators and Users
- 6) **Add Trader:** The administrator must be able to add traders to Smart Trader
- 7) **Edit Trader:** The administrator must be able to edit traders' information
- 8) **View Trader:** The administrator must be able to view traders
- 9) **Delete Trader:** The administrator must be able to delete traders
- 10) **Search Trader:** The administrator must be able to search for Traders
- 11) **Add Farmer:** The administrator must be able to add Farmers to Smart Trader. Farmers must be assigned and products they produce and sell.
- 12) **Edit Farmer:** The administrator must be able to edit Farmers information
- 13) **View Farmer:** The administrator must be able to view Farmers
- 14) **Delete Farmer:** The administrator must be able to delete farmers
- 15) **Search Farmer:** The administrator must be able to search for Farmers
- 16) **Add Units:** The administrator must be able to add units of measure to Smart Trader
- 17) **Edit Units:** The administrator must be able to edit Units information
- 18) **View Units:** The administrator must be able to view Units
- 19) **Delete Units:** The administrator must be able to delete Units
- 20) **Search Units:** The administrator must be able to search for Units
- 21) **Add Product Categories:** The administrator must be able to add product categories to Smart Trader. Product categories are categories of products Smart Trader will be selling.
- 22) **Edit Product Categories:** The administrator must be able to edit product categories information
- 23) **View Product Categories:** The administrator must be able to view Product categories
- 24) **Delete Product Categories:** The administrator must be able to delete Product Categories

- 25) **Search Product Categories:** The administrator must be able to search for Product Categories
- 26) **Add Products:** The administrator must be able to add products for sale to Smart Trader.
- 27) **Edit Products:** The administrator must be able to edit products information
- 28) **View Products:** The administrator must be able to view Products
- 29) **Delete Products:** The administrator must be able to delete Products
- 30) **Search Products:** The administrator must be able to search for Products
- 31) **Import Product Categories:** The administrator must be able to import product categories information from an excel file into Smart Trader. This will allow to import information from another system or the web.
- 32) **Import Products:** The administrator must be able to import products information from an excel file into Smart Trader. This will allow to import information from another system or the web.
- 33) **Add Locations:** The administrator must be able to add Locations at which products can be collected by Traders after buying products. The location must be any place in Zambia.
- 34) **Edit Locations:** The administrator must be able to edit Location information
- 35) **View Locations:** The administrator must be able to view Locations
- 36) **Delete Locations:** The administrator must be able to delete Locations
- 37) **Search Locations:** The administrator must be able to search for Locations
- 38) **Add Threshold:** The administrator must be able to add product thresholds to Smart Trader. Product threshold is a number set by the administrator that defines the lowest quantity Smart Trader can hold for a particular product. If the quantity of the product goes below the threshold, Smart Trader must notify the Administrator
- 39) **Edit Threshold:** The administrator must be able to edit product threshold
- 40) **View Threshold:** The administrator must be able to view product thresholds
- 41) **Delete Threshold:** The administrator must be able to delete product thresholds
- 42) **Search Threshold:** The administrator must be able to search for Thresholds
- 43) **View Transactions Due Transportation:** The administrator must be able to view trader's transactions due to be transported. Every time a Trader buys a product, Smart trader records the transaction as due for transportation. The

administrator must be able to mark transactions as transported once the bought products are delivered to the Trader. The administrator must be able to search transactions and export the information to an excel file.

- 44) **View Products below threshold:** The administrator must be able to view products that are below their thresholds. This will ensure that Smart Trader never runs out of products to sale to Traders. The administrator must be able to search products below threshold and export the information to an excel file.
- 45) **View Transactions:** The administrator must be able to view transactions. When a transaction is marked as transported, Smart Trader must keep the information perpetually under a separate window. The administrator must be able to search transactions and export the information to an excel file.
- 46) **View Inquiries:** Smart Trader must allow users to query for information about Smart Trader. The administrator must be able to view, search and export queries to an excel file.
- 47) **View Product Location Consumption Graphs:** The administrator must be able to view statistical graphs of how products are consumed by different location in the country. This will allow implement product's traceability. The graphs must be printable and exportable.
- 48) **View Summarised Graphs:** The administrator must be able to view summarized statistical graphs of products financial contribution to the revenue and transactions per Traders across a period of time. This information will be used for business decision. The graphs must be printable and exportable.
- 49) **View System logs:** Smart Trader must keep records on the usage of the system. The administrator must be able to view, search and export logs to an excel file.
- 50) **Manage Modem:** The Administrator must be able to start and stop the GSM Modem. The GSM modem is the channel through which Smart Trader must send and receive SMSs from Traders.

- **USER**

- 1) Manage Farmers (add, edit, delete, view and search)
- 2) Manage Units (add, edit, delete, view and search)
- 3) Manage Product Categories (add, edit, delete, view and search)
- 4) Manage Products (add, edit, delete, view and search)
- 5) Import Product Categories from excel file
- 6) Import Products from excel file
- 7) View, search and export Transactions Due Transportation
- 8) View, search and export inquiries

b. Non-Functional Requirements

Non-Functional requirements can be defined as global constraints on the software system and they include development costs, operational costs, performance, reliability, maintainability, portability, robustness etc. they usually cannot be implemented in a single module of a program

Smart Trader has the following non-functional requirements.

1. The System must be user friendly. The Traders must be able to buy products with at most eight SMSs
2. The system must be fast. Smart Trader must take less than 10 seconds to respond to an SMS from a Trader.
3. The System must be accurate. The System must handle all financial transactions accurately and if an error occurs, the system must revert back to the previous state
4. The System must allow more than one Trader to buy at the same time
5. The system must comply to the laws of Zambia concerning trade

c. Use case diagrams

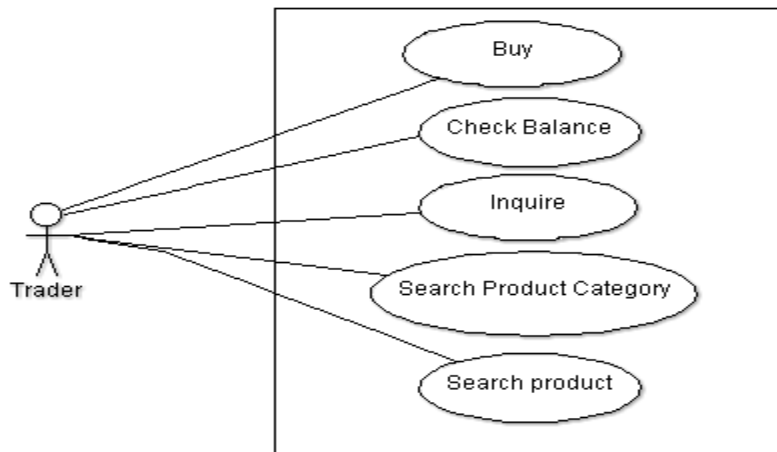


Figure 12: Use Case diagram for Trader

The use case diagram, shown in Figure 12. shows how the trader interacts with the system. The trader is able to do this through an SMS enabled GMS mobile phone.

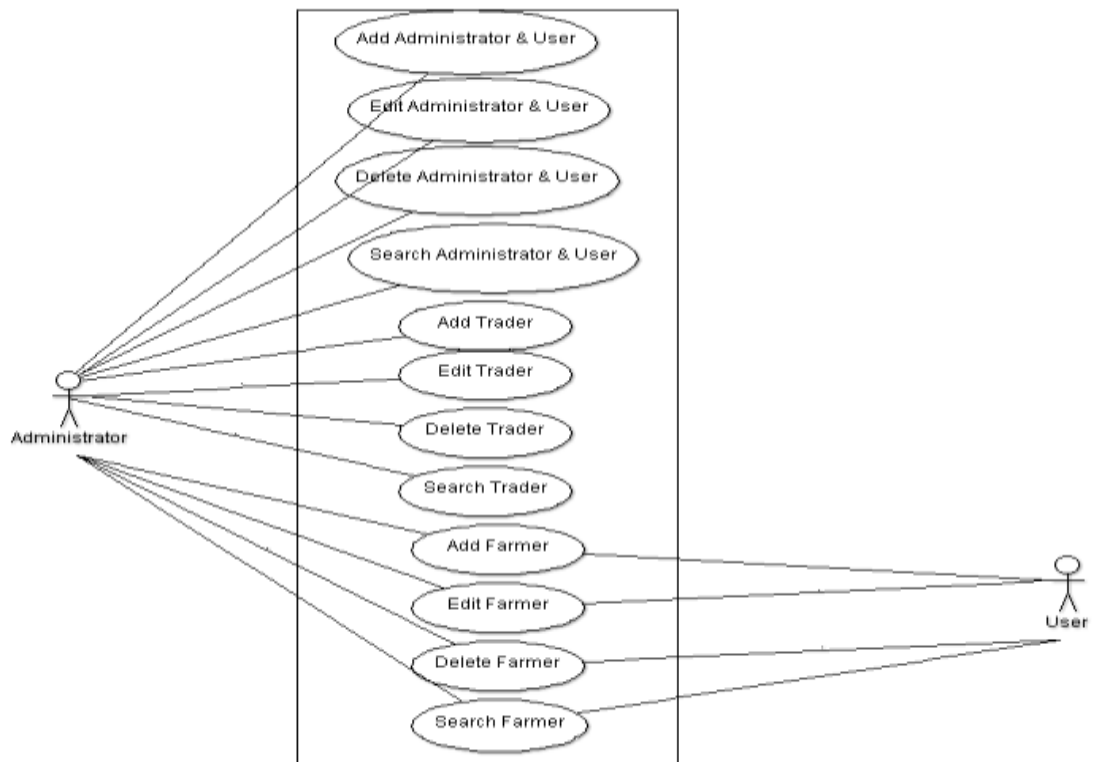


Figure 13: Use case diagram for the administrator and user

The use case shown in Figure 13, Shows how the administrator and the user of the system interact with the system. The administrator can add, edit, delete or search a user or another

administrator. The administrator can also add, edit, delete or search a trader. Both the administrator and the user can add, edit, delete and search for a farmer on the system.

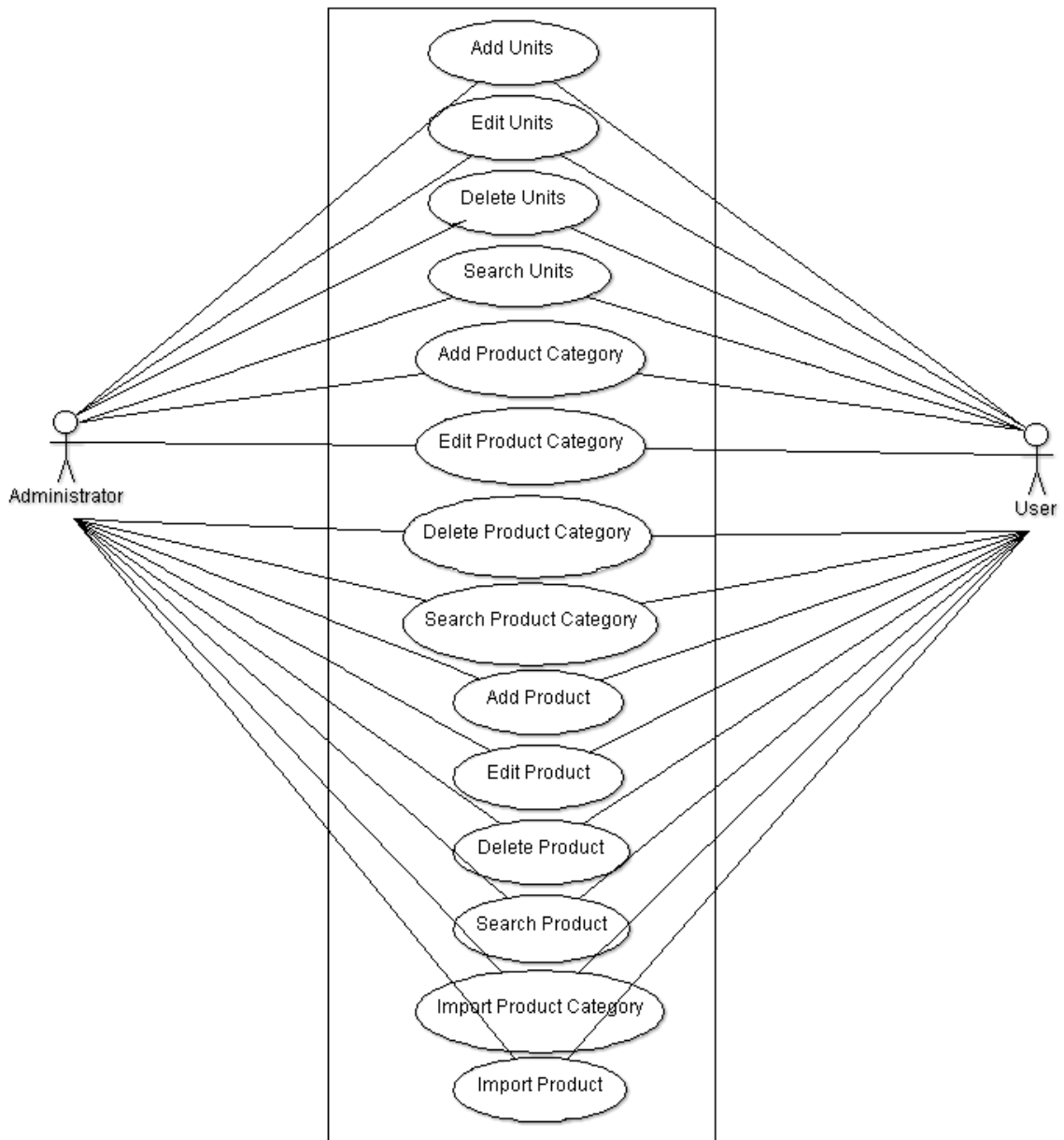


Figure 14: Use case diagram for the Administrator and the user

In the use case diagram shown in figure 14. Both the administrator and the user can add, edit, delete, search, import product category and import, products. They can perform similar operations on units.

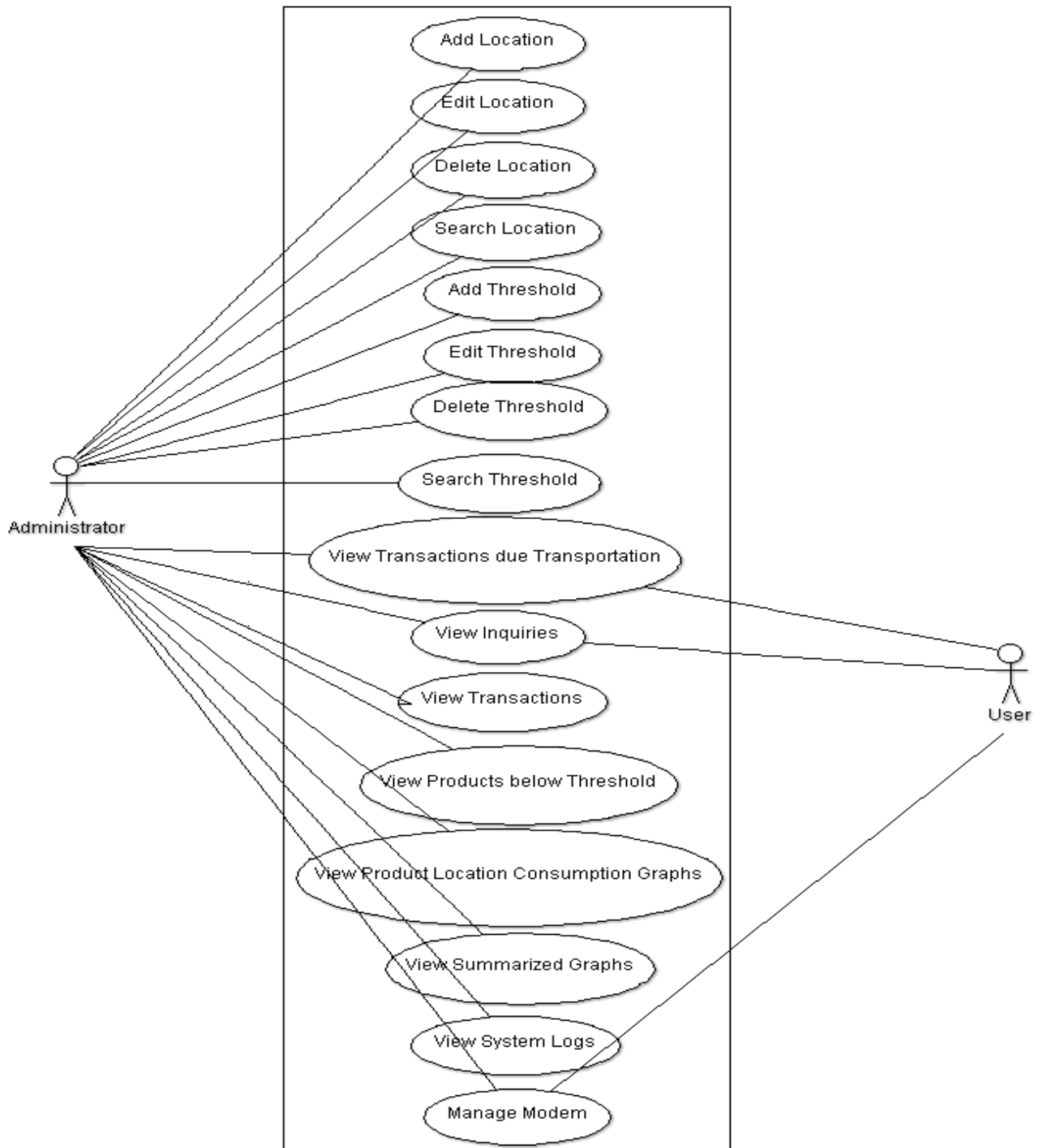


Figure 15: Use case diagram for Administrator and User

As shown in Figure 15, the administrator is able to view various transactions which include add, edit, search, delete and search location. The administrator is also able to add, edit, search, delete and search Thresholds. The administrator is also able to view the transactions due to transportation, inquires, transactions, products below threshold, product location consumption graphs, summarised graphs, and system logs. Both the administrator and the

user are able to manage the modem, view transaction due to transportation and view inquiries.

d. Use case text

The use case text is a methodology that is used in system analysis to identify, clarify, and organise system requirements.

This section shows the textual story of how the user interacts with the system to perform his/her functional requirements. Only some functional requirements are shown.

The use case text for inquire, which is a function that is performed by the trader on his mobile phone, is shown in Table 11. It shows the actor, precondition, post condition, the main scenario and alternative flow. This explanation follows for Tables 12 to 38, where different use cases and actors are featuring.

Table 11: Use case text for Inquire

Use case Name	Inquire
Actor	Trader
Pre-condition	Know the system number
Post Condition	Information given
Main Scenario <ol style="list-style-type: none"> 1. Trader: Types the inquire Keyword and send the message 2. System: system sends information about the system 3. Trader: Views the information 	
Alternative flow <ol style="list-style-type: none"> 1a Wrong keyword <ol style="list-style-type: none"> 1. System: system tells the user to resend the message 2. User: user sends Inquire key word again 	

Table 12: Use case text for Check Balance

Use case Name	Check Balance
Actor	Trader
Pre-condition	Know the system number
Post Condition	Information given
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Trader: Types the balance Keyword and send the message 2. System: system sends balance information of the account of the user 3. Trader: Views the balance information 	
<p>Alternative flow</p> <p>1a Wrong keyword</p> <ol style="list-style-type: none"> 1. System: system tells the user to resend the message 2. User: user sends balance key word again 	

Table 13: Use case text for Buy

Use case Name	buy
Actor	Trader
Pre-condition	Have an account with the system
Post Condition	Products bought
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Trader: enters the buy keyword and sends 2. System: displays the product category 3. Trader: select product category 4. System: Displays products under that category 5. Trader: Select Product 6. System: Asks for quantity 	

Table 14: Use case text for Buy “Table 13, Cont”

7. Trader: Enters quantity
8. System: requests for delivery location
9. Trader: Enters delivery location
10. System: Displays payment option (product price, product+transportation or product+transportation+insurance)
11. Trader: Selects payment option
12. System: Displays confirmation option
13. Trader: Selects the confirm
14. System: Debits the Trader account with the bought amount, reduces the quantity of the bought product and informs the Administrator about the transaction

Alternative flow

3a,5a,7a,9a,11a Wrong Selection or entry

1. System: system informs the user to enter or select the right option
2. User: user selects or enters the right input

5a Enters quantity greater than available

1. System: System displays the following message (Sorry we do not have enough product to meet your demand. Either reduce the quantity or try again later)
2. Trader enters the reduced quantity.

5b balance less than order

1. System: System displays the following message (Sorry we do not have enough product to meet your demand. Either reduce the quantity or try again later)
2. Trader:

7a Enters a deliver location not registered in System

1. System: asks the trader to try again (sorry the system does not recognise the location. Try again.)

Trader: enter a registered delivery location

13a User Cancels the transaction

1. System: Ends session

Table 14: Use case text for Search Product Category

Use case Name	Search Product Category
Actor	Trader
Pre-condition	Have an account with the system
Post Condition	Products bought
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Trader: enters the Search pc [product Category] keyword and sends 2. System: displays the product category 3. Trader: select product category 4. System: Displays products under that category 5. Trader: Select Product 6. System: Asks for quantity 7. Trader: Enters quantity 8. System: requests for delivery location 9. Trader: Enters delivery location 10. System: Displays payment option (product price, product+transportation or product+transportation+insurance) 11. Trader: Selects payment option 12. System: Displays confirmation option 13. Trader: Selects the confirm 14. System: Debits the Trader account with the bought amount, reduces the quantity of the bought product and informs the Administrator about the transaction 	
<p>Alternative flow</p> <ol style="list-style-type: none"> 3a,5a,7a,9a,11a Wrong Selection or entry 3. System: system informs the user to enter or select the right option 4. User: user selects or enters the right input 	

Table 15: Use case text for Search Product Category- “Table 14, Cont”

<p>5a Enters quantity greater than available</p> <ol style="list-style-type: none"> 3. System: System displays the following message (Sorry we do not have enough product to meet your demand. Either reduce the quantity or try again later) 4. Trader enters the reduced quantity <p>5b balance less than order</p> <ol style="list-style-type: none"> 3. System: System displays the following message (Sorry we do not have enough product to meet your demand. Either reduce the quantity or try again later) 4. Trader: <p>7a Enters a deliver location not registered in System</p> <ol style="list-style-type: none"> 2. System: asks the trader to try again (sorry the system does not recognise the location. Try again.) 3. Trader: enter a registered delivery location <p>13a User Cancels the transaction</p> <ol style="list-style-type: none"> 1. System: Ends session
--

Table 16: Use case text for Search Product

Use case Name	Search Product
Actor	Trader
Pre-condition	Have an account with the system
Post Condition	Products bought
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Trader: enters the Search p [product] keyword and sends 2. System: displays the product 3. Trader: Select Product 4. System: Asks for quantity 5. Trader: Enters quantity 6. System: requests for delivery location 	

Table 17: Use case text for Search Product - "Table 16, Cont"

7. Trader: Enters delivery location
8. System: Displays payment option (product price, product+transportation or product+transportation+insurance)
9. Trader: Selects payment option
10. System: Displays confirmation option
11. Trader: Selects the confirm
12. System: Debits the Trader account with the bought amount, reduces the quantity of the bought product and informs the Administrator about the transaction

Alternative flow

3a,5a,7a,9a,11a Wrong Selection or entry

5. System: system informs the user to enter or select the right option
6. User: user selects or enters the right input

5a Enters quantity greater than available

1. System: System displays the following message (Sorry we do not have enough product to meet your demand. Either reduce the quantity or try again later)
2. Trader enters the reduced quantity

5b balance less than order

1. System: System displays the following message (Sorry we do not have enough product to meet your demand. Either reduce the quantity or try again later)
2. Trader:

7a Enters a deliver location not registered in System

1. System: asks the trader to try again (sorry the system does not recognise the location. Try again.)
2. Trader: enter a registered delivery location

11a User Cancels the transaction

1. System: Ends session

Table 18: Use case text for Add trader

Use case Name	Add Trader
Actor	Administrator
Pre-condition	Logged in
Post Condition	Trader added
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. admin: Selects the add Trader option 2. System: displays the add trader form 3. admin: Enter Trader information (name, NRC, Address, Phone number and balance) and select the add option 4. System: add the trader and displays the success message 	
<p>Alternative flow</p> <p>3a Missing information</p> <ol style="list-style-type: none"> 1. System: Informs the user 2. Admin: corrects the information 	

Table 19: Use case text for Edit Trader

Use case Name	Edit Trader
Actor	Administrator
Pre-condition	Logged in
Post Condition	Trader Edited
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. admin: Select the edit Trader option 2. System: displays the traders 3. admin: Selects and edit Trader information (name, NRC, Address, Phone number and balance) and select the add option 4. System: edit the trader and displays the success message 	

Table 20: Use case text for Edit Trader - “Table 20, Cont”

Alternative flow
3a Missing information
3. System: Informs the user
4. Admin: corrects the information

Table 21: Use case text for Delete Trader

Use case Name	delete Trader
Actor	Administrator
Pre-condition	Logged in
Post Condition	Trader deleted
Main Scenario	
<ol style="list-style-type: none"> 1. admin: Select the delete Trader option 2. System: displays the traders 3. admin: select the trader to be delete and select the delete option 4. System: delete the trader 	

Table 22: Use Case text for Search Trader

Use case Name	Search Trader
Actor	Administrator
Pre-condition	Logged in
Post Condition	Trader searched
Main Scenario	
<ol style="list-style-type: none"> 1. admin: Select the search Trader option 2. System: displays the search trader form 3. admin: Enter Trader information (name, or part of the name) 4. System: the details of the trader displays 	

Table 23: Use case text for Add farmer

Use case Name	Add Farmer
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Farmer added
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. admin: Selects the add Farmer option 2. System: displays the add Farmer form 3. admin: Enter Farmer information (name, NRC, Address, Phone number, product categories and products the Farmers produces he sells) and select the add option 4. System: add the Farmer and displays the success message 	
<p>Alternative flow</p> <p>3a Missing information</p> <ol style="list-style-type: none"> 1. System: Informs the user 2. admin : corrects the information 	

Table 24: Use case text for Edit Farmer

Use case Name	Edit Farmer
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Farmer Edited

Table 25: Use case text for Edit Farmer - “Table 24, Cont”

<p>Main Scenario</p> <ol style="list-style-type: none"> 1. admin: Select the edit Farmer option 2. System: displays the Farmers 3. admin: Selects and edit Farmer information (name, NRC, Address, Phone number, product categories and products the Farmers produces he sells) and select the add option 4. System: edit the Farmer and displays the success message 	
<p>Alternative flow</p> <p>3a Missing information</p> <ol style="list-style-type: none"> 1. System: Informs the user 2. Admin: corrects the information 	

Table 26: Use case text for Delete farmer

Use case Name	delete Farmer
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Farmer deleted
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. admin: Select the delete Farmer option 2. System: displays the Farmers 3. Admin: select the Farmer to be delete and select the delete option 4. System: delete the Farmer 	

Table 27: use case text for Search Farmer

Use case Name	Search Farmer
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Farmer searched
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. admin: Select the search Farmer option 2. System: displays the search Farmer form 3. Admin: Enter Farmer information (name, or part of the name) 4. System: the details of the Farmer displays 	

Table 28: Use case text for Add Units

Use case Name	Add units
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Unit added
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the add units' option 2. System: displays the add units' frame 3. Admin: Enter name of Units (Kg, l, g) and description, and select the add option 4. System: add the units displays the success message 	
<p>Alternative flow</p> <p>3a Wrong invalid unit or missing information</p> <ol style="list-style-type: none"> 1. System: Informs the user that entered information is invalid 2. Admin: corrects the information 	

Table 29: Use case text for Search Units

Use case Name		Search units
Actor		Administrator and User
Pre-condition		Logged in
Post Condition		Unit searched
	<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the search units' option 2. System: displays the search units' frame 3. Admin: Enter name of Units (Kg, l, g) and select the search option 4. System: Displays the searched item 	

Table 30: Use case text for Delete Units

Use case Name		Delete units
Actor		Administrator and User
Pre-condition		Logged in
Post Condition		Unit deleted
	<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the delete units' option 2. System: displays the units' 3. Admin: select the unit to be deleted and select the delete option 4. System: deletes the selected Unit 	

Table 31: Use case text for Edit Units

Use case Name	Edit units
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Unit Edited
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the edit units' option 2. System: displays the units 3. Trader: select the unit to be edited and selects the edit option 4. System: selected item edited 	

Table 32: Use case text for Add Product Category

Use case Name	Add Product category
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Product category added
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the add product categories option 2. System: displays the add product category frame 3. Admin: Enter name of product category and description, and select the add option 4. System: add the Product category and displays the success message 	
<p>Alternative flow</p> <p>3a Wrong invalid unit or missing information</p> <ol style="list-style-type: none"> 1. System: Informs the user that entered information is invalid 2. Admin: corrects the information 	

Table 33: Use case text for Search Product Category

Use case Name	Search product category
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	product category searched
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the search product categories option 2. System: displays the search product category frame 3. Admin: Enter name of product category and select the search option 4. System: Display the search the Product category 	

Table 34: Use Case text for Delete Product category

Use case Name	Delete product category
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Product category deleted
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the delete Product category option 2. System: displays the Product Categories 3. Admin: select the Product category to be deleted and selects the delete option 4. System: deletes the selected Product category 	

Table 35: use case text for Edit Product category

Use case Name	Edit Product category
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Product category Edited
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the edit Product category option 2. System: displays the Product categories 3. Admin: select the Product category to be edited and selects the edit option 4. System: selected item edited 	

Table 36: use case text for Add Product

Use case Name	Add Product
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Product added
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the add product option 2. System: displays the add product frame 3. Admin: Enter name of product information (name, product category, units, quantity, price per unit and description), and select the add option 4. System: add the Product and displays the success message 	
<p>Alternative flow</p> <p>3a Wrong input or missing information</p> <ol style="list-style-type: none"> 1. System: informs the user 2. Admin: corrects the information 	

Table 37: Use case text for search Product

Use case Name	Search product
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	product searched
<p>Main Scenario</p> <ol style="list-style-type: none"> 5. Admin: Select the search products option 6. System: displays the search product frame 7. Admin: Enter name of product and select the search option 8. System: Display the search the Product 	

Table 38: Use case text for Delete Product

Use case Name	Delete product
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Product deleted
<p>Main Scenario</p> <ol style="list-style-type: none"> 5. Admin: Select the delete Product option 6. System: displays the Products 7. Admin: select the Product to be deleted and selects the delete option 8. System: deletes the selected Product 	

Table 39: Use case text for Edit Product

Use case Name	Edit Product
Actor	Administrator and User
Pre-condition	Logged in
Post Condition	Product Edited
<p>Main Scenario</p> <ol style="list-style-type: none"> 5. Admin: Select the edit Product option 6. System: displays the Product categories 7. Admin: select the Product to be edited and selects the edit option 8. System: selected item edited 	

Table 40: Use case text for View Product Location graph

Use case Name	View Product Location Graph
Actor	Admin
Pre-condition	Logged in
Post Condition	Product Location Graph Views
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the View Product Location Statistics option 2. System: displays the Graph Options 3. Admin: Select the Graph information (product and the dates) and Select view graph option 4. System: displays the Graph showing product consumption in Locations 	

Table 41: Use case text for View Summarized Statistics

Use case Name	View Summarized Statistics
Actor	Admin
Pre-condition	Logged in
Post Condition	Financial distribution Viewed
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the view Summarized statistics option 2. System: displays the Graph Options form 3. Admin: select the period of report and select View Graphs 4. System: Displays summarised statistics (Financial Distribution and Trader Transactions) 	

Table 42: Use case text for View Transaction due to transport

Use case Name	View Transaction due to transport
Actor	Admin
Pre-condition	Logged in
Post Condition	Transported
<p>Main Scenario</p> <ol style="list-style-type: none"> 1. Admin: Select the Transaction due to transport option 2. System: displays the Transaction due to transport form 3. Admin: select the transaction to be transported and select transported 4. System: displays the transaction successful 	

e. Hardware and Software Requirements

A Laptop computer was used in the implementation of the mobile application (Smart trader System) were running on the AMD A6-5200 APU with Radeon™ HD Graphics at 2.0GHz with a minimum of 8GB RAM. This is the device is used to manage requests from mobile via SMS. It runs Windows 8.1 64-bit operating systems, but the system is able to work on both

windows 7 and Windows 10. The other software requirements included the Java language SDK. For the database, the MySQL database is used to store both the Smart Trader system templates and the other credentials captured during registration so that they are used for the authentication process. NetBeans IDE is used as the development environment. The modem that was used is a Huawei Mobile Broadband LTE USB stick Model E3272. It was configured to handle SMSs on the Airtel 4G network.

f. System Implementation of the Smart Trader

In this section, the system design for the Smart Trader System whose concept is based on cloud computing is looked at. Cloud computing is a metaphor for the internet. In cloud computing the computers and other networking devices use the internet as a network backbone as opposed to having on premises computer and server devices, where the information is accessed on the local hard drive.

The decision to implement the mobile application on standard phone and not smartphone is because of the target group of user of the Smart Trader System, who are mainly small scale traders and farmers use the standard phones. Small scales traders and farmer are very sensitive to prices and find the standard phone affordable. These phones are easy to operate and they have low demand for battery power, as such, they have a longer talk time as compared to the smart phones. They are quite robust and can sustain rough handling. They can be used in most of the rural areas of Zambia where the Mobile phone operators have already installed 1G 2G networks which may not support Web mobile applications but SMS.

3.3 Smart Trader System Design

3.3.1 Context diagram

The following diagram shows how Smart Trader System interacts with its environment.

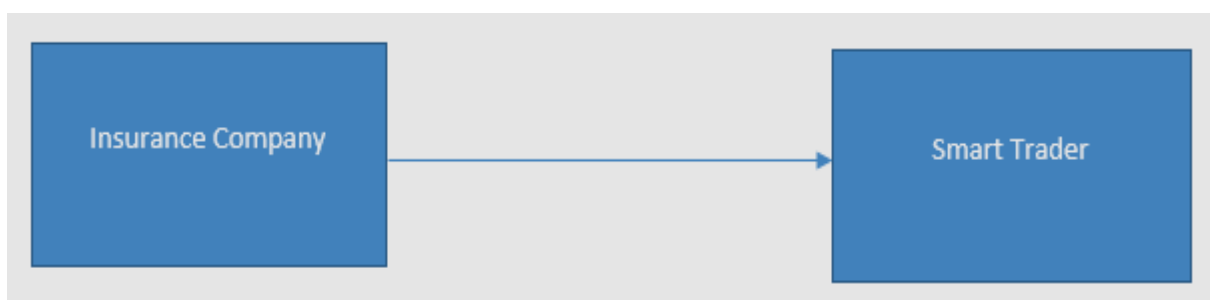


Figure 16: Context diagram:

The context diagram of the smart trader system is as shown in Figure 16. The smart trader system offers traders and option to buy products with insurance. The system gets its insurance information about different products from an Insurance company via the network. The insurance rates are determined by the insurance company and may vary based on distance and mode of transportation.

3.3.2 System Software Level Architectural Design

The large scale organization of Smart Trader System is as shown in Figure 17.

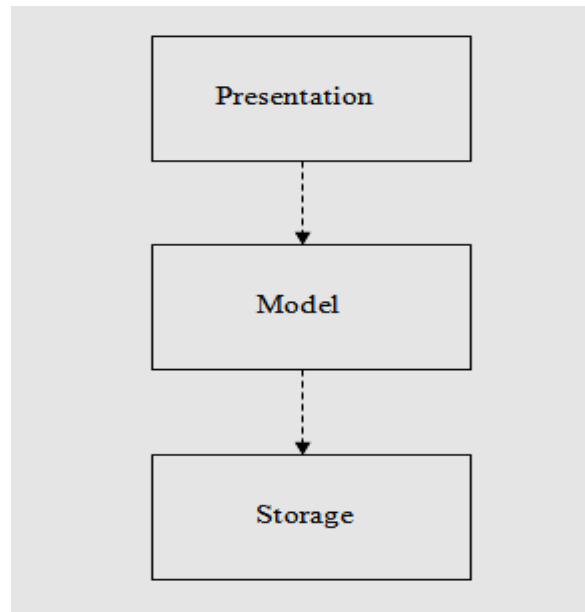


Figure 17: Large Scale System architecture

The system is divided into three layers. The presentation layer is responsible for handling user – system interactions. The presentation layer allows the administrator and user to perform all administrative tasks. When the system handles transactions with the Traders via SMS, the presentation layer is responsible for displaying these transactions to the administrator for processing. As shown in the diagram, the presentation layer depends on the Model layer.

The Model layer implements Smart Trader System logic. It is responsible for implementing all administrative tasks and the Gateway/SMS [135] module. It saves the generated data in the Storage layer.

3.3.3 Modular design of the System functions

The sub-systems that make up the Smart Trader System is as shown in Figure 18. The subsystems of the system are the administrative, the gateway, the storage, the presentation, the insurance and the export & imports modules.

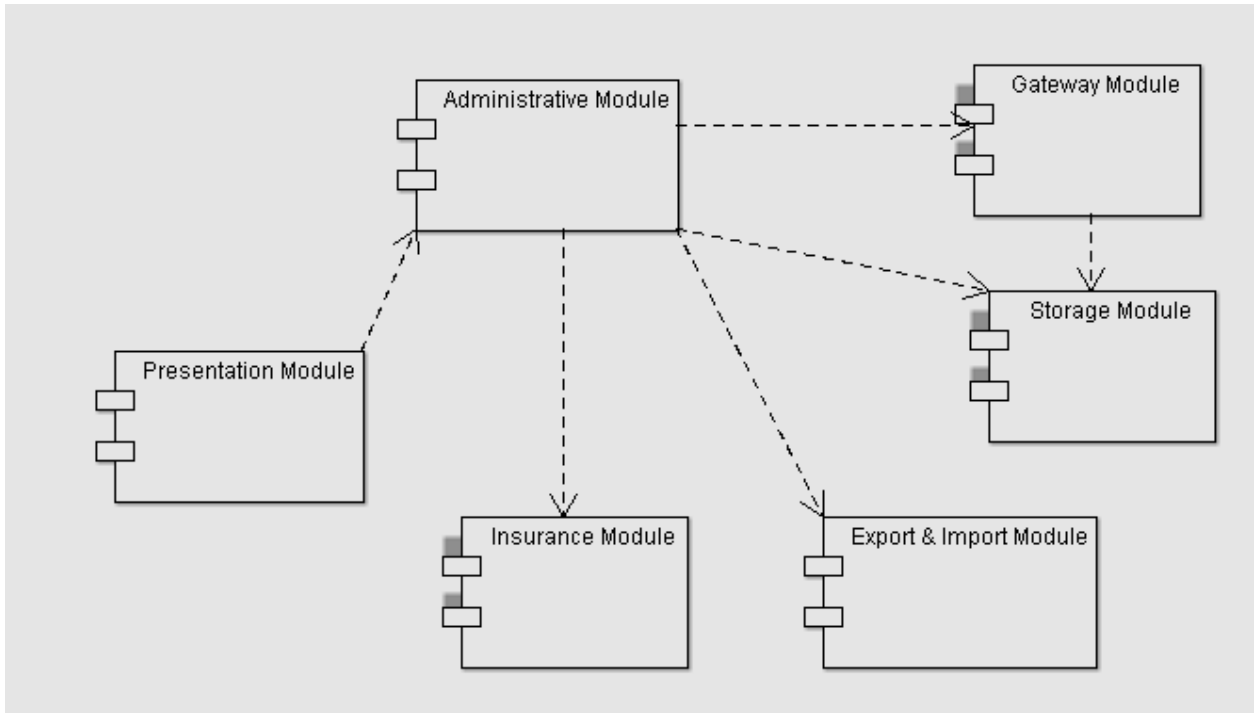


Figure 18: System Package Diagram

The system has the following sub-system;

3.3.4 Presentation Module

The presentation module is responsible for handling user-system interactions. It provides a GUI interface for the user to interact with the system. It allows the user to perform all administrative tasks, start and stop the SMS gateway module. This sub-system belongs to the presentation layer of the System.

3.3.5 Administrative Module

The administrative module is responsible for implementing all administrative tasks. This sub-system belongs to the model layer of the System. It interacts with the administrator or the standard user on the Smart Trade System.

3.3.6 Insurance Module

This sub-system is responsible for pulling insurance information about products from an Insurance company via the network. Smart Trader System allows Traders to purchase products with insurance cover. This sub-system belongs to the model layer of the System

3.3.7 Export and Import Module

Export and Import Module is responsible for exporting data from Smart Trader System to

excel file and import data from excel file into Smart Trader system. This sub-system belongs to the model layer of the System.

3.3.8 Gateway Module

This sub-system is responsible for communicating to Traders via SMS. It uses AT-Commands to communicate with an SMS modem via a serial port. It sends and receives all SMSs from the Trader. This module allows more than one Trader to transact at the same time. This sub-system belongs to the model layer of the System.

3.3.9 Storage Module

Storage is responsible for storing Smart Trader System data. This sub-system belongs to the Storage layer of the system.

3.3.10 System Class Diagram

The system class diagram of the Smart Trader System is presented as shown in Figure 19. The diagram is an illustration of the classes and their associations represented by the Unified Modeling Language (UML).

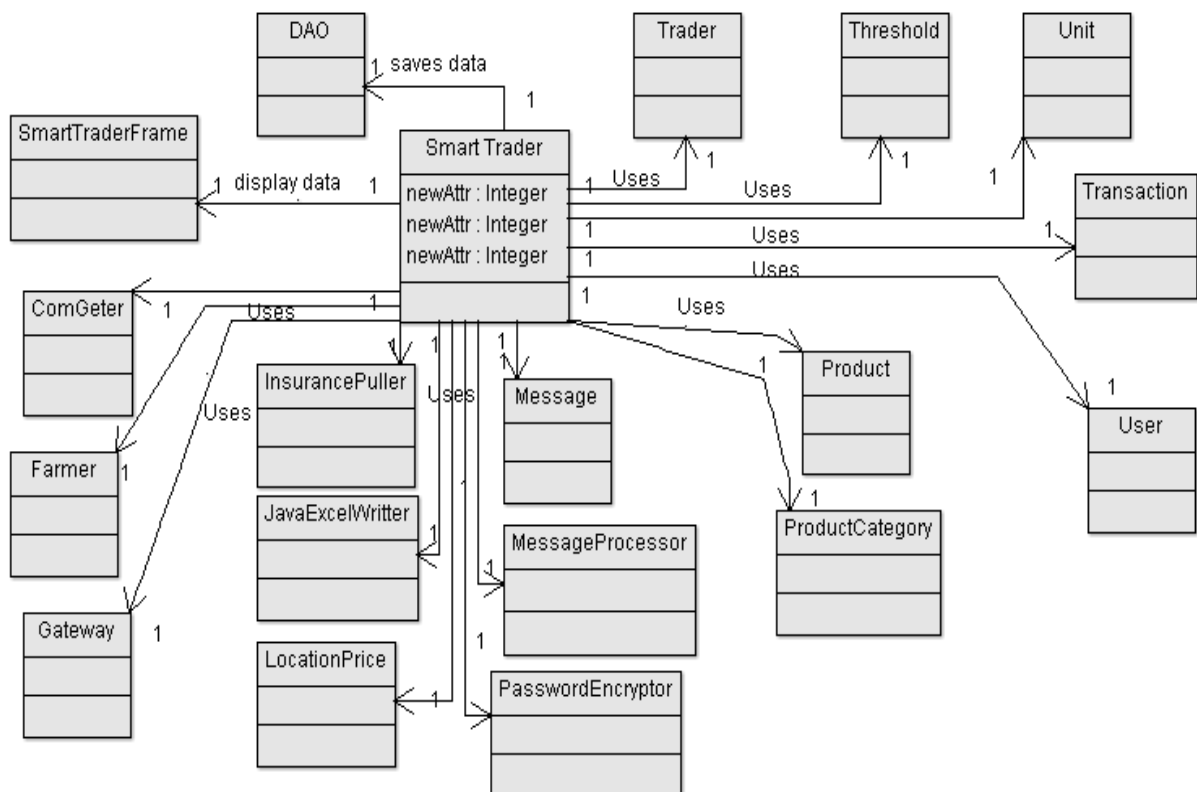


Figure 19: System Class Diagram

The class diagram is the main building block of object oriented modeling. It is used both for general conceptual modeling of the system, and for detailed modeling translating the models into programming code. The diagram below does not show all the details. Methods and attributes of each class are left out because of space.

The system class diagram uses the Data Access Object (DAO) design pattern in Java. It is used to implement persistence layer of the Java application [136].

- i) **DAO Class:** This class is the interface to the MySQL database. All queries to the database (inserting data, updating data, deleting data and retrieving data) is done through this class.
- ii) **SmartTraderFrame class:** This is the main GUI class. It holds all the menus and other windows through which the administrator interacts with the system.

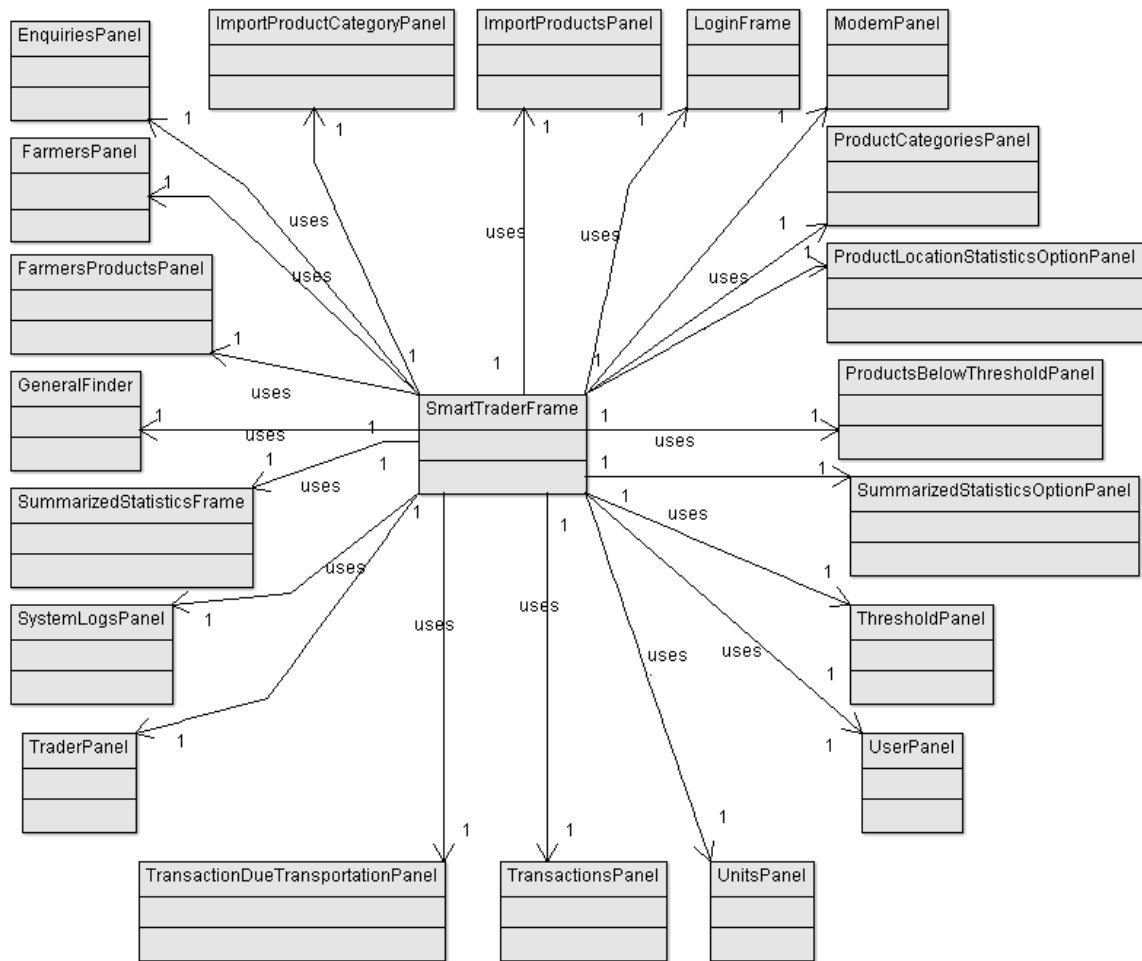


Figure 20: System Class Diagram – panels

- iii) **SmartTrader Class:** This is the main class of the system. It glues the presentation, model/logic and storage layers of the system. All interactions from the presentation layer are sent through this class to the model/logic layer and all queries to the database are sent through this class to the DAO class, as shown in Figure 20.
- iv)
- v) This design decision decouples layers of the system which makes it easy to replace one layer with another with minimum change.
- vi) **Trader Class:** This class represents the Trader object. It includes all the Trader attributes and behaviors.
- vii) **Farmer Class:** This class represents the Farmer object. It includes all the Farmer's attributes and behaviors.
- viii) **Unit:** This class represents the Unit of Measure object.
- ix) **Product:** This class represents the Product object. It includes all the Product's attributes and behaviors.
- x) **ProductCategory:** This class represents the product category object. It includes all the product category's attributes and behaviors
- xi) **Threshold:** Represents the Threshold object. Product threshold is a number set by the administrator that defines the lowest quantity Smart Trader System can hold for a particular product. If the quantity of the product goes below the threshold, Smart Trader System must notify the Administrator.
- xii) **User Class:** Represents the administrator and User object. It includes all the Product's attributes and behaviors.
- xiii) **Transaction Class:** This class represents a transaction done by the Trader when he/she buys a product from Smart Trader.
- xiv) **ComGeter Class:** This class is responsible for detecting the COM Number that the SMS modem is attached to.
- xv) **Message Class:** Represents an SMS sent or received by Smart Trader.
- xvi) **PasswordEncryptor Calss:** This class is responsible for encrypting User password before they are saved to the database.
- xvii) **InsurancePuller Class:** This class is an interface to the Insurance Company. It pulls insurance prices of all the products sold by Smart Trader System.
- xviii) **JaveExcelWriter Class:** This class is responsible for exporting data from Smart Trader System to an excel file.

- xix) LocationPrice Class:** This class represents a location where Traders can collect products after the purchase. It includes insurance and transportation prices from Lusaka to the location.
- xx) Gateway Class:** This is the interface of Smart Trader System to the SMS modem. It uses AT commands to communicate with an SMS modem through a serial interface of the computer. It sends and receives SMSs from traders. It implements a protocol for communication between Smart Trader System and the Trader, namely; buy->for buying products, inquire->for inquiring about Smart Trader, search pc [product category] ->for searching product categories, search p [product name] ->for searching products and balance->for checking account balance: Gateway class implements an algorithm that allow multiple traders to buy products at the same time through the MessageProcessor class.
- xxi) MessageProcessor Class:** This is a helper class to the Gateway class. It implements the buy product algorithm. When a trader wants to buy a product, Gateway class instantiates a new instance of MessageProcessor class to handle the transaction. MessageProcessor is a Thread class allowing many instances of this class to run at the same time.
- **Buy product Algorithm**
The Buy product algorithm processes all the purchases that are made on the smart trader system. Part of the buy product algorithm is as shown below and the rest is shown in appendix A1:
 1. *Begin:*
 2. declare a stack **tasks**;
 3. declare **productCategoryCounter** = 0;
 4. declare **productCounter** = 0;
 5. push items; (confirm payment, process payment, process location, display quantity, products, and product categories) into **tasks** stack;
 6. while(true){
 7. for every SMS that has come call **buyProduct** procedure;
 8. }
 9. Procedure **buyProduct**(SMS){
 10. Item item = **tasks**.peek(); //get the item from a stack
 11. If(item == “product categories”){
 12. If(SMS = “*”) {//check if the user wants to go to the previous menu

```

13.     //reduce the counter by 4
14.     productCategoryCounter = productCategoryCounter- 4;
15.     }else if(SMS ="#"){
16.         String sms;
17.         for(productCategoryCounter <4 ){
18.             //get four product categories at a time
19.             sms = sms +getProductCategory(productCategoryCounter);
20.             productCategoryCounter++; //increment product category counter

```

The rest of the Buy algorithm is shown in appendix A.

- xxii) EnquiriesPanel Class:** This is a GUI class that shows all the inquiries made by the general public and Traders about Smart Trader
- xxiii) FarmersPanel Class:** This is a GUI class that allows the administrator to manage farmers (add, edit, delete, search and view)
- xxiv) FarmersProductsPanel Class:** This is a GUI class that allows the administrator to view products associated with a farmer.
- xxv) GeneralFinder Class:** This is a GUI class used by all GUI classes when the administrator wants to search.
- xxvi) SummarizedStatisticsFrame class:** This is a GUI class that displays product's contributions to the revenue, products consumption in locations and Trader transactions over a specific period of time.
- xxvii) SystemLogsPanel Class:** This a GUI class that shows all the activities of users. Smart Trader System keeps track of user activities
- xxviii) TraderPanel Class:** This is a GUI class that allows the administrator to manage Traders (add, edit, delete, search and view)
- xxix) TransactionsDueTransportationPanel Class:** This is a GUI class that shows all the transactions done by Traders and they are due to be transported to the location selected by the Trader. The panel allows the administrator to mark transactions as transported and export the data to excel file.
- xxx) TransactionsPanel Class:** This is a GUI class that shows all the transactions done by Traders. The panel allows the administrator to export the data to excel file.
- xxxi) UnitsPanel Class:** This is a GUI class that allows the administrator to manage Units of measure used by Smart Trader System (add, edit, delete, search and view)

- xxxii) **UserPanel Class:** This is a GUI class that allows the administrator to manage Administrators and Users (add, edit, delete, search and view)
- xxxiii) **ThresholdPanel Class:** This is a GUI class that allows the administrator to manage Thresholds (add, edit, delete, search and view)
- xxxiv) **SummarizedStatisticsOptionPanel class:** This GUI class allows the administrator to choose a time frame from which to generate product's contributions to the revenue and Trader transactions graphs.
- xxxv) **ProductsBelowThresholdPanel Class:** This is a GUI class that shows all products below their threshold.
- xxxvi) **ProductLocationStatisticsOptionPanel Class:** This GUI class allows the administrator to choose a time frame from which to generate product's consumption in location graphs.
- xxxvii) **ProductCategoriesPanel Class:** This is a GUI class that allows the administrator to manage product categories (add, edit, delete, search and view)
- xxxviii) **ModemPanel Class:** This GUI class allows the administrator and user to start and stop the SMS gateway.
- xxxix) **LoginFrame Class:** This GUI class displays the login window for administrators and Users of the system.
- xl) **ImportProductsPanel Class:** This GUI class allows the administrator to import products data from excel file into Smart Trader. It implements all the logic to interpret excel data formats.
- xli) **ImportProductCategoryPanel Class:** This GUI class allows the administrator to import product Categories data from excel file into Smart Trader. It implements all the logic to interpret excel data formats.

3.3.11 System Data Model Design

This section gives the design of the database at conceptual level. Smart Trader System uses MySQL database for storage of data. MySQL is a free and open source database management system

The entities, relationships, and attributes in the domain, are as shown in Figure 21. The tables are used to hold data and the following are their functions:

- 1) **User Table:** Holds data about administrator and User of the System
- 2) **Transaction Table:** Holds data about the transactions that are done by Traders when they buy products from Smart Trader

3) **Trader Table:** Holds information about Traders. You cannot trade with Smart Trader System if you don't have an account with the system

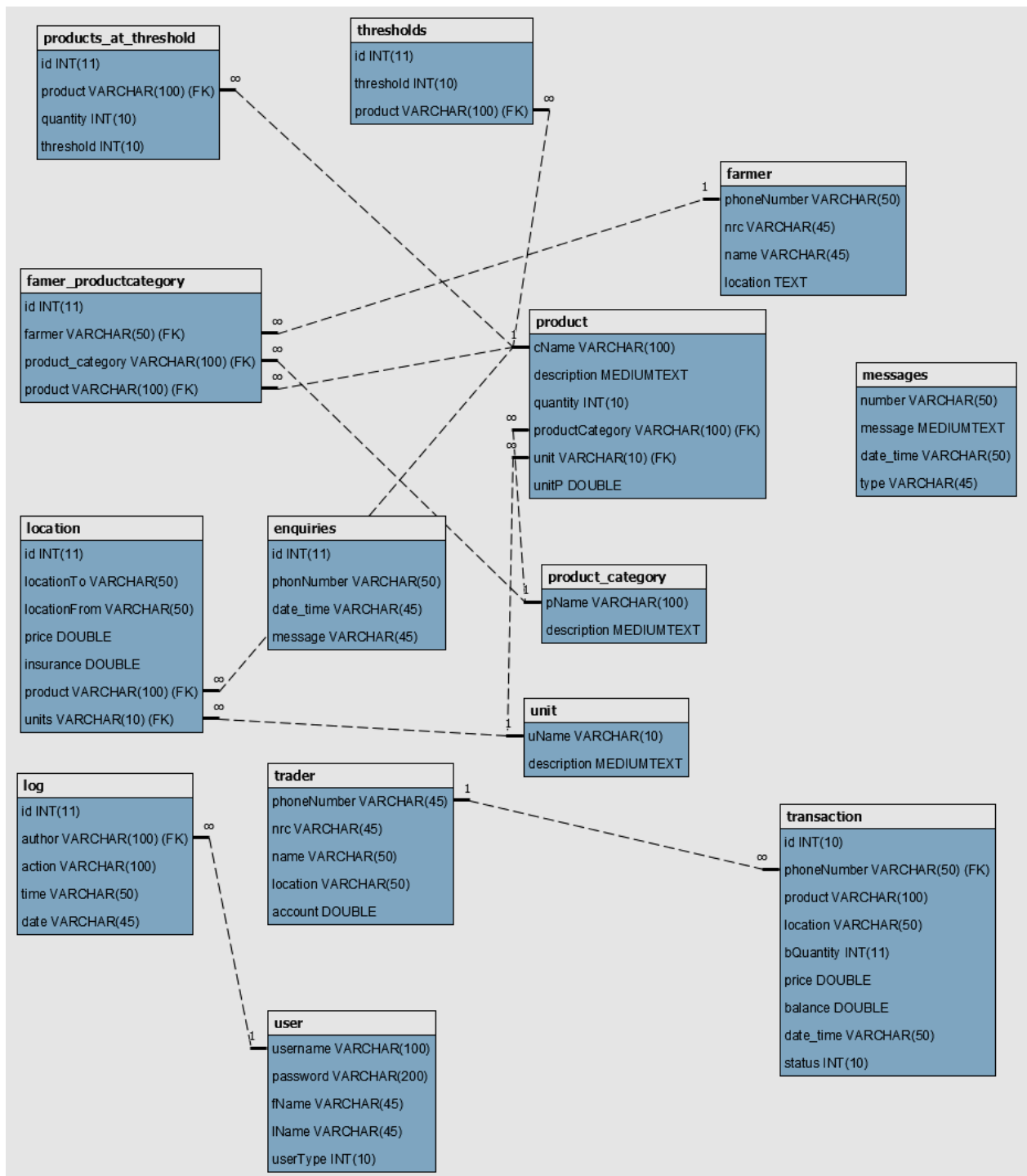


Figure 21: Entity relation Diagram

4) **Log Table:** Log keeps data about the usage of the system. Smart Trader System tracks all activities of the users of the system and keeps the data in this table.

- 5) **Unit Table:** Holds information about the units of measure used by Smart Trader.
- 6) **Location Table:** Holds data about all the locations in the country where bought products can be collected from. Transportation and insurance costs from Lusaka to specific locations is also kept.
- 7) **Enquiries Table:** Holds inquiries made by the general public and Traders about Smart Trader.
- 8) **Product_Category Table:** Holds information about the product groupings defined in Smart Trader.
- 9) **Product Table:** Holds information about all the products for sale to the Traders.
- 10) **Messages Table:** Keeps a record of all the received and sent SMS messages by Smart Trader
- 11) **Farmer Table:** Keeps information farmers.
- 12) **Farmer_productcategory Table:** Farmers are associated with products and product category. This table holds information about the associations between Farmers and products.
- 13) **Threshold Table:** Product threshold is a number set by the administrator that defines the lowest quantity Smart Trader System can hold for a particular product. If the quantity of the product goes below the threshold, Smart Trader System must notify the Administrator. Threshold table holds thresholds defined by the administrator.
- 14) **Products at threshold table:** Holds the association between products and threshold values.

3.3.12 User Interface Design

This section shows the user interface design. It shows the design decisions taken as well as the design style adopted by the system. All GUIs uses the java Nimbus look and feel. Colors white, blue and grey are adopted for all the GUIs in order to keep the interface simple and easy to use. The GUI interface is made up of a main JFrame window which contains all the menus. When a menu item is selected, then main JFrame window creates an internal frame which displays the functions under that menu item. The use of internal frames makes the organization of windows easy because the user does not need to open a lot of separate JFrame windows buy work in one JFrame window. Below are some of the screen shots of the system.

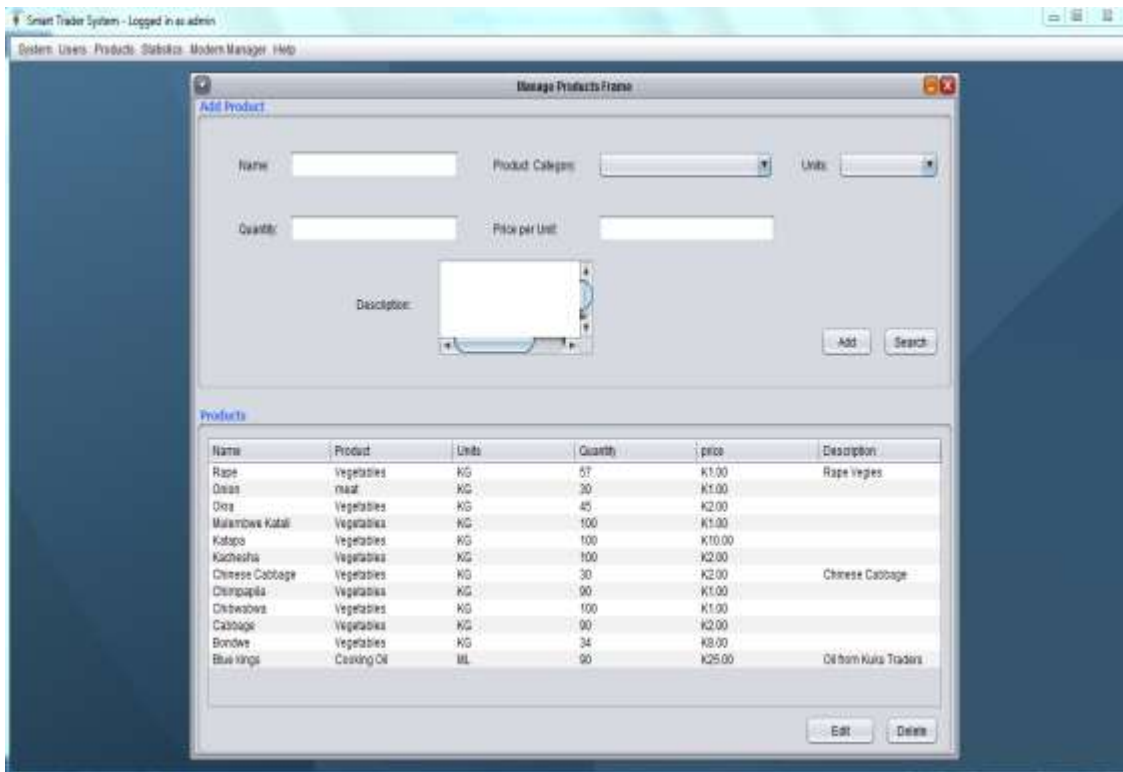


Figure 22: Interface design - manage Product Frame

The screen shot shown in Figure 22, is the manage Product frame that is used to populate the database of the Smart Trader System with the product name, unit of measure, quantity, unit price and description. This is the window that is used to perform the search, add, edit and delete functions..

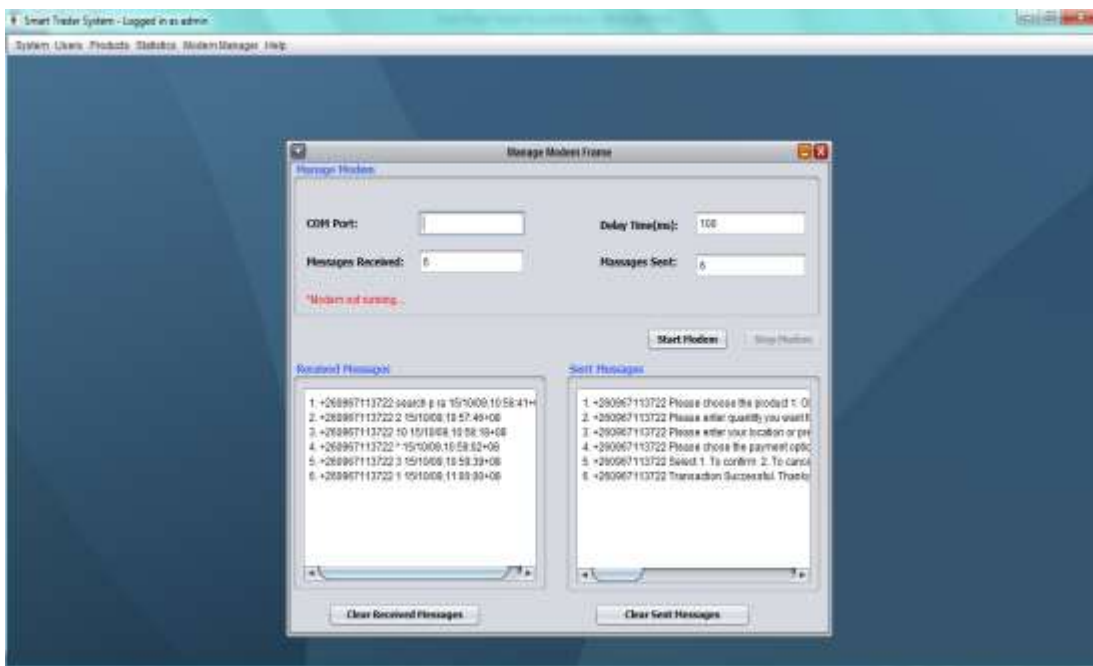


Figure 23: Interface design - manage modem frame

The manage modem frame shown in Figure 23, is used to manage the activities that involve the modem during a transaction. The window enable the selection of the interface port. It also shows the received and sent including their count. It gives provision to clear both the sent and recieved messages. This is the window which is used to start or stop the modem.

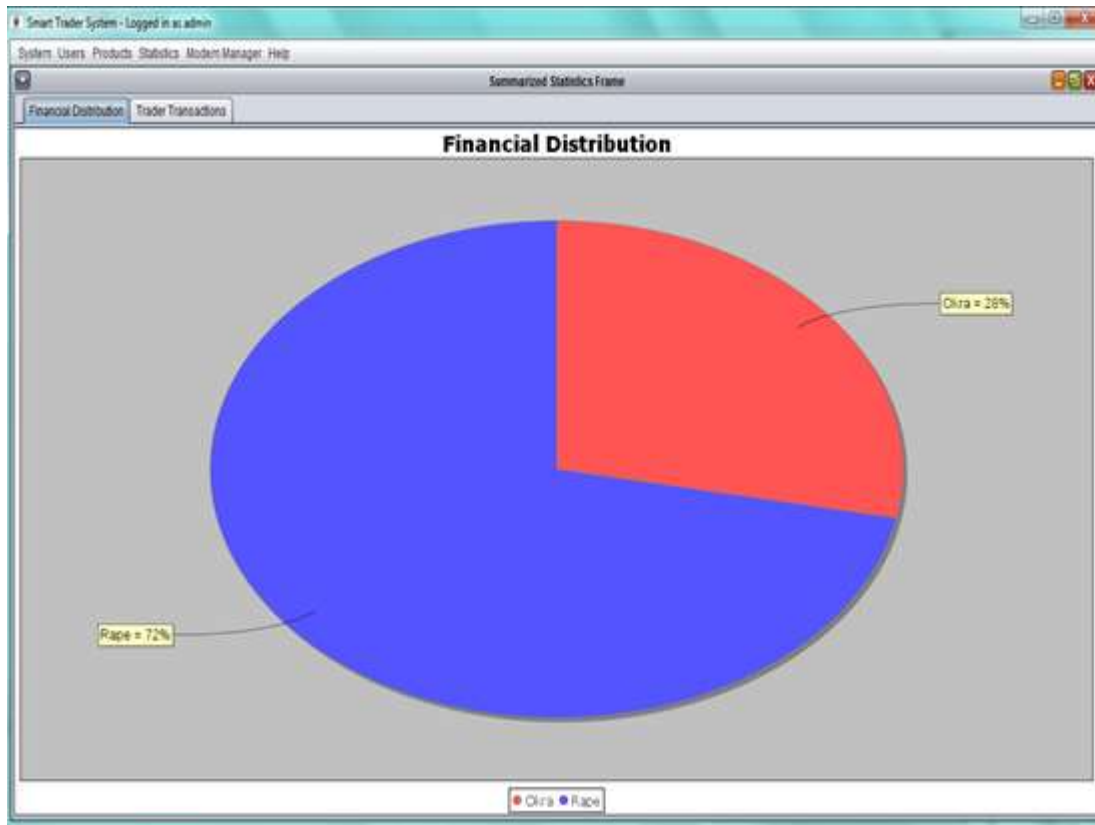


Figure 24: Interface design - Summarized Statistics frame

The summarized statistics frame, shown in Figure 24, shows the financial distribution report which is in the form of a pie chart. This will show the administrator the performance of a product in terms of sales. This feature is used a business decision making tool.

3.3.13 The Smart Trader System Implementation

This section will show how the Smart Trader System works after programming the server which is used by the cooperative or the owners of the Trading system.

The application which is being proposed uses an SMS mobile application to link a cooperative to traders. The cooperative is operated by farmers who grow various agricultural produce, and it is administrated by the cooperative. Through a cooperative, the produce is transported to the trader, after payment has been made. The trader through the SMS decides

to inquire or buy a produce, or make a balance inquiry on his account. The trader need to enrol with the cooperative and deposit some money into his trading account on the system, using a mobile money agent. The cooperative has internal arrangements for transport and insurance so that the produce can be transported in an expeditious manner with an option of insurance cover on the produce.

Below are the keywords that be used on the mobile phone in order for the trader to process a transaction. All that a trader need to do is to send the keyword to the system phone number such as 0971198851,

- Send “balance”
- Send “buy”
- Send “inquire”
- Send “search P [product]” e.g. “search P gold chick”
- Send “search pc [product category]” e.g. “search pc chicken”

When the keywords are sent, the system will respond automatically through an exhaustive menu that will be displayed on the phone.

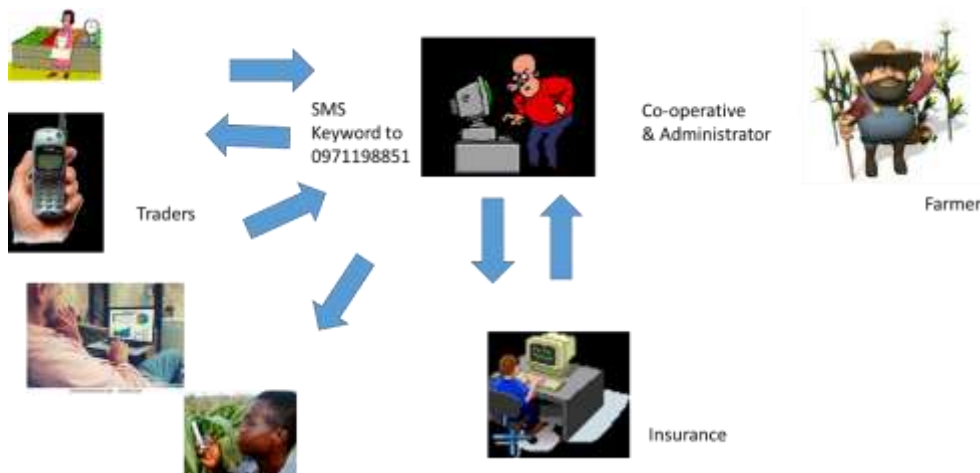


Figure 25: Context Architectural diagram of the Smart Trader System

The context architectural diagram of the proposed system is shown in figure 25. The system is designed to handle multiple transactions from at least eight traders simultaneously without dropping the connection with a trader in the middle of a transaction.

3.4 Summary

In this chapter, looked at the baseline study, sample design and sampling, approach and the development of the application. The Development and implementation of the mobile

application, which is the proposed solution to reduce the cost of doing business by the small scale traders and farmers, was described in detail. The chapter also looked at the methodology that was used for the software development process, function and non-functional requirements, process maps, implementation of languages and the configuration of equipment. The Smart Trader System was developed using the agile method. Finally the implementation of the system was described in detail.

CHAPTER FOUR

RESULTS

4.1 Introduction

In this chapter, looks at the results of the research that was conducted at Soweto market in Lusaka and Libuyu market in Livingstone with regard to the establishment of the food supply chain in Zambia, in as far as the small scale farmers and traders' involvement was concerned. The survey revealed that the respondents (traders) were exposed to risks of losing their money, goods and even their lives while conducting their business as they travel while gathering their goods. The results also showed the appreciation in the used of ICT, such as mobile phone and the use of technological innovations such as Mobile money transfers and cashless transactions, among the respondents.

Finally, we look at the results of the survey that enabled us to determine the development of the mobile application. We also look at the results of the implementation of the trading system, that we have called the Smart Trader System using the information fusion developed in Chapter 3. A cloud based system is developed using NetBeans IDE, Java programming language and MySQL database. The system uses SMS for the actors to interact with it. The prototype is tested using a server that runs Windows operating system on an A6 AMD Processor.

4.2 Baseline Study Results

In this section, we look at the results of the survey which was conducted as part of this research, on which the justification for development of the mobile application is based. In the next section, we look at the results of the implementation of the mobile application.

4.2.1 Survey Results and Discussion

In this section, the results of the survey that was done in this study are discussed. The Statistical package for Social Sciences (SPSS) application software was used to analyse the data, which was gathered from the survey.

a) **Demographic Characteristics**

• **Gender**

The respondents at both Soweto and Libuyu markets in Lusaka and Livingstone respectively were as shown in Tables 43 and 44.

Table 43 Gender – Soweto Market in Lusaka

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	26	50.0	51.0	51.0
	Female	25	48.1	49.0	100.0
	Total	51	98.1	100.0	
Missing	System	1	1.9		
Total		52	100.0		

The results showed the gender distribution for the study that was conducted in Lusaka as 51% and 49% for male respondents and female respondents respectively. This result showed that there was no gender imbalance. May be the result would have shown otherwise due to the small sample that was used in this survey.

Table 44 Gender - Libuyu Market in Livingstone

Gender		Frequency	Percent	Valid Percent	Cumulative Percent
	male	16	34.8	34.8	34.8
	Female	30	65.2	65.2	100.0
	Total	46	100.0	100.0	

In Livingstone, the results showed 34.8% and 65.2% for male respondents and female respondents respectively. This result is typical of most of the markets in the country, where females are very active in trading at markets. This is so because most females trade in vegetables and other food commodities in small quantities unlike at market like Soweto where large quantities of food commodities are handled, and that is where males will be found in large numbers

- Respondents at Soweto, where do they come from?

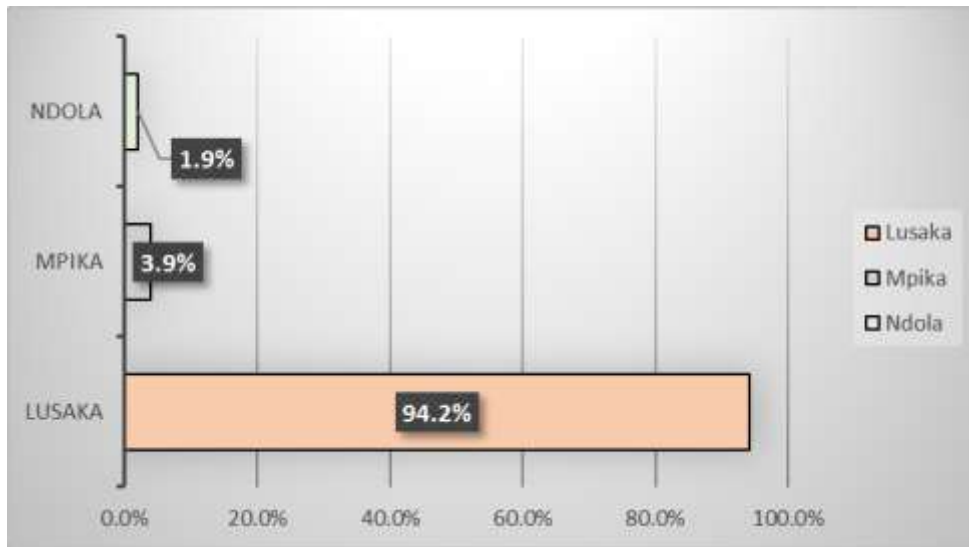


Figure 26: Trader Participation at Soweto Market

The survey showed that 94.2% of the respondents who trade at Lusaka’s Soweto market live in Lusaka and the rest live in other cities. The respondents from the Copperbelt of Zambia accounted for 2% while those from Mpika in the Northern Province were 4%, as shown in Figure 26.

- Respondents at Libuyu, where do they come from?

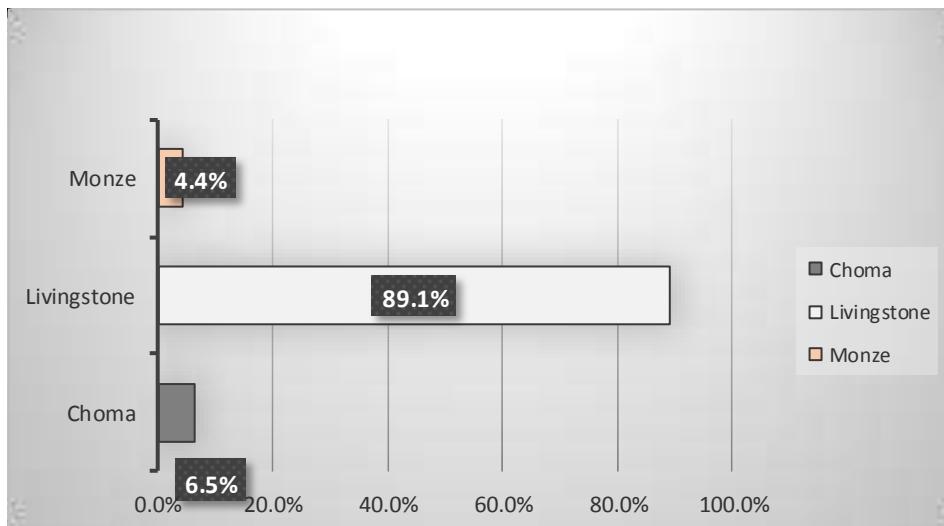


Figure 27: Trader Participation at Libuyu market in Livingstone

As can be seen from Figure 27, 89.1% of the respondents at Libuyu market live in Livingstone, and the rest live in other towns.

- **The sources of the food commodities at Soweto and Libuyu markets**

Table 45: Sources of Food Commodities that are found at Soweto and Libuyu

	Soweto Market in Lusaka		Libuyu Market in Livingstone	
	Where the respondents buy their commodities from.	Percent	Where respondents buy their commodities from.	Percent
1.	Nakonde	14.7	Nakonde	7.3
2.	Tanzania	8.8	Siavonga	12.2
3.	Mongu	14.7	Lusaka	22.0
4.	Siavonga	8.8	Malawi	2.4
5	Lusaka	41.2	others	26.8
6.	Solwezi	5.9	Livingstone	29.3
7.	Malawi	5.9		
	Total	100.0		100.0

The results of the survey show that commodities are sourced from across Zambia including some neighbouring countries such as Malawi. As shown in Table 45, 41.2% of the respondents get their commodities from within Lusaka and the rest of the respondents get their commodities from other towns. A similar situation applies to Libuyu where 29.3 % of the respondents get their commodities from within Livingstone.

- **Utilisation of mobile phone**

From Figure 28, 84.6% of the respondents at Soweto Market in Lusaka use mobile phones while 65.9% of the respondents at Libuyu market use mobile phones. Of the respondents at Soweto and Libuyu markets, 13.5% and 29.5%, respectively would make business by face to

face discussions.

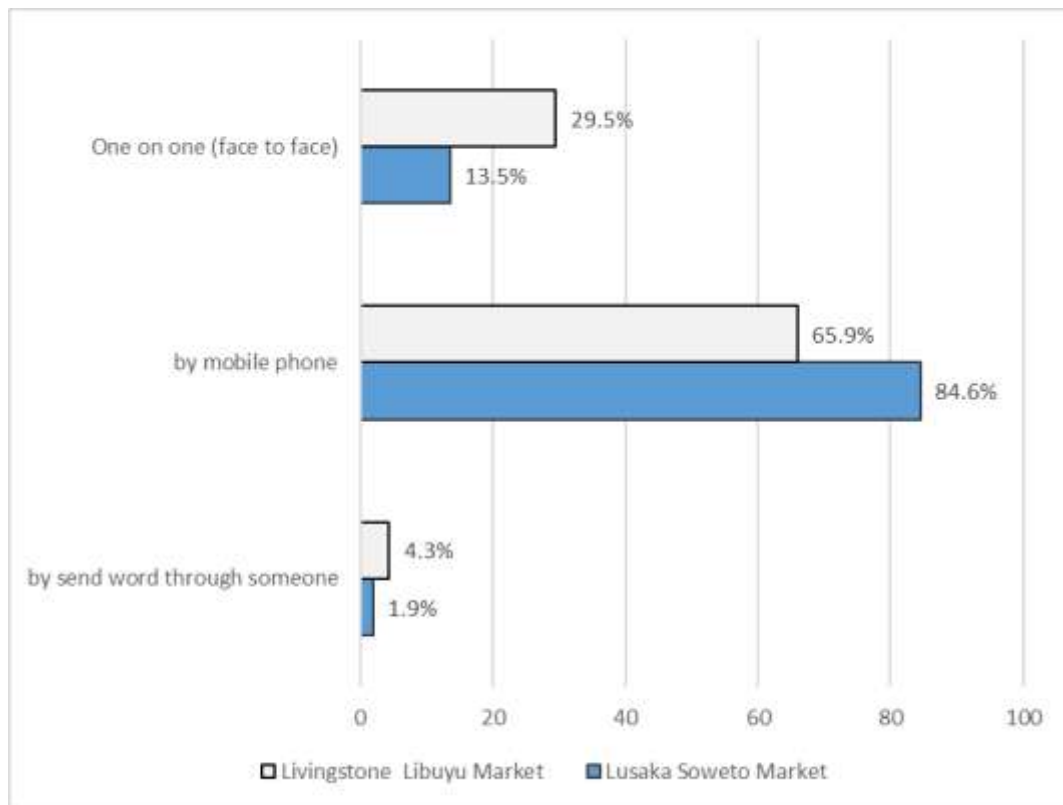


Figure 28: Utilization of the phones by respondents

. It is a common practice to send word through another person to carry out a task. It was found that 4.3% of the respondents at Libuyu and 1.9% at Soweto used this practice.

- **Utilisation of Mobile money**

According to the survey, the respondents at Soweto 55.1% said that they use mobile money facilities in their day to day business activities and 44.9% did not. Whereas 45.7% of the respondents at Libuyu market used mobile money in their business 54.3% did not. This is shown in Figure 29. The respondents said that they use mobile money to receive money from their relatives who send them money in order for them to do business. Others said that they use it to send money to the farmers in remote places who gather agricultural commodities, such as beans and cow peas, on their behalf. The traders used Airtel money and MTN money, a service that is offered by mobile Network operators. Others used Zoono another mobile money operator whose services are very popular among the small scale traders and farmers, and the general public.

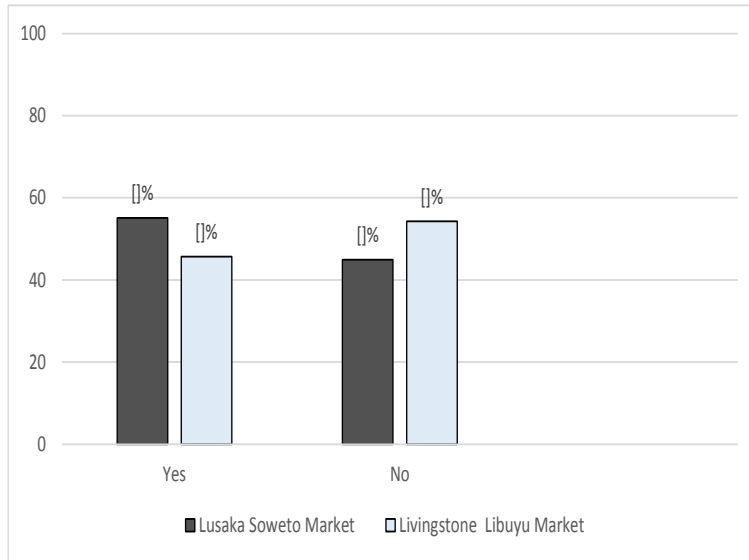


Figure 29: Utilization of Mobile Money Facilities

- **Respondent that carried cash on themselves**

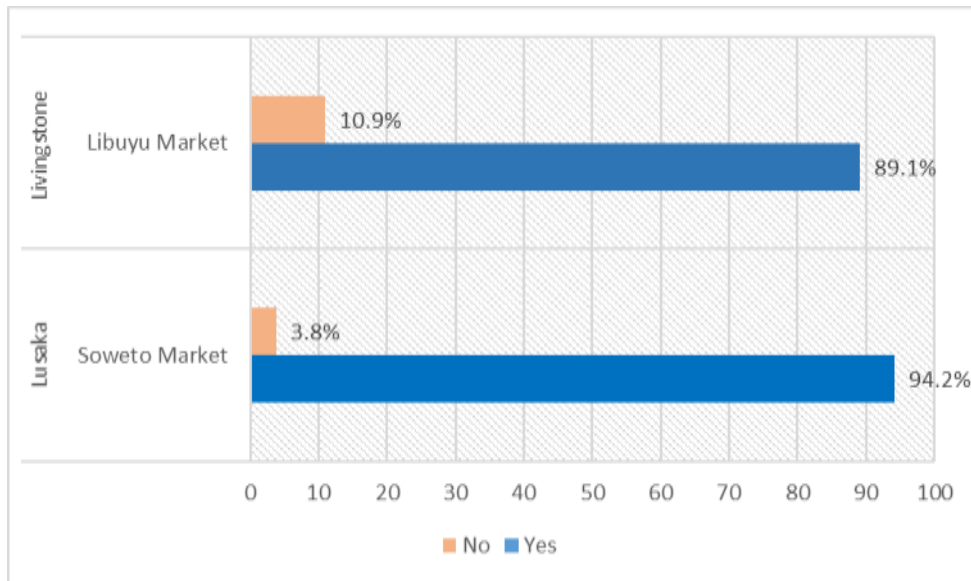


Figure 30: Traders who carried cash on them each time they traveled

The survey revealed that 89.1% of the respondents at Libuyu market carry cash whenever they travel to buy their commodities for resale and 10.9% used other means other than carrying of cash. As for the respondents at Soweto market, 3.8% used other means, while 94.2% carried cash whenever they traveled. This as shown in Figure 30.



Figure 31: Utilization of banking facilities

Figure 31, shows that the respondents do not use the bank to purchase their commodities and the rating were at 88.5% and 86.7% at Soweto Market and Libuyu Market respectively.

- **Use of Public and Private Transport**

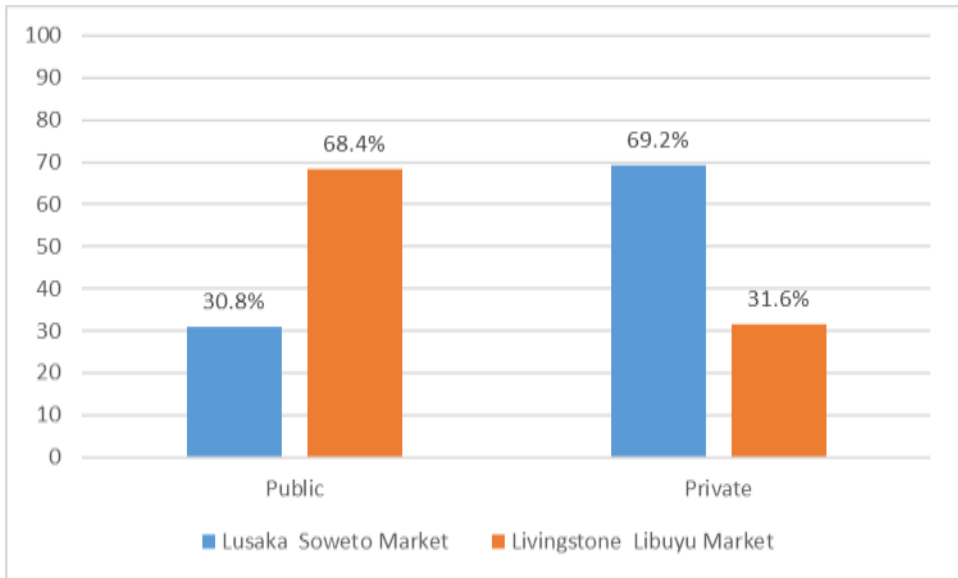


Figure 32: Utilization of Public and Private Transport

Figure 32, shows that the 69.2% of the respondents used private transport to haul their commodities while 30.8% used public transport while at Libuyu market, 68.4% used public transport and 31.6% used private

The losses while conduction business

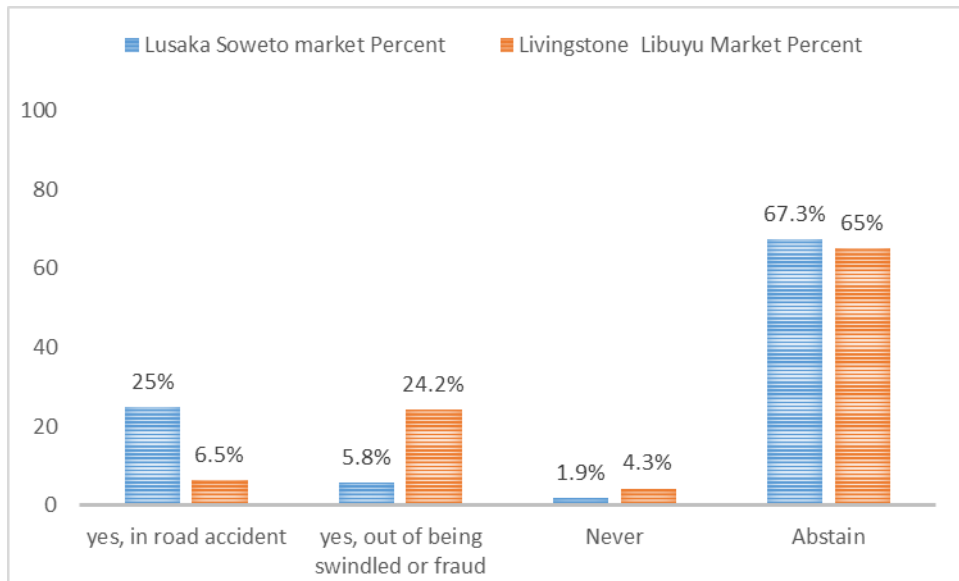


Figure 33: Losses incurred while conducting Business

The survey showed that 25% of the respondents admitted to have ever lost their commodities, while 5.8% had been swindled before and 1.9% have never lost any commodity, while 67.3% abstained to answering this question. As for the respondents at Libuyu, 6.5% have ever lost their commodities in a rood accident, 24.2% have been swindled, 4.3% have never lost any commodity and 65% did not answer this question. This is as shown in Figure 33.

Type of transport used to transport commodities

Transport is very important to the small scale traders as it is the most expensive part of their business. There are times when, the cost of transport is too high for return to be realized. Because the food supply chain is not well established in Zambia, some of the traders place order of commodities that may arrive at the market when the market is flooded with the same commodity resulting in loses due to high supply and low demand.

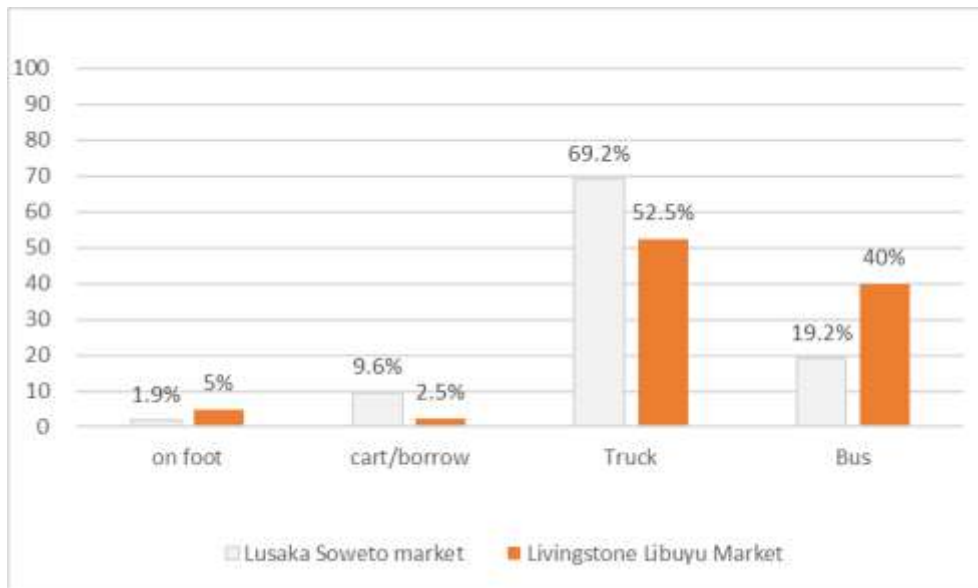


Figure 34: Type of transport used to move commodities

It can be seen from Figure 34, that 69.2% of the respondents at Soweto used truck to transport their commodities as compared the 52.5% at Libuyu market. 19.2% of the respondents at Soweto market and 40% at Libuyu use of buses to transport their commodities. The respondents who transport there commodities using cart or wheel barrow accounted for 9.6% at Soweto and 2.5% at Libuyu market. On the other hand 1.9% of the respondents at Soweto and 5% at Libuyu carried their commodities on foot, mainly due to close proximity to the wholesales.

The time it takes for a message to be delivered

The time between when an inquiry is made and the time a response or acknowledgement is received was also studied. It was found that 6.5% of the respondents at Libuyu and 1.9% at Soweto, received an acknowledgement after one week. The 30.4% of the respondents at Libuyu and 3.8% at Soweto, received an acknowledgement within one day. As shown in Figure 35, 94.2% of the respondents at Soweto and 63% at Libuyu markets received their messages instantaneously.

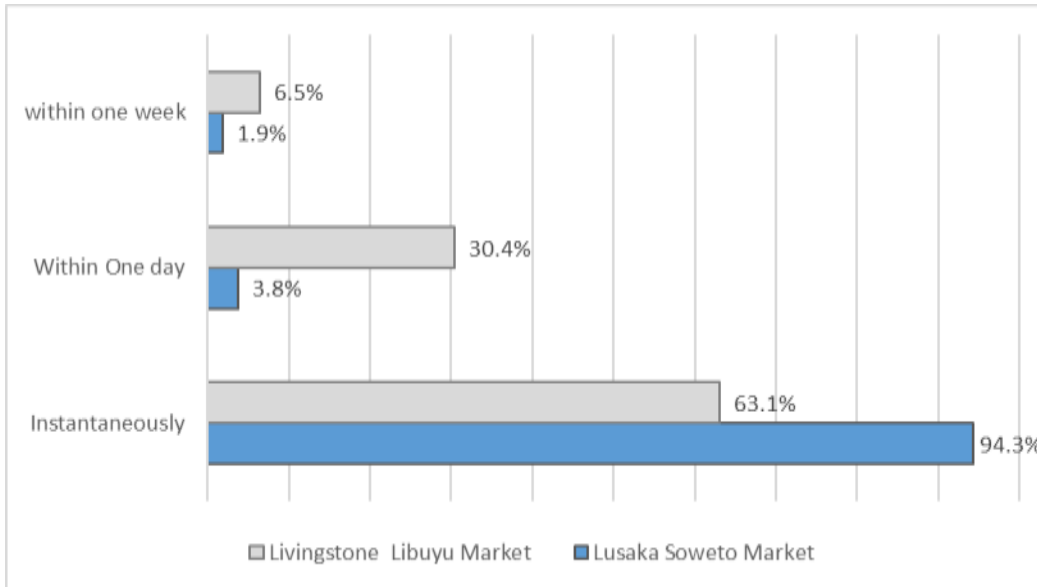


Figure 35: Time it takes for a message to be delivered

It was seen that the latency had something to do with the mode of communication.

Affiliation to cooperatives



Figure 36: Affiliation to Cooperatives

According to the survey and as shown in Figure 36, 19.6% of the respondents from Libuyu market belong to a cooperative and 80.4% do not. While at Soweto Market in Lusaka 2% of

the respondents belonged to a cooperative and 98% do not.

4.3 System Implementation Results

In this section, the results of the Smart Trader System which is a cloud based system, are covered. Initially, the interaction of the trader with the Smart Trader System is explained. Then later, the interaction of the owner of the Smart Trader system (being the administrator or cooperative) is also explained. The testing of the Smart trader System was done.

4.3.1 The Trader

The standard mobile phone is used by the trader to send the Keywords using SMS to a phone number that is provided by the Smart Trader System as discussed in 3.4.13.

When the keywords are sent, the system will respond automatically through an exhaustive menu that will be displayed on the phone, as shown in Figure 37 – 39.

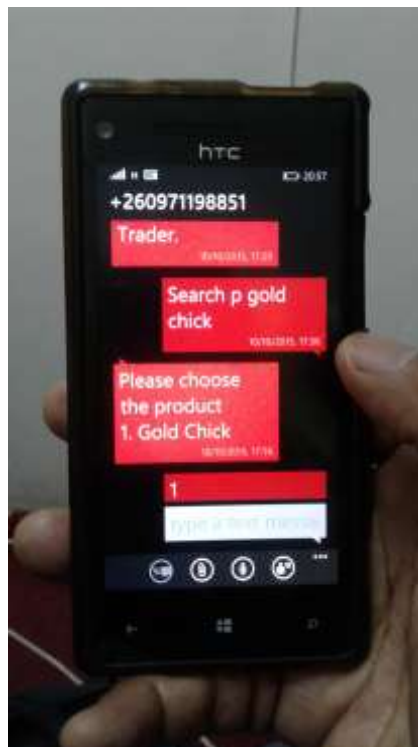


Figure 37: A trader performing a search product using a mobile phone

Using a mobile phone, a keyword is sent “search P [product]” e.g. “search P gold chick”, a response is received and a prompt message is received to choose a product.

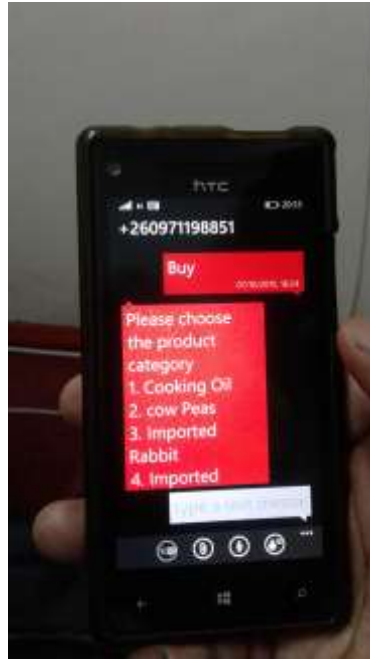


Figure 38: A trader performing a buy using a mobile phone

As shown in Figure 39. A trader is prompted to buy and has a choice to select an option.

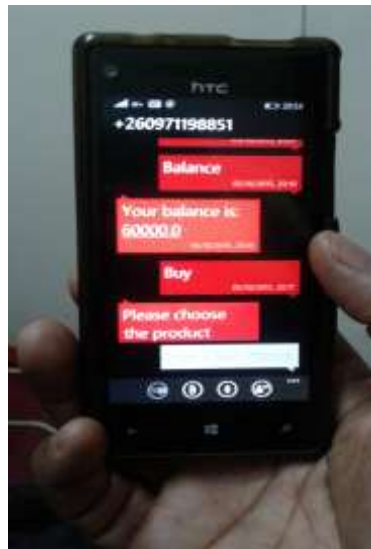


Figure 39: A trader performing a check balance using a mobile phone

4.3.2 The Owner of the Smarter Trader System

The owner of the System can be either a firm, cooperative or a sole trader. The owner assumes the role of the administrator or user of the smart trader system.

The system has a login screen for the system administrator or user to access in order to gain entry into the system. The access levels have been included in order to define the roles of

each user. The other category of the system user is the standard User who is restricted to managing products only.



Figure 40: The Log in Screen for the Administrator and the User

As can be seen in Figure 40, the system administrator logs into the system using a username and password. The system administrator then creates the users on the system according to the standard and operating procedure that the owner of the system will have set in place.

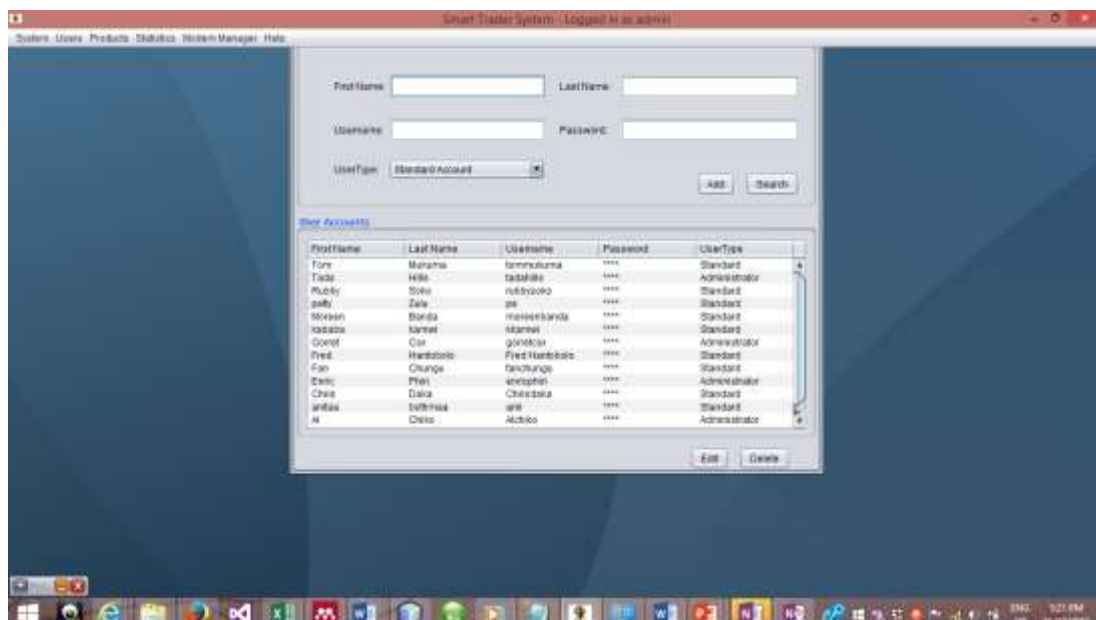


Figure 41: The add, search, delete and edit window of the administrator

The screen that the administrator uses to perform the add, search, delete and edit functions, is shown in Figure 41.

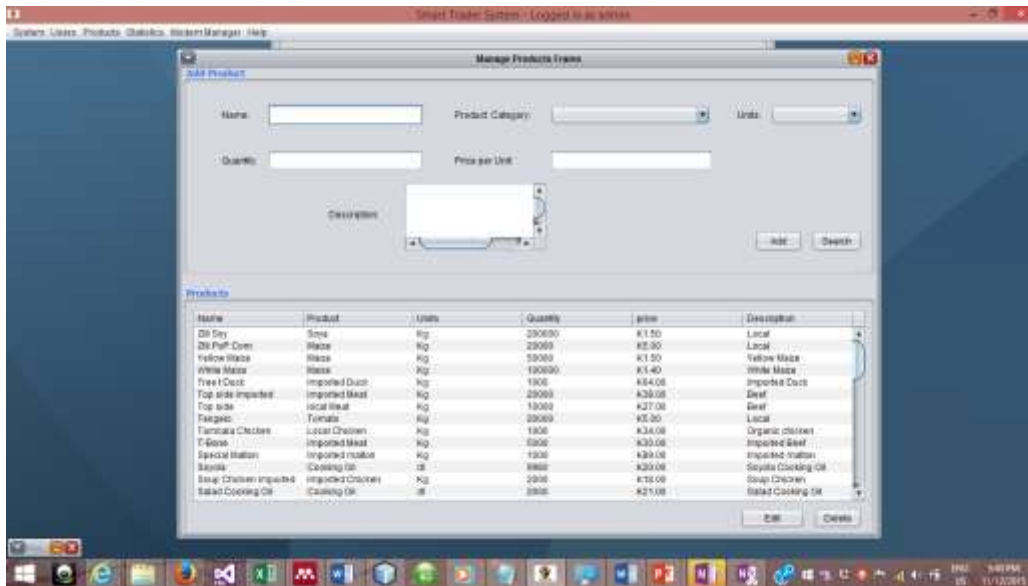


Figure 42: The Manage Product screen

Produce can be added, edited, searched and deleted on the system using the window, shown on Figure 42.



Figure 43: The manage Modem Screen

The modem which is the gateway between the server and the GPRS/GSM network is monitored using the window shown in figure 43. This window can be used to control the modem by way of starting it or stopping it. The window can be used to view or delete the sent and received messages.

The system has a number of functionalities which include the generation of reports among other things.

4.3.3 Mobile application evaluation

The post implementation evaluation was done where 10 participants from the community tested the application. These included representatives from Food Reserve Agency, Ministry of Agriculture, Ministry of Cooperatives, and University of Zambia. The participant performed a role play as traders while others played the role of the Smart Trader System users. The results are as shown in Table 46.

Table 46: Mobile application Evaluation Results

Item	Attribute	Number of participants that agree	Number of participants that Disagree	Total number of participants
1	Ease of use	8	2	10
2	Network connectivity	8	2	10
3	Fit for purpose	10	0	10

After testing the system, it was found that 8 participants were satisfied with the attribute of ease of use while 2 did not agree. The network connectivity attribute was said to be acceptable while two did not agree because they got cut off due to credit that ran out on their phones. As for the Fit for purpose attribute, everyone agreed that the system met the needs of the users.

4.4 Summary

This Chapter presented the results of the baseline study and the development of the Smart Trader System. It covers the successful implementation of a cloud based prototype that is able to successfully register a trader and then perform successful trading sessions with remote users (traders) using all the authentication factors on the Smart Trader System, on which it was implemented. The traders interrogated the Smart Trader System using SMS on mobile

phones. It concludes with the testing of the Smart Trader System by people from industry and the academia.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Introduction

From the discussion in Chapter 4, the following are some of the recommendation that were deduced from the data that was gathered. The chapter begins with the discussion then conclude with recommendation based on the results of the research. It then looks at the possible future works pertaining to this research. The findings of this research were published in the International Journal of Innovative research in Science, Engineering and Technology¹ (IJIRSET)²

5.2 Discussion

This section discusses the implementation and results that were outlined in the previous chapter and how they relate to the objectives of this study.

As a way to justify the development of a mobile application that will mitigate the risks associated with travel, loss of cash, commodities and lives, the questions were asked and the corresponding responses from the respondents were as shown in Table 43. The Table below shows the main findings of this research with respect to the objectives of the research.

5.2.1 The baseline study

The first objective sought to establish the status of the Food supply chain in Zambia pertaining to the small scale trade participation. The study revealed that food commodities are produced from various parts of Zambia and transported to Soweto market in Lusaka and Libuyu Market in Livingstone. The research, show showed that a food supply chain can be established as 41.2% of the respondents at Soweto obtained the food commodities from other parts of Zambia. This also applies to Livingstone, were the survey showed that 29.3% of the respondents sold commodities that came from other parts of the country. These food commodities are delivered to these markets as raw materials or as partially processed or as fully processed and ready for use. Further, 14.7% of the respondents obtained their commodities from Mongu, 5.9% got theirs from Malawi and 8.8% from Tanzania. As for Libuyu market, 12.2% of the respondents obtain their commodities from Siavonga, 22.2% from Lusaka and 2.4% from Malawi.

The survey also revealed that respondents reside in other towns but travel to Soweto market and Libuyu market respectively, in order to conduct trading activities at these markets. At Soweto market, 41.2% of the respondents are Lusaka residents while 2% of the respondents are from Ndola and 4% of the respondents are from Mpika. This could be attributed to the fact that this study did not cover the whole country so as to include large markets on the Copperbelt such as Chisokone market in Kitwe and Masala market in Ndola. The players in the food supply chain at the two markets were categorized into 4 categories namely, producers/farmers, wholesales, transporters, and those who buy from Producers. These are involved in processing transporting and packaging of the commodities. In so doing, some value addition may take place and thus affecting the price and state of a particular food commodity.

The research, showed that a Food Supply Chain can be established as 35.25% of the total respondents obtained their food commodities from outside their locality. It can be deduced from the study that a food supply Chain exist and can be enhanced so that it is defined. This can be done by improving the transport infrastructure.

5.2.2 Use of Technology

The second objective was to determine the level of utilisation of ICTs among traders in the food supply chain. This objective was based on assessing the usage and appreciation of technology as a way of mitigation the risks associated with travelling as the traders gather the food commodities.

a) Carrying of cash

Firstly, the survey revealed that 89.1% of the respondents at Libuyu and 94.2% at Soweto, travel with cash on themselves because there are no banking facilities in the places where they conduct trade. Further, the small scale farmers that they deal with do not have access to banks or mobile money facilitates. Poor transport and communication infrastructure may be the cause of this problem. From the survey, it was noted that 91.65% of the total respondents carried cash on themselves when conducting their business.

b) Use of Mobile phone

The survey revealed that 84% of the traders at Soweto Market in Lusaka use mobile phones while 65% of the traders at Libuyu market use mobile phones. From the survey, it was noted that 72.25% of the total respondents used mobile phone when conducting their business

c) Use of Mobile Money

The survey also revealed that 58% of the respondents at Soweto market and the 45% at Libuyu market use mobile money facilities that telecommunication operators such as Airtel, MTN are offering. The respondents also use mobile money services that are offered by other money transfer service firms such as Shoprite [137] and Zoono [138], [139]. From the survey, it was noted that 50.4% of the total respondents used mobile money when conducting their business.

d) Use of Banking Facilities

The results of the survey show that 3% of the respondents, at Soweto market, use of banking facilities, while 8% did not. Further, 89% did not answer the question in the questionnaire. As for Libuyu 9% of the respondents used banking facilities and 5% did not. And 86% did not answer the questionnaire. Those who did not use the banking facilities said that the bank charges were too high for them as they handle small amounts of cash. Others said that the banking process was very cumbersome and highly regulated, and that processing take a lot of time. They also cited long queues. Some traders abstained from answering this question because of peer pressure as it was embarrassing to admit that they do not use banking facilities in this time and age. From the survey, it was noted that 6.3% of the total respondents used banking facilities when conducting their business

e) The use of public and private transport

The study showed that 38.8% of the respondents at Soweto market transported their food commodities on public transport and 69.2% used private transport. As for Libuyu market in Livingstone 68.4% of the respondents used public transport while 31.6% used private transport. The possible reason as why many respondents preferred the use of private transport is that there is a large number of private vehicles that are used for transport hire in Lusaka. As for Livingstone, there is relatively smaller number of vehicles that may be available for use as transport for hire.

f) Loss of goods and cash while conducting business

Due to poor roads that lead to the sources of the food commodities, traders have lost their merchandise, money and lives because of road accidents. The study revealed that, 25% of the respondents at Soweto market had lost either money or commodities in a road accident, 5.8% had been swindled by fraudsters, but 1.9% had never had that experience. Further 67.3%

abstained from answering the question.

At Libuyu market 6.5% of the respondents admitted to have lost their commodities in a road accident, while 24.4% had been swindled before, but 4.3% said that they have never had such an experience. And 65% abstained from answering this question.

It can be deduced that majority of the traders did not want to show their peers that they have had such a misfortune as it was seen as bad omen. While others did not disclose due to peer pressure.

This study showed that the traders were exposed to this risk which could be avoided if they could trade without the need to travel.

5.2.3 Development of the mobile application as a solution

The third object was to develop a mobile application using cloud computing that would reduce the cost of doing business.

The survey revealed that there was a considerable appreciation in the use of mobile phones among the traders. The mobile phone is a tools with which the traders could use to order their food commodities. The phone could be used to send messages to among the traders. Doing so would reduce the need to travel and hence reduce the exposure to risks that are associated with travelling. The survey also shows an appreciation in the use of mobile money in both markets, and it would not be a challenge to reorient the traders to use mobile applications on their mobile phones. Despite the low usage of banks facilities by traders in the two market, the use of ICTs would encourage the trader to start using them with mobile money because the risk of losing money would reduce.

On the whole the use of ICTs can limit the need to travel, hence reducing the exposure to road accidents and other risks.

The discussion above, motivated the development of a mobile application that would be used by small scale traders to do business in cost effective way. The mobile application was build using the agile software development method, using Java Netbean IDE and MySQL and explained in Chapter 3 and 4.

The Prototype was developed with some policy and regulatory aspects being addressed. The aspect of traceability was addressed in line with the EU regulation which obligates all business operators to incorporate traceability at all stages of the supply chain. The prototype

requires that in order for a trader to be registered on the Smart Trader Platform, he would need to supply a mobile number, which will be used as a primary key on the system. All mobile phone subscribers, in Zambia and some neighbouring countries, are required by law to register their SIM cards. Doing this, enables the authorities to track each mobile phone subscriber when need arise. The other requirement on the system is the need for the trader to supply a local identification card number (National Registration Card Number or passport number), and his address.

Table 47: Research Objectives

	Research Question	Objective	Methodology	Result
1.	Is it possible to source food commodities in Zambia using ICTs?	To establish the current status of the food supply chain in Zambia pertaining to small scale farmer/trader participation	Questionnaire Oral interview	The research, showed that a Food Supply Chain can be established as 35.25% of the total respondents obtained their food commodities from outside their locality.
2.	Can the levels of utilization of ICT among the traders in the food supply chain be determined	To determine the level of utilisation of ICTs among traders in the food supply chain	Questionnaire Oral interview	50.4% of the total number of respondents used mobile money. 75.25% of the total respondents used mobile phones when conducting business.
3.	Is it possible to develop a mobile application for Food Supply Management through cloud computing that would reduce the cost of doing business?	To develop a mobile application using cloud computing that would reduce the cost of doing business.	<ul style="list-style-type: none"> • Agile Software Development • Using Java, • MySQL, • Netbeans • Apache Server. 	The mobile application prototype was implemented and tested.

The system also, requires the subscriber to state where the food product will be delivered to. On the other hand, the Smart Trader Platform operator has to maintain a record of all transactions of all his suppliers, in order to trace back the food products and raw materials.

The mobile application prototype was implemented and tested.

5.2.4 Comparison with Other Similar Works

As has been covered in Chapter 2, significant work has been made in the area of innovative use of ICTs that cover various fields of such as health, education, commerce and banking. This research acknowledges the work that have been done by the Zambia National Farmers Union (ZNFU), where an SMS based system called the ZNFU information system is used to link farmers and traders in Zambia. This system only provides pricing of commodities, contact details and location of the farmer. The Smart Trader System has built in features such as financial handling, insurance and transportation in order to assure speedy transactions and confirm orders.

5.2.5 Possible Application

The work in this study is an attempt to reduce the cost of doing business among farmers and traders by reducing the need to travel in order to search for the commodities in distant areas. This mobile application may help government (Zambia Revenue Authority) to capture more revenue, as this application may be linked to financial institutions in order to enable trade. This application can be used by any institution or individual who is involved in the trading of goods and services.

5.3 Summary

This study proposed the development of a mobile application that was going to be used by small scale farmers and small scale trader, in order to reduce the risks and cost of doing business. This same application can be used by other players in the trading of goods and services. In the urban areas, the fast food Industry can use this application to enable both formal and informal traders to conduct trade. The cooperative movement in Zambia can be stimulated to grow if they adopt this application. Further Mobile applications and in particular, mobile trading systems, such as this one, are one of the solutions that can be used to address the problem of mobility and access to retail trading, for both able bodied and persons with reduced mobility as deliveries can be delegated to delivery professionals or experts. The need for traceability will become easy to implement as the requirement to adhere to standards will be a given. It is fairly easy to implement traceability features with the use of mobile and web technologies, and ICTs as a whole.

5.4 Conclusion

ICTs can be used to address the plight of the cooperatives, small scale farmers and small scale traders. A mobile application such as the Smart Trader System can help trading parties to save on their resources that include time, money and commodities they trade in. Application of ICTs in this manner will stimulate good governance in the food traceability and food supply chain industry. Government policies and regulations will become more enforceable and this will give rise to more jobs as consumers continue to demand better quality of goods and services.

The Smart Trader System was implemented to work on the SMS platform because the standard phones are cheaper than the smartphones, and they are very popular among the small scale traders and farmers. The prototype was implemented and demonstrated.

5.5 Future Works

The research implemented a number of functionalities in the application but the following was not covered:

- Comprehensive integration of backend financial transactions, such as the link between the Smart Trader System and a financial institution or a bank.
- Comprehensive integration for backend insurance transactions.
- Comprehensive integration for backend transport and delivery transactions.
- A web based version of the Smart Trader System can be developed for use on desktop, laptop and other mobile computing devices.

These functionalities were not covered due to limited financial resources and time which was allocated to this study.

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APPENDIX

A.1: Buy Product Algorithm

The buy algorithm is as shown below;

1. **Begin:**
2. declare a stack **tasks**;
3. declare **productCategoryCounter = 0**;
4. declare **productCounter = 0**;
5. push items; (confirm payment, process payment, process location, display quantity, products, and product categories) into **tasks** stack;
6. while(true){
7. for every SMS that has come call **buyProduct** procedure;
8. }
9. Procedure **buyProduct(SMS){**
10. Item item = **tasks.peek()**; //get the item from a stack
11. If(item == "product categories"){
12. If(SMS == "**") { //check if the user wants to go to the previous menu
13. //reduce the counter by 4
14. **productCategoryCounter = productCategoryCounter - 4**;
15. }else if(SMS == "#"){
16. String sms;
17. for(**productCategoryCounter < 4**) {
18. //get four product categories at a time
19. sms = sms + getProductCategory(**productCategoryCounter**);
20. **productCategoryCounter++**; //increment product category counter
21. }
22. send sms; //send 4 categories
23. If(**productCategoryCounter == productcategories size**){
24. **productCategoryCounter = 0**; //reinitialize the counter
25. }
26. }else{
27. //user has selected a product category

```

28.         get products associated with the chosen category;
29.         tasks.pop();//remove “product categories” from tasks stack
30.     }
31. }
32. else If(item == “products”){
33.     If(SMS = “*”) {//check if the user wants to go to the previous menu
34.         //reduce the counter by 4
35.         productCounter = productCounter- 4;
36.     }else if(SMS =”#”){
37.         String sms;
38.         for(productCounter <4 ){
39.             //get four product categories at a time
40.             sms = sms +getProduct(productCounter);
41.             productCounter++; //increment product category counter
42.         }
43.         send sms; //send 4 prodcuts
44.         If(productCounter == products size){
45.             productCounter = 0; //reinitialize the counter
46.         }
47.     }else{
48.         //user has selected a product
49.         send SMS asking for quantity;
50.         tasks.pop();//remove “products” from tasks stack
51.     }
52. }
53. else if(item == “display quantity”){
54.     if(product’s quantity is less than SMS(quantity entered by user){
55.         Inform the Trader to reduce quantity;
56.     }else{
57.         Send SMS asking user for his location;
58.         tasks.pop();//remove “display quantity” from tasks stack
59.     }
60. }
61. else if(item == “process location”){

```

```

62.         if(location does not exist){
63.             Inform the Trader to choose another location;
64.         }else{
65.             //compute the costs
66.             double amount = product unit price * quantity entered by the user;
67.             double amount+transportation= product unit price * quantity + location
                transportation cost;
68.             double amount+transportation+insurance= product unit price * quantity
+
                location transportation cost + location insurance
                cost;
                send sms of three costs;
69.             tasks.pop();//remove “process location” from tasks stack
70.         }
71.     }
72.     else if(item == “process payment”){
73.         if(trader has less in his account than the selected cost){
74.             Inform the Trader that he has insufficient funds;
75.         }else{
76.             Send SMS asking user to confirm payment;
77.             tasks.pop();//remove “process payment” from tasks stack
78.         }
79.     }
80.     else if(item == “confirm payment”){
81.         reduce the product quantity;
82.         If the remaining product quantity is less than threshold, inform admin;
83.         reduce the traders account;
84.         record transaction and mark it due for transportation;
85.         send SMS telling the Trader that the transaction is successful;
86.         end this thread;
87.     }
88. }
89. End:

```

A.2: Sample code

The diagram below shows code structure of the software prototype. The diagram shows the hierarchy as was seen in the Netbean integrated Development Environment.

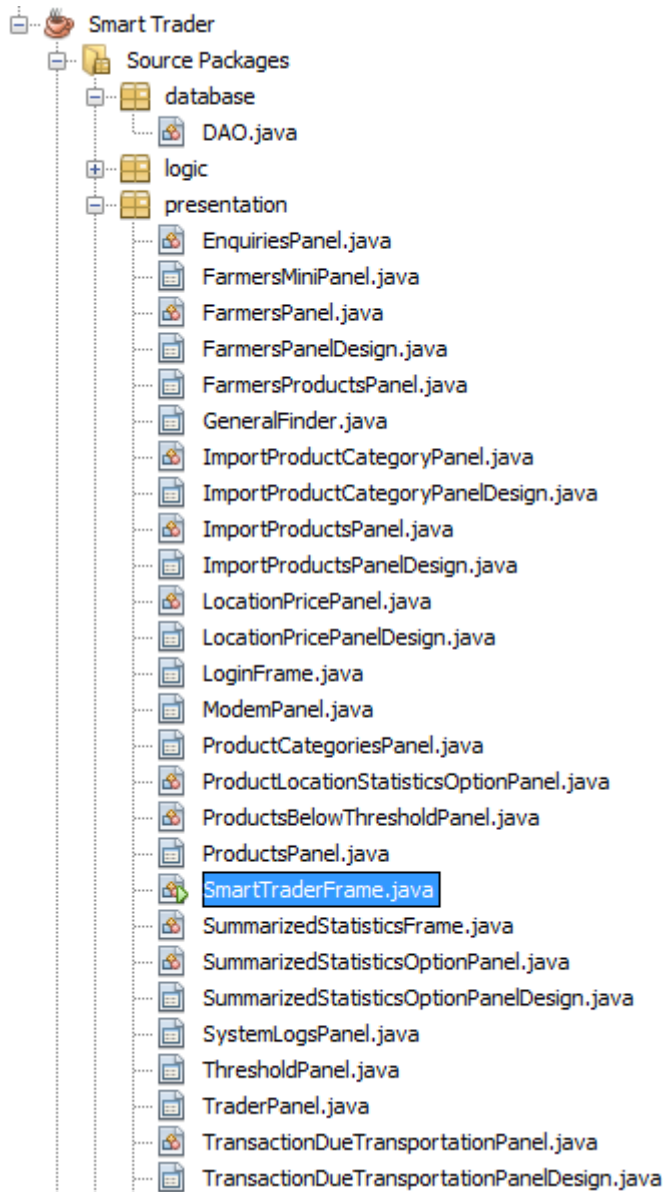


Figure 44 Code Structure for the prototype

A.2: Database Access Code sample

The diagram below shows the sample source code that accessed the database. This code is used to add a farmer to the system.

```
public boolean saveFarmer(Farmer farmer) throws SQLException {
    // ensure database connection is available
    if (!connectedToDatabase) {
        throw new IllegalStateException("Not Connected to Database");
    }
    String query = "INSERT INTO farmer(phoneNumber,nrc,name,location) VALUES(?,?,?,?)";
    PreparedStatement statement = connection.prepareStatement(query);//create statement

    statement.setString(1, farmer.getPhoneNumber());
    statement.setString(2, farmer.getNRC());
    statement.setString(3, farmer.getName());
    statement.setString(4, farmer.getLocation());

    int stat = statement.executeUpdate();
    boolean inserted;
    if (stat > 0) {
        inserted = true;
    } else {
        inserted = false;
    }
    return inserted;
}
```

Appendix B.

B.1: Questionnaire

THE UNIVERSITY OF ZAMBIA

DIRECTORATE OF RESEARCH AND GRADUATE STUDIES

SCHOOL OF ENGINEERING

QUESTIONNAIRE NO:.....

TOPIC:

THE FOOD SUPPLY CHAIN IN ZAMBIA

Dear Respondent,

You have been randomly selected to complete this questionnaire. You are earnestly requested to complete it objectively. Tick responses or fill in the spaces provided where applicable. The information you will provide will be treated with the strict confidence which it deserves.

Instructions

1. Please do not indicate your name on the questionnaire.
2. Answer the questions in the space provided by putting a tick against your answer
3. Give a brief explanation to questions where space has been provided

Your corporation is greatly appreciated.

For more details please contact the researcher on:

Telephone / cell: 0977848418 Email: ahphiri@gmail.com

PART I: Background Information

For
Official

		Use only
1	Sex: 1. Male 2. Female	
2.	Age on Last Birthday:	
3.	Marital Status: 1. Single 2. Married 3. Widowed 4. Separated 5. Divorced	
4.	Where do you live? 1. Province..... 2. Town..... 3. Township.....	
5.	Where do you operate from? Market.....Town.....Province.....	
6.	What do you do? A. Producer/Farmer B. Buy from Producers C. Wholesaler D. Retailer E. Transporter (from to)	
7.	Where do you buy your commodities from? 1. Nakonde 2. Tanzania 3. Mongu 4. Siavonga 5. Lusaka 6. Solwezi 7. Malawi Others.....state where.....	
8.	How long have you been trading in agricultural commodities in Zambia	

PART III: Commodity Trading

9. What commodities do you trade in?
Grain
 a) Maize
 b) Rice
 c) Others

10. What commodities do you trade in?
Fish
 a) Kapenta
 b) Dry fish
 c) Others.....

11. What commodities do you trade in?
Meat
 a) Beef
 b) Pork
 c) Chicken
 d) Goat
 e) Others

12. What commodities do you trade in?
Vegetables
 a) Dry beans
 b) Fresh beans
 c) Rape
 d) tomatoes
 e) onions
 f) Cabbage
 g) Others

10. Fill the table the buying, selling prices and quantities of the commodities you trade in when in Plenty?
 Unit of measure is: A= meda, B=10kgs, C= 25kgs, D=50kg, E=90kg, F=box

	Grain	Buying		Total Qty	Selling	
		Unit	Price(K)		Units	Price (K)

	e.g.	Wheat	E	40	200	D	30																																																	
	1.	Maize																																																						
	2.	Rice																																																						
	3.	millet																																																						
	4.	sogham																																																						
11.	<p>Fill the table the buying, selling prices and quantities of the commodities you trade in when in Plenty? Unit of measure is: A= meda, B=10kgs, C= 25kgs, D=50kg, E=90kg, F=box</p> <table border="1"> <thead> <tr> <th></th> <th>FISH</th> <th colspan="2">Buying</th> <th>Total Qty</th> <th colspan="2">Selling</th> </tr> <tr> <th></th> <th></th> <th>Unit</th> <th>Price(K)</th> <th></th> <th>Units</th> <th>Price (K)</th> </tr> </thead> <tbody> <tr> <td>e.g.</td> <td>fish</td> <td>E</td> <td>40</td> <td>200</td> <td>D</td> <td>30</td> </tr> <tr> <td>1.</td> <td>Fresh Fish</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.</td> <td>Dry fish</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3.</td> <td>Kapenta</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>4.</td> <td>Imbowa</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>								FISH	Buying		Total Qty	Selling				Unit	Price(K)		Units	Price (K)	e.g.	fish	E	40	200	D	30	1.	Fresh Fish						2.	Dry fish						3.	Kapenta						4.	Imbowa					
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e.g.	Wheat	E	40	200	D	30																																																									
1.	Maize																																																														
2.	Rice																																																														
3.	millet																																																														
4.	sogham																																																														
	<p>Fill the table the buying, selling prices and quantities of the commodities you trade in when in short supply. Unit of measure is: A= meda, B=10kgs, C= 25kgs, D=50kg, E=90kg, F=box</p> <table border="1"> <thead> <tr> <th></th> <th>FISH</th> <th colspan="2">Buying</th> <th>Total Qty</th> <th colspan="2">Selling</th> </tr> <tr> <th></th> <th></th> <th>Unit</th> <th>Price(K)</th> <th></th> <th>Units</th> <th>Price (K)</th> </tr> </thead> <tbody> <tr> <td>e.g.</td> <td>fish</td> <td>E</td> <td>40</td> <td>200</td> <td>D</td> <td>30</td> </tr> <tr> <td>1.</td> <td>Fresh Fish</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>2.</td> <td>Dry fish</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>3.</td> <td>Kapenta</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>							FISH	Buying		Total Qty	Selling				Unit	Price(K)		Units	Price (K)	e.g.	fish	E	40	200	D	30	1.	Fresh Fish						2.	Dry fish						3.	Kapenta																				
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	MEAT	Buying		Total Qty	Selling	
		Unit	Price(K)		Units	Price (K)
e.g.	Matton	E	40	200	D	30
1.	Beef					
2.	Pork					
3.	Goat					
4.	Chicken					

Fill the table the buying, selling prices and quantities of the commodities you trade in when in short supply.
Unit of measure is: A= meda, B=10kgs, C= 25kgs, D=50kg, E=90kg, F=box

	Vegetables	Buying		Total Qty	Selling	
		Unit	Price(K)		Units	Price (K)
e.g.	Carrot	E	40	200	D	30
1.	Dry beans					
2.	Fresh Beans					
3.	Rape					
4.	Tomatoes					
5.	Cabbage					

12. How many times do you trade?
 1. Everyday
 2. At least Twice in a week
 3. At least Once in a month
 4. At least Every three months
 99. Any Other, Specify:

PART III: Transport

13. What form of transport do you use when buying your commodities
 1. On foot
 2. Bicycle
 3. Cart

	<p>4. Truck</p> <p>5. Bus</p>	
14.	<p>What is the frequency of your travel?</p> <p>1. Once in a week</p> <p>2. Twice in a week</p> <p>3. Once a month,</p> <p>4. Once every quarter</p>	
15.	<p>How would you categorize the transport you use?</p> <p>1. Public</p> <p>2. Private</p>	
16.	<p>Do you use the same transports as your goods?</p> <p>1. Yes</p> <p>2. No</p>	
17.	<p>How much do you pay for your transport?</p> <p>1. K.....</p>	
18.	<p>How much you pay for your commodities?</p> <p>1. K.....per bag/box.....Kg</p>	
19.	<p>Have you ever lost your commodities due to,</p> <p>1. Being swindled or fraud</p> <p>2. In a road accident</p> <p>3. State the circumstances</p>	
20.	<p>How much worth of goods were lost?</p> <p>K.....</p>	
PART III: FINANCIAL TRANSACTION		
21.	<p>How much worth of goods do you buy per trip?</p> <p>K.....</p>	
22.	<p>Do you use banking facilities to pay for your commodities?</p> <p>1. Yes</p> <p>2. No</p>	
23.	<p>Do you use mobile money?</p> <p>1. Yes</p> <p>2. No</p> <p>If yes, who is your service provider.....</p>	
24.	<p>Do you carry cash for your orders on you?</p> <p>1. Yes</p>	

	2. No	
25.	Have you ever lost your money due to, 1. Being swindled or fraud 2. In a road accident 3. State if there were others challenges.....	
26.	How much did you lose? K.....	
PART IV: TIME SPENT ON TRAVEL		
27.	How long do it take you to travel from your base to where you collect the commodities and back? 1. Within One day 2. Within One week 3. Within two weeks 4. Within One month	
28.	When you order your commodities, how long do you have to wait for the delivery? 1. Within One day 2. Within One week 3. Within two weeks 4. Within One month	
29.	What do you use to communicate with your business parties? 1. by sending someone 2. by phone 3. one on one (face to face)	
30.	How long does the message take to be received? 1. Instantaneous 2. Within One day 3. Within One week 4. Within two weeks 5. Within One month 6. Never	

PART V: Any Policy Suggestion on Food Supply Chain

31.	<p>Do you belong to any cooperative?</p> <p>1. Yes</p> <p>2. No</p> <p>If yes, what does it specialize in?</p>	
32.	<p>Does your cooperative participate in any Supply Chain?</p> <p>1. Yes</p> <p>2. No</p> <p>If yes, what does it specialize in?</p>	
33.	<p>What challenges do you face on the ordering your commodities?</p> <p>.....</p> <p>.....</p> <p>.....</p>	
34	<p>What do you think Government should put in place in order to alleviate the difficulties that traders face in Zambia?</p> <p>.....</p> <p>.....</p> <p>.....</p>	

LIST OF PUBLICATIONS

1. Ariel Henry Phiri, Gift Lyoko, Jackson Phiri, “The Use of SMS Mobile Phone Technology to Improve the Food Supply Chain in Zambia”, International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Volume 4, Issue No. 12, pp, 12412-12418, 2015.
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