ENHANCING THE ADMINISTRATION OF NATIONAL EXAMINATIONS USING MOBILE CLOUD TECHNOLOGIES: A CASE OF MALAWI NATIONAL EXAMINATIONS BOARD

BY

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A Dissertation submitted to the University of Zambia in partial fulfillment of the requirements for the award of the degree in Master of Science in Computer Science

UNIVERSITY OF ZAMBIA

LUSAKA

NOVEMBER 2017

DECLARATION

I, the undersigned, declare that this dissertation is a preparation of my original research work and that it has not been submitted for any degree or being concurrently submitted in candidature for any degree. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature and acknowledgement of collaborative research and discussions.

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ACKNOWLEDGEMENT

I give praise and thanks to God our Lord for the wisdom, good health and all the capabilities throughout the study period. I wish to express my sincere gratitude and appreciation to all those who have assisted me in one way or another during the course of this research project and in particular those mentioned here after.

I am truly grateful to the Government of Malawi through the Department of Human Resource and Management Development for providing the sponsorship needed to finish the program. I would like to express my deepest gratitude to my supervisor, Dr. Jackson Phiri who agreed to guide me through the study and for the selfless guidance that was a great source of insight. Special mention goes to all the lecturers of the University of Zambia – department of Computer Science who shared their knowledge and deep understanding of matters pertaining to this course. I would also like to thank all my classmates for the numerous fruitful ideas shared throughout the time we have been together. I am also indebted to MANEB and Ministry of Education staff and all the respondents who participated in the study for the information provided.

I finally want to thank my wife, Lydia Solomon for her moral support. She had always been there cheering me up and taking care of the family when I was away.

DEDICATION

This work is dedicated to my wife, Lydia Solomon and my children Praise and Comfort. For the many sacrifices you made when I totally focused my energies to my academic pursuit, kindly accept my appreciation for your endless love. I also dedicate this to my parents, Mrs. Daina Malinda and late Mr. John Solomon Malinda for the support, patience, love and encouragement that have been a source of inspiration.

LIST OF KEYWORDS

Barcode

Candidate

Cloud Computing

Examinations Results

Gateway

Global System for Mobile Communication

Malawi National Examinations Board

Mobile Cloud Computing

Mobile Money Payment

Mobile Network Service Provider

National Examinations

Registration

Short Message Service

Unstructured Supplementary Service Data

Verification

ABSTRACT

National examinations are standardized and centrally set tests that are administered to learners of the same grade within a particular country's system of education. Technological advances and the search for efficiency have catalyzed recently a migration from paper-and-pencil based way of doing things to computer-based in education and training at all levels. The drivers of this migration have been faster administration, processing and delivery of examination results, error free marking of test items and enhanced interactivity. This study aims at establishing the challenges currently faced by Malawi National Examinations Board (MANEB) when registering candidates for national examinations as well as disseminating examinations results. A mobile application designed based on Simple Message Service (SMS) and Unstructured Supplementary Service Data (USSD) which is deployed using cloud computing infrastructure is being proposed to address the challenges. A baseline study was conducted to determine the challenges that the current system has regarding candidate registration, verification of registration details and dissemination of examinations results. The study involved 80 respondents and the sample consisted of teachers, students as well as parents. Interviews with MANEB and Ministry of Education officials were also conducted to get details of MANEB's current business processes. The findings of the baseline study depicted that the current MANEB processes have a number of challenges i.e. missing entries, wrongly captured details, difficult to read verification sheets, time consuming, delayed examinations results, theft of examinations fees by schools authorities etc. Based on the findings from the baseline study, we developed the cloud based model for candidate registration and results dissemination using cloud computing and mobile application technologies. The system prototype's performance was measured in terms of its throughput, response time and error rate and it was found out that the system is faster and more reliable than the traditional computer based approach that is currently being employed. It is therefore, envisaged that when the fully fledged application is deployed, it will greatly reduce the problems currently faced.

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RESEARCH INTRODUCTION

1.1 Introduction

This chapter of the paper gives the general description of the research on managing national examinations data in Malawi. The first section of the chapter presents a broad introduction to the research by highlighting the methods currently employed to register candidates, verify candidates' registration details as well as disseminate examinations' results. Subsequent sections of the chapter look at the statement of the research problem, aim of the research, objectives and research questions, significance of the research, scope and motivation for the research. The final two sections highlight the way the dissertation is organized as well as the summary of the chapter.

1.2 Introduction to the Research

In almost every nation, public examinations tend to put forth the enormous influence on the nature of learning and teaching. They dictate not only what is taught but also how it is taught. Educational assessment is understood to be concerned with determination of progress that students have made towards educational goals at a particular time. It is also understood to be an evaluation on the extent to which set out educational goals and objectives are met over a period of time with their main function being to select students for the next highest level of the education system [53]. Globally, many school going children are accessing education as a result of development and implementation of policies aimed at increasing enrolment in schools. While this may be a positive move in as far as development of human capacity is concerned, all these children have to sit for national examinations at the various levels of the education system, resulting in a tremendous increase in candidature. This causes numerous challenges to national bodies that are constituted to organize as well as administer these national examinations [4].

There has been increasing concern in the rising of learner absenteeism from public examinations in many countries across the globe. Research has been conducted to examine the extent, trends and cause of learner absenteeism during public examinations at various grades of primary and

secondary education [52]. A number of these studies reveal that the causes of such absenteeism are either system related factors, school related factors or home background factors [3]. There are several system related factors that contribute to the phenomenon of learners failing to sit for national examinations, one of which being the process of administration of various national examinations that these learners are supposed to take at various levels of the education system as designed for a particular country. When learners fail to sit for national examinations for a particular year, they are likely to drop out of school or repeat in that grade.

The Malawi National Examinations Board (MANEB) is a government statutory body that was enacted by act of parliament in 1969 to administer schools national examinations in Malawi. It was then called Malawi Certificate Examination (MCE) Board. Later, MCE Board was merged with the Regional Test center which offered psychological tests and research services for Malawi, Botswana, Lesotho and Swaziland and hence came to be called Malawi School Certificate of Education and Testing Board (MSCE & TB). Malawi Government, in 1987, ordered that all assessment activities be carried out by one body. Therefore, the examination section in the ministry of Education which had previously been running the Primary School Leaving Certificate (PSLCE) and Junior Certificate Examinations (JCE) was merged with MSCE & TB to become MANEB. By setting and administering high-stakes public examinations that are based on the school curriculum, the Board is capable of providing the needed influence for achieving educational goals [53]. The three main national examinations that MANEB administers are Primary School Leaving Certificate (PSLCE), Junior Certificate Examinations (JCE) and Malawi School Certificate of Education (MSCE). PSLCE is written by learners in grade 8 and upon passing, a learner is assured progression into secondary school, JCE is taken by students in grade 10 of Malawi education system and passing JCE sees a student progressing to the last two years of secondary education whereas MSCE is for those students that reach grade 12 and when a student passes he/she proceeds to tertiary education. Prior to introduction of e-registration (use of spreadsheets), all candidates' data capture outside of MANEB was completely manual [53]. Forms filled by candidates were sent to MANEB which would in turn transcribe all the data at the Computer Services Department, a task that was laborious and time consuming.

Although the so called e-registration was introduced, MANEB still experiences a number of challenges administering school national examinations. This largely results from the pressure that MANEB faces to accommodate the ever increasing candidature of national examinations due to the introduction of free primary education. Apart from basic or lower grades (i.e. standards 1, 2 and 3), high levels of school dropout as well as grade repetition in Malawi are also observed in grades where students sit for national examinations [8]. Notwithstanding the fact that a lot of students fail in these examinations and that others fall short of writing because of several other reasons, it is highly evident that the way these examinations are administered contributes to the number of students who fail to write these examinations. The administration of these examinations is associated with a big challenge in making sure that all the students who register to sit for the examinations in a particular year have their registration details properly captured and that they are not missed out. The current system of registering students uses Microsoft excel spreadsheets and CDs/DVDs to gather and transfer data within the registration process. This leads to data loss as well as data incorrectness as the tools used are not reliable. Secondly, when students register with their respective schools or centers, it is hard for them to verify, and in case of anomalies, rectify their registration details before the date of examinations. As a result of these shortfalls in the current process, each year a good number of students fail to sit for national examinations because their registration details are either incorrect or are completely missing. The incorrect details include names, identification numbers, center numbers as well as subjects registered and paid for. When this happens, students have no option but to wait and re-register the following year thereby repeating the class. If they do not have money to re-register, they just dropout. MANEB also faces another big challenge disseminating examinations results to students when marking and grading are completed. Apparently, MANEB produces nominal rolls and hard copy books that are sent to schools as well as District Education Offices where candidates check their results from. Apart from wastage of resources in the form of stationery, this method of results dissemination usually takes long to be accomplished and as a result examinations results are always delayed.

Looking at the magnitude of the challenges that MANEB encounters during registration of candidates, verification of candidates' registration details as well as dissemination of examination results and the ultimate effects that these challenges have both on the students as well as MANEB itself, there is need to improve the way MANEB handles its data in as far as the

administration of schools national examinations is concerned. Administration of national examinations is a collection of processes that include registration of students for examinations, verification of registered students' details before examinations, preparation of examinations, scoring and grading students as well as release and dissemination of examinations results. This study focuses only on the registration and verification of students as well as dissemination of examinations results. An SMS and USSD based mobile application that utilizes cloud computing architecture is being proposed in this study. The proposed solution is deemed to be ideal considering the diverse literacy levels of the intended users some of whom can only afford to use SMS or USSD facilities of a mobile phone and no other sophisticated mobile applications. Secondly SMS and USSD facilities are found on any mobile phone be it feature or smart phone. The proposed solution also has a web interface for data manipulation.

1.3 Motivation

MANEB has been experiencing the aforementioned challenges since its establishment. The e-registration that was introduced some years ago has not solved MANEB's challenges. These challenges in a long run affect the students who after years of learning look forward to being assessed by MANEB. It is the need to eliminate these challenges that has brought the urge to carry out this research.

With the ubiquitous nature of mobile phones coupled with the emergence of other modern technologies, the researcher felt motivated to design and develop a system for MANEB that will use mobile text to enable candidates register and rectify registration details and help MANEB disseminate information to different stakeholders including examination results. Simply put the system will ease the management of candidates' examinations data.

1.4 Problem Statement

The Malawi National Examinations Board does not directly register students. Learners that are eligible to sit national examinations are supposed to register their details with any approved examination center/school within a specified registration period. For each examination, MANEB prepares a spread sheet template, on a CD, containing three worksheets: one for data entry and the other two for reference as data are being entered [54]. A copy of the CD is given to each of

the 34 education districts in the country. Once received, the District Education Manager (DEM) makes available copies of the template to all eligible examination centers in the district. When registration ends, the DEMs collect data on CDs from all centers in their districts with corresponding documentation i.e. associated hard copies and submit the same to MANEB. At MANEB, the data is cleaned and merged into a Microsoft Access database. This process leads to data loss and capturing of incorrect data. After merging and cleaning of data, nominal rolls are produced and sent to all centers for verification of accuracy of the captured data by candidates. These nominal rolls are at times not clear so that candidates hardly see their details. If errors are observed, the process of rectifying those takes too long as the head of the school has to formerly write MANEB to effect the changes. When the examinations results are out, candidates have to travel to their respective schools to check the results, a thing which is costly and time consuming. Examinations fees for the examinations are paid through the school cashiers or bursars.

The major problems that result from the above explained processes are that eligible candidates fail to write examinations because their registration details are either missing or incorrect, examinations results are always delayed as they await the printing of books and also some school authorities defraud candidates of their examinations fees.

The following table depicts the differences in figures between registered students and those that actually sat for examinations in 2014 and 2015.

Year	PSLCE			JCE			MSCE		
	Registered	Sat	Disparity	Registered	Sat	Disparity	Registered	Sat	Disparity
2014	145,271	130,293	14,978	134,178	124,999	9,179	261,207	259,251	1,956
2015	157,746	136,296	21,450	170,090	134,490	35,600	290,121	249,031	41,090

Table 1.1: Disparities between registered and sitting students (*www.maneb.com*)

1.5 Aim of Research

The overall aim of the study is to establish the challenges that MANEB, teachers and candidates face and designing a solution to address the challenges.

1.6 Research Objectives

In order to realize the aim above, the following objectives were met during the study.

i. To carry out a baseline study to establish the challenges faced by MANEB, teachers, parents and candidates during registration, verification and results dissemination processes for public examinations.
ii. Design a model based on cloud architecture and SMS/USSD mobile application technologies to address the challenges.
iii. Map the current business process for MANEB using the model developed in the above objective.
iv. Develop a prototype based on the business process and the model to address the challenges.

1.7 Research Questions

To guide, direct and focus this study, the following research questions were answered:

i. What are the challenges that MANEB, teachers, parents as well as candidates are currently facing during registration and dissemination of results for public examinations?
ii. How can the best model based on cloud architecture and mobile technologies be designed to address the challenges?
iii. How to map the current business process for MANEB using the designed model?
iv. Can a prototype based on the business process and the model be developed to address the challenges?

1.8 Scope

The administration of national examinations is an enormous task that is composed of a number of stages such as registration of candidates, verification of candidates' registration details, preparation of examinations, marking and grading of candidates as well as release and dissemination of results. The study focused on the challenges encountered during registration and verification of registration details as well as dissemination of examinations results. The study involved a baseline survey conducted in selected districts. The major outcomes of the study were the statistical analyses of the data collected during the baseline study and the development of the proposed system prototype.

1.9 Research Significance

It is believed that this research will be helpful to the nation, development agencies and local organizations as it will assist to address some of the challenges faced by MANEB during administration of schools national examinations. There will be commitment to share the analytical results of the study with Malawi National Examinations Board as well as Ministry of Education, Science and Technology (MoEST), in the hopes that the work will not just be an extraction of truths, but will give them information with which they can better control problems to do with students examinations registration and verification as well as results dissemination.

1.10 Organization of the Thesis

The study is divided into five chapters. Chapter 1 forms the introduction to the study. It describes the background to the problem. It states the problem, purpose and objectives of the study. Chapter 2 looks at the literature review. It contains previous research and opinions by other researchers and summarizes the key findings of the literature reviewed by the researcher. Chapter 3 sets out the design and the methodology of the study. It points out the design of the study, the population of the study, sample and sampling procedures, research instruments, data collection and analysis procedures. It also gives a detailed design and modeling of the proposed system. Chapter 4 presents the research findings of the baseline study and the system implementation. Chapter 5 gives a discussion of the findings, conclusion and recommendations for further research.

1.11 Summary

This chapter has introduced the work of the researcher. It begins by hinting at the significance of examinations in every system of education. The education system in Malawi is also outlined and the types of national examinations that are written by candidates with the associated challenges that MANEB experiences when administering the examinations. The motivation, problem statement, aim and objectives of the study are also outlined. The chapter ends by giving the scope of the study, significance of the study and the organization of the thesis.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter of the paper gives a review of the literature that focuses on similar research work, how similar challenges that MANEB faces have been addressed as well as how the proposed solution to the challenges has been implemented in other parts of the world. The literature looks at the role of ICT in organizations, how ICT is used in management and development, cloud based computing technologies, how some national examinations councils register candidates for national examinations in other countries, SMS and USSD technologies. The chapter goes on to explore some technologies that are widely integrated into modern systems such as barcode technology, biometrics, Geographical Information Systems (GIS) as well as mobile payment systems. The last section discusses the different education systems across the globe and the type of national examinations that are written in various countries.

2.2 Dropout and Grade Repetition in Schools

School dropout has been defined as leaving education (in this case primary and secondary school) without obtaining a minimal credential (most often a higher secondary education certificate)[1]. On the other hand, grade retention/repetition is the practice of holding a student/learner in the same school grade or class for an additional year rather than promoting them to the next level grade with their age peers [2]. Dropping out of school is associated with numerous detrimental consequences including low wages, unemployment, incarceration and poverty whereas grade repetition usually results in retarding a student's progression in school [3]. Research on the causes of school dropout and grade repetition has been done all over the world. Results indicate that school dropout as well as grade retention is an issue that can be an indication of the academic, intellectual and social economic level of the students but also as the success level of the education system [3]. Effective policies to improve school progression and

reduce the numbers of children dropping out of school are critical if Universal Primary Education (UPE) is to be achieved.

In Bangladesh, although entry into grade one has reached near universal levels, the primary school completion rate has remained around 60% since 2000 making grade repetition and dropout to remain a substantial problem [4]. The European council intends to reduce the proportion of school dropout by young people to 10%. The council believes that the phenomenon of early school leaving by young people is the main risk factor in case of unemployment and the precarious social position [5]. 14.4% of young people aged between 18 and 24 years have completed only primary school education (Eurostat, 2010) with Romania, Malta, Portugal and Spain among countries with highest school dropout rate.

While basic school enrolment in Ghana has improved significantly to above 95% (MOESS, 2007), one major challenge facing it has been high cases of dropout. Over 20% of school-age Ghanaian children have either dropped or never enrolled in school [6]. In many countries children are starting school in great numbers than ever before but dropout rates are significant and lead to low levels of primary and secondary school completion. For instance Benin, the primary school completion rate in 2005 was 62% and in Democratic Republic of Congo, the primary school completion rate in 2007 was 51 % while the secondary school cycle in Kenya faces internal efficiency challenges such as low transition rates between primary and secondary school as well as high dropout rates [7].

Malawi has a total of 4,449,000 pupils enrolled in primary and secondary education and 3,688,000 of these are enrolled in primary education. Although youth ages between 15 and 24 may still be in school and working towards their educational goals, it is notable that approximately 5% of youth have no formal education and 57 % of youth have attained at most incomplete primary education [8]. Further, Malawi's primary net enrolment rate is 97% and the completion rate is 74%. Both these indicators provide a sense of progress a country is making towards universal primary education. Analogous research indicates that in Malawi students are more likely to repeat in grade one of primary school and in those grades where progression to next level requires sitting for national examinations with an average repetition rate of 19.5% [8].

Generally, national education plans assume that school progression will improve automatically as a result of interventions designed to improve initial access to educational quality, which is not the case. There is not one single cause of dropout rather it is often a process and therefore has more than one proximate cause. Apart from the most general causes of dropout and repetition, the system of educational provision generates conditions that can ultimately input on the likelihood of children to drop out from school [7]. Both demand and supply driven factors are embedded in cultural and contextual realities. Properly managed national examinations can significantly reduce the number of dropouts and repeating students in grades that sit for national examinations. Presently, the examination system is one of the key contemporary moral issues as technology continues to play a transforming role in societies in all over the world. The prospects for the utilization of new technologies in the field of education continue to be part of human consciousness from a number of angles one of which is that of public examinations. ICT is exerting a powerful influence on almost every facet of life. However, insufficient attention has been paid to the relationship between formal assessment and use of ICT (Harding and Craven, 2001). Accordingly, the education system can be the most effective sector to anticipate and possibly eliminate the negative impact of ICT [9].

2.3 Review of the Literature

2.3.1 Registration for National Examinations in other Countries

In this subsection, the processes and procedures of administering public examinations in some countries within Africa are examined. We look at how students register for national examinations, the systems they use, the challenges that the systems face and proposed solutions if any.

The National Examinations Council of Tanzania (NECTA) utilizes a process to register and verify candidate's details that involves a lot of documentation. District Education Officers (DEO) and Regional Education Officers (REO) conduct the actual registration using attendance registers and Optical Mark Reader (OMR) [10]. After compiling, they send the details to NECTA where the files are combined and a verification sheet is produced. As a result of making use of a lot of documentation, the DEOs and REOs face a number of challenges which include difficulty in identifying repeaters, shortage of registration forms and storage facilities, misspelled

names and incorrect entries in some schools, some head teachers sign M1 attendance forms on behalf of the candidates, omission in entry forms, delay in the announcement of the national registration dates, lack of clear distinction between male and female names, truancy among candidates, same registration number given to more than one candidate. Hence a more convenient method of registration and verification of candidates is being proposed by NECTA [10].

In Swaziland, the Examinations Council developed a new method of registering candidates known as e-registration. Candidates' registration entries are made at examinations centers using Excel Spreadsheet files. After capturing, the spreadsheet files are sent to the council by email or copied on a memory stick and sent to the council [11]. Centers with no Information Technology infrastructure use internet cafes at a nearest town or go to their Regional Education Offices for help. Later, an entry list report is produced that shows the entry details of each candidate entered for the examination. Amendments to errors are made on the report signed by candidates and then submitted to the council before amendment deadline. The process is characterized with such problems as being slow and time consuming and also there is some data loss when transferring the files [11].

Uganda is one of the countries that have taken steps towards improvement of registration of candidates for national examinations. The Ugandan National Examination Board (UNEB) has currently designed and developed a Windows-based desktop system for electronically registering candidates in bulk [12]. The system contains inbuilt controls for most common checks in anomalies. It can be installed on a single desktop where capturing of details is done. It has an export facility which allows the user of the system to extract data and export it into excel workbook that is subsequently uploaded to the UNEB web portal. At the end of registration, UNEB broadcasts a message to alert candidates of the end of registration. Parents/guardians of candidates are able to check the status of the candidates (whether registered or not) by sending an SMS using a code that is provided. As a way of further improving the system, UNEB is in the process of developing a fully-fledged online registration system [12].

National examinations in Kenya have been used mainly for selection and certification purposes and because of this, the examinations have been found to create undue competition that has affected the teaching and learning process whereby so much time has been devoted to the

preparation for examinations as opposed to covering the syllabus for the purpose of achieving the curriculum objectives (Mwanyumba and Mutwiri, 2009). According to Adeyegbe (2007), before the introduction of institutional online registration, there used to be numerous examination malpractices. These were over the quality of entry data, duration of processing of entries, security and storage of entry documents, physical transfer of data from the satellite stations to the main computer installation, prompt release of results, communication of assessment information to major stakeholders, logistics problems and escalation of costs. This prompted the Kenyan National Examinations Council (KNEC) to introduce the electronic registration system as the modern way of addressing the concerns raised, in order to maintain an efficient service delivery [13]. With this system, each school is given a unique 8-digit code to use for accessing the online registration application [14]. A school member of staff responsible for examinations logs on to the KNEC website where a candidate's registration application is downloaded. Then the application is filled with candidate's details to create the registration file, the registration file is then uploaded into the KNEC website. At a later point, a nominal roll is generated and printed for students to verify their registration details [13].

The Rwanda Education Board (REB) is a Rwandan national body that administers national examinations that include primary, ordinary level as well as advanced level candidates [15]. Candidates fill two duplicate registration forms with supporting documents like recent passport size photos, copy of National ID etc. The head teacher of the school signs and stamps on the forms and thereafter return the filled registration forms to the District Education Office. One copy of registration form remains at the school and is given to the candidate during the examination period. A complete candidate's index number includes Province Code (2 digits), District Code (2 digits), Sector Code (2 digits), School Code (2 digits) and Personal Candidate's Code (3 digits) hence the full index number is made up of 11 digits i.e. 03 04 05 10 001. This manual system of registering learners experiences a number of challenges that include misplaced registration forms, wrongly captured candidate's index number, wastage of stationery and slowness [15].

The West African Examinations Council (WAEC) is an examination board that conducts the West African Senior School Certificate Examination. It has contributed to education in Anglophonic countries i.e. Ghana, Nigeria, Serra Leone, Liberia and Gambia. WAEC has a

mandate to administer public examinations and award certificates. Its operations include test development, candidates' registration, test administration and processing of scores culminating in the release of results and printing of certificates [16]. In early days, WAEC used Optical Mark Readers which eliminated the card punching process in order to shorten processing time. As time passed by, with increases in candidate numbers, particularly in Nigeria, member countries embarked on educational reforms which were accompanied with several data-related problems. Thus WAEC was compelled to constantly seek modern ways of addressing the concerns in order to maintain an efficient service delivery system. [16]. WAEC uses a user friendly e-registration system. The system allows schools to register their candidates online through the internet [17]. The online registration system has several modules that include a module for examination payment, candidates' registration module, reviewing/editing of candidates' information module as well as generation of examination numbers module [16].

2.3.2 Information and Communication Technology in Education

The application of Information and Communications Technology (ICT) is gathering momentum and it is evidently a necessity. The utilization of technology based assessment is increasingly becoming part of the mainstream in the educational system [18]. According to Dietel, Herman, and Kunth (1991), good assessment provides an accurate measure of students' performance to enable teachers, administrators and other key decision makers to make effective decisions. Computer based assessment refers to the use of electronic technologies in assessment which includes computer programs for testing [19]. These programs display questions on the monitor of computer and the respondent selects/enters his/her response to each question (Ridgway, McCusker and Pead, 2004). Technological advances and the search for efficiency have catalyzed recently a migration from paper-and-pencil based assessment to computer-based assessment (CBA) in education and training at all levels. The drivers for this being faster administration, processing and delivery of examination results, error free marking of test items, enhanced interactivity and items which are composed of multimedia objects allowing for the measurement of skills not easily measurable by traditional tests and radical cuts in waste paper that is generated by paper-and-pencil tests (Chapman, 2005; Katerina and Kollias, 2008).

Technological innovations have enabled global interaction, e-commerce, e-learning, online examinations and certification. Management of public examinations is a great task that calls for

integrity, validity, fairness and credibility of examinations [20]. With the innovations in information technology, the majority of the work force will soon be working virtually. This paradigm shift is happening now and progressively, larger segments of the population, even government works are going online. Assessment of education is not to be left out during this virtual paradigm shift with the need to transform the education sector regionally or globally [20].

ICTs have become within a very short time, one of the basic building blocks of modern society. Many countries now regard understanding ICT and mastering the basic skills and concepts of ICT as part of the core of education, alongside reading, writing and numeracy [18]. According to (UNESCO, 2002), Information and Communications Technology may be regarded as the combination of informatics technology with other related technology, specifically communication technology. Informatics refers to the science dealing with the design, realization, evaluation, use and maintenance of information processing systems, including hardware, software, organizational and human aspects and the industrial, commercial, government and political implications of these. Hence Informatics Technology can be defined as the technological applications (artifacts) of information technology [18].

The most advanced computer based assessment systems have been constructed using specialized packages, e.g. Questionmark Perception which is a rich configured system that has been accepted widely [19]. It supports 21 question types and it is the model that is used by university of Maiduguri. It has some functions that are of particular interest like laboratory preparation questions that allow students to construct a virtual experiment. The availability of students' data and feedback can help an educational institution to align its business processes according to the needs of its students and stakeholders. The effective management of these data can help institutions reach out directly to their students and stakeholders and also to streamline its activities [21]

2.3.3 Cloud Computing

The National Institute of Standards and Technology (NIST) defines cloud computing as a model for enabling convenient, on demand network access to shared pool of configurable computing resources i.e. networks, servers, applications and services that can be rapidly provisioned and released with minimal management effort or service provider interaction [54]. Cloud computing

refers to both the applications delivered as services over the internet and the hardware and systems software in the data centers that provide those services [55]. It is argued that cloud computing is not a new technology but rather a new delivery model for computing infrastructure, services and information using many existing technologies that have been harnessed and made available by the cloud service providers. A cloud, from a client perspective, is an abstraction for remote infinitely scalable provisioning of computation and storage resources whereas from an implementation point of view, a cloud system is based on large sets of computing resources located somewhere which are allocated to applications on demand [54].

Cloud computing has become one of the most significantly achieved development in the IT industry which gives a platform to use applications in the form of services which is more scalable, reliable, high performance and relatively low cost as compared to the other distributed computing infrastructure. Today, many nations are considering switching to e-governance, a phenomenon where almost all government activities are done electronically. Simply put, e-government can be seen as simply moving citizen activities online, but in its broadest sense it refers to the technology-enabled transformation of government [22]. It is increasingly accepted that in the future most information sources and desktop applications currently in use will be mainly accessed through the internet, now increasingly referred to as 'the cloud'. The web software and cloud computing will definitely have an impact on enterprise IT. But the impact on the educational system will be astounding and many in educational system don't see it coming. These trends are moving much faster than the current educational systems can handle [26].

Web based systems have become increasingly important due to the fact that the internet and the World Wide Web have become ubiquitous, surpassing all other technological developments in our history [27]. There has been a huge growth in low-cost and free technology for social interaction, publishing, collaborating, editing, content creation, computing etc. [26]. Many technologies that were previously expensive or unavailable are now becoming free to anyone with a web browser. This is true for websites, blogs, video sharing, music sharing, social sharing, collaboration software, editing, presentation, and publishing computing platforms in the cloud etc. Web –based systems and applications now deliver a complex array of functionality to a large number of diverse groups of users. As our dependence and reliance on the web has increased dramatically over the years, their importance, reliability and quality have become paramount

important. As a result, the development of Web applications has become more complex and challenging than most of us think [27].

2.3.3.1 How Cloud Computing Works

Uniquely from other distributed system paradigms, cloud users are not required to have knowledge of, expertise in or control over the technology infrastructure that supports them [59]. A cloud computing system has got the front end and the backend sections. The front end is where the computer user or client sees. It includes the computer and the applications required to access the cloud computing system. The backend is the cloud section of the system where there are various computers, servers and data storage systems that create the cloud of computing services. A central server administers the system, monitoring traffic and client demands to ensure everything runs properly. The system follows a set of rules called protocols and uses a special kind of software called middleware that allows networked devices to communicate with each other. The applications, services, data and infrastructure in the cloud have certain features that define them i.e. services and data are remotely hosted on remote infrastructure, they are ubiquitous meaning that they are available anywhere and also the pay-per-use feature that brings in utility computing model similar to that of traditional utilities and electricity where one pays for what they use [55].

2.3.3.2 Architecture of Cloud Computing

Generally speaking, the architecture of cloud computing environment can be divided into four layers; the hardware or data center layer, the infrastructure layer, the platform layer and the application layer [56].

The hardware layer is responsible for managing the physical resources of the cloud, including physical servers, routers, switches, power and cooling system. This layer is typically implemented in a data center where there are thousands of servers that are organized in racks and interconnected through switches, routers or other fabrics. Typical issues in this layer include hardware configuration, fault-tolerance, traffic management, power and cooling resource management.

The infrastructure layer which is also referred to as virtualization layer creates a pool of storage and computing resources by partitioning the physical resources using virtualization technologies such as Xen, KVM and VMware. Many key features such as dynamic resource management occur in this layer hence it is an essential component of cloud computing.

The platform layer is built on top of the infrastructure layer and consists of Operating Systems and application frameworks. The purpose of this layer is to minimize the burden of deploying applications directly into VM containers i.e. the Google App Engine operates at the platform layer to provide API support for implementing storage, database and business logic of typical web applications.

The application layer consists of the actual cloud applications found at the highest level of the hierarchy. Different from traditional applications, cloud applications can leverage the automatic scaling feature to achieve better performance, availability and operating cost.

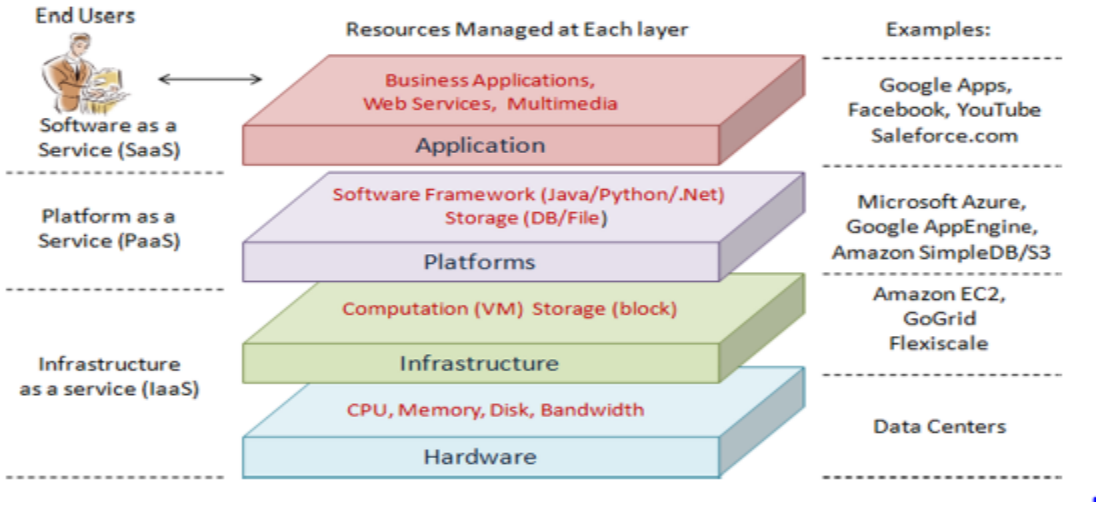


Figure 2.1: Cloud computing architecture [56]

Compared to traditional service hosting environments such as dedicated server farms, the architecture of cloud computing is more modular. Each layer is loosely coupled with the layers above and below allowing each layer to evolve separately, similar to the design of the OSI model for network protocols [56].

2.3.3.3 Cloud Computing Business Model

Cloud systems are classified on the basis of their service models. The different cloud services include infrastructure, platform and application. These services are delivered and consumed in real time over the internet [58].

Software-as-a-Service (SaaS) – Defines a delivery model in which software and data are provided through internet to users. It offers an easier way to access many of users' standard business applications and services such as emails, word processing packages etc. The Software-as a-Service applications of cloud computing are the currently most widely used cloud applications in secondary education with popular applications that include Google's Gmail, Google Docs, Zoho Office Suite, Microsoft Web apps (Office Live), Quick Mint, Adobe Buzzword, WriteRoom, Facebook, e-learning SaaS in a multi-tenant platform. It uses common resources and a single instance of both the object code of an application as well as the underlying database to support multiple customers simultaneously. Commonly referred to as the Application Service Provider (ASP) model, SaaS is heralded by many as the new wave in application software distribution [58] with examples of the key providers such as SalesForce.com (SFDC), NetSuite, Oracle, IBM, Microsoft etc. [23].

Platform-as-a-Service (PaaS) – This is a set of delivered services that provide an environment for applications development, deployment, management and integration in the cloud. Platform-as-a-Service provides the infrastructure on which SaaS applications are built and run, which can be Windows, Unix or Open Source systems such as Linux or Ubuntu. Examples include Google's App Engine, Heroku (a Ruby on Rails Platform) and Joyent's cloud software for service providers, Smart Machines and SmartPlatform [23]. PaaS facilitates the development and deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers. Other examples include GAE, Microsoft's Azure etc. Compared with conventional application development, this strategy can slash development time, offer hundreds of readily available tools and services, and quickly scale [57].

Infrastructure-as-a-Service (IaaS) – It is a hiring model where customers rent resources like CPUs, disks or Operating Systems. Users of IaaS usually have skills on system and network administration as they must deal with configuration, operation and maintenance tasks. The hired

resources are provided by some huge IT companies at an agreed price. Infrastructure-as-a-Service, the third group of cloud services, offers virtual computing resources as a service meaning instead of buying server, software, data center space or network equipment, consumers can buy these resources as a fully outsourced cloud service (utility computing). Examples include Amazon's Elastic Compute Cloud (EC2), GoGrid, and Windows Azure [23]. A key benefit of IaaS is the usage based payment scheme that allows customers to pay as they grow, and by always using the latest technology, customers can achieve a much faster service delivery and time to market. Other examples include, Flexiscale, Layered Technologies, Joyent and Masso/Rackspace etc [58].

Clouds are also categorized according to their deployment model:

Public cloud – This is when services are provided to the general public through the internet using web applications and/or services. Users have little or no control over the underlying technology infrastructure. It offers more benefits including no initial capital investment on infrastructure. However, public clouds lack fine-grained control over data, network and security settings. Resources are dynamically provisioned on a fine-grained, self-service basis over the internet via web applications or web service from an off-site third-party provider who shares resources [59].

Private cloud – Private cloud offers operations and functionalities as a service deployed over a company intranet or hosted in a remote data center. It refers to internal data centers of a business or other organization not made available to the general public. Private clouds offer the highest degree of control over performance, reliability and security. However, they are often being criticized for being similar to traditional proprietary server farms and do not provide benefits such as no upfront capital costs [56].

Hybrid cloud – This is the composition of two or more (private or public) clouds that remain different entities but linked together. Organizations can extend their private clouds using other private clouds from partner organizations, or public clouds thereby satisfying peaks of requests and better serve user requests. This model is recommended by many organizations [59].

2.3.3.4 Cloud Computing advantages

Cloud computing technologies have been there for a long time. Today, their confluence with an environment where information can be accessed independent of device location represents a major shift in computing as we know it. Cloud computing offers a number of advantages [57]:

No upfront investment as cloud computing uses pay-as-you-go pricing model. Individuals and companies utilize resources when they are needed without having to assemble any hardware or software requirements. Service providers also do not need to invest in the infrastructure; instead they rent from the cloud according to their own needs and pay for the use. This leads to a faster time market in many businesses.

Lowering of operating costs as cloud computing resources can be rapidly allocated and de-allocated on demand i.e. users in a business entity can demand a resource only when it is required and service providers no longer need to provision capacities according to peak load. This is more advantageous to smaller firms trying to benefit from computer-intensive business analytics that were available only to the largest of corporations.

Cloud computing is highly scalable as service providers can easily expand their services to large scales by using a pool of resources from data centers made available by infrastructure providers in order to handle rapid increase in service demands (Surge computing).

Services in the cloud are generally web based hence easily accessed through a variety of devices with internet connection.

Cloud computing helps freeing up internal resources because staff are no longer for routine maintenance works and as a result they can be released for other high priority works.

There is lowering of IT innovation barriers with cloud computing as can be seen from the many promising startups, from the ubiquitous on time applications such as Facebook to the more focused applications like Mint.

Cloud computing also makes possible for new classes of applications and delivers services that were not possible before i.e. a) mobile interactive applications that are location, environment and context aware and that respond in real time to information provided by human users, non-human

sensors or even from independent information services, b) parallel batch processing power to analyze terabytes of data for relatively small periods of time, c) business analytics that can use the vast amount of computer resources to understand customers, buying habits, supply chains.

2.3.3.5 Cloud Computing disadvantages

There is need for constant and strong internet connectivity in order for the users to connect remotely to the cloud.

Cloud applications have limited features. Since individuals and companies do have diversity of needs, some of which are not present in the cloud.

Data and information safety is a concern for many cloud users as well as those wishing to move to into the cloud. If the cloud was to go down and a user does not have a backup the user will simply lose the data. Cloud systems can also be hacked and accessed by unauthorized users hence compromising the confidentiality of data in the cloud.

Using cloud computing can also bring a number of risks. The major potential risks include security problems, low controllability, financial burden, weak openness, lack of auditing features and service agreement issues [60].

2.3.3.6 Characteristics of Cloud Computing

[56] highlights some of the characteristics of cloud computing in comparison to other distributed computing services:

Cloud computing provides multi-tenancy in the sense that services owned by multiple providers are co-located in a single data center while the performance and management issues of these services are shared among service providers and the infrastructure provider. The owner of each layer only needs to focus on the specific objectives associated with that layer. However, multi-tenancy brings difficulties in understanding and managing the interactions among various stakeholders.

Shared resource pooling is another feature in the cloud where the infrastructure provider offers a pool of computing resources that can be dynamically assigned to multiple resource consumers. For instance, an IaaS provider can leverage VM migration technology to attain a high degree of

server consolidation, hence maximizing resource utilization while minimizing costs such as power consumption and cooling.

There is also Geo-distribution and ubiquitous network access as clouds are generally accessible through the internet and use the internet as a service delivery network. With this, any device with internet connectivity is able to access cloud services. Today's clouds consist of data centers located at many locations around the globe in order to achieve high network performance and localization and as a result a service provider can easily leverage geo-diversity to achieve maximum service utility.

Cloud computing is service oriented hence it places a strong emphasis on service management. Each IaaS, PaaS, SaaS provider offers its service according to the Service Level Agreement (SLA) negotiated with its customers.

One of the key features in cloud computing is that computing resources are obtained and released on the fly. This is called dynamic resource provisioning. This allows service providers to acquire resources based on the current demand and not according to peak demand thereby considerably lowering the operating cost.

Cloud computing employs a per-use pricing model i.e. utility-based pricing. This also lowers operating costs as it charges customers on a per use basis.

2.3.3.7 Cloud Computing Obstacles and their Opportunities

This subsection describes some of the obstacles to the growth of cloud computing and suggest possible solutions to the obstacles [55][58].

The first obstacle is that of fault tolerance in case of failure. As a way of overcoming this, there will be a hot backup instance of the application ready to take over without disruption, a scenario called failover. Cloud computing outages extend into the more refined version of cloud service platforms. Some of the outages were quite lengthy. For example, Microsoft Azure had an outage that lasted 22 hours in March 2008. Cloud reliance can cause significant problems if the control of down time and outages is removed from your control.

Service and Outage	Duration	Date
Microsoft Azure: malfunction in Windows Azure	22 hours	March 13-14, 2008
Gmail and Google Apps Engine	2.5 hours	February 24, 2009
Google Search outage: programming error	40 minutes	January 31, 2009
Gmail: site unavailable due outage in contacts system	1.5 hours	August 11, 2008
Google AppEngine partial outage: programming error	5 hours	June 17, 2008
S3 outage: authentication service overload leading to unavailability	2 hours	February 15, 2008
S3 outage: single bit error leading to gossip protocol blowup	6-8 hours	July 20, 2008
FlexiScale: core network failure	18 hours	October 31, 2008

Table 2.1: Outages for different cloud services [58]

Another obstacle related to fault tolerance is that of load balancing. Load balancing is often used to implement failover i.e. continuation of a service after a failure of one or more of its components. The components are monitored continually and when one becomes non-responsive, the load balancer is informed and no longer sends traffic to it – an inherited feature from grid-based computing for cloud based platforms. With proper load balancing in place, resource consumption can be kept to a minimum. It also enables other important features such as scalability.

Interoperability is another obstacle. It is needed to allow applications to be ported between clouds, or to use multiple cloud infrastructures before critical business applications are delivered from the cloud. A Cloud Computing Interoperability Forum (CCIF) was recently formed to

define an organization that would enable interoperable enterprise class cloud computing platforms through application integration and stakeholder cooperation.

Availability of service; Individuals and organizations worry about whether utility computing services will have adequate availability and this makes some wary of cloud computing. Ironically, existing SaaS products have set a high standard in this regard. For instance Google Search is effectively the dial tone of the internet. Users expect the similar availability from new services which is hard to do. The only plausible solution to very high availability is multiple cloud computing providers.

Data Lock-In comes in as a result of APIs for cloud computing which are still essentially proprietary, or at least have not been the subject of active standardization (though software stacks have improved interoperability among platforms). Concern about the difficult of extracting data from the cloud is preventing some organizations from adopting cloud computing. Customer lock-in may be attractive to cloud computing providers, but cloud computing users are vulnerable to price increases, to reliability problems, or even to providers going out of business. The solution to this is to standardize APIs so that a SaaS developer could deploy services and data across multiple cloud computing providers so that the failure of a single company would not take all copies of customer data with it though it is feared that this would lead to a "race-to-the-bottom" of cloud pricing and flatten the profits of cloud computing providers.

Another issue is to do with data confidentiality and auditability. Current cloud offerings are essentially public (rather than private) networks, exposing the system to mere attacks. Many of the security obstacles can be overcome immediately with well understood technologies such as encrypted storage, Virtual Local Area Networks, and network middle boxes (e.g. firewalls, packet filter). Auditability could be added as an additional layer beyond the reach of the virtualized guest OS (or virtulised application environment), providing facilities arguably more secure than those built into the applications themselves and centralizing the software responsibilities related to confidentiality and auditability into a single logical layer.

Performance unpredictability also happens in cloud computing. Experience has shown that multiple virtual machines can share CPUs and main memory surprisingly well in cloud computing, but that I/O sharing is more problematic. To improve this is by improving

architectures and operating systems to effectively virtualize interrupts and I/O channels. IBM mainframes and operating systems largely overcame these problems in the 1980s, so we have successful examples from which to learn.

Scalable storage has also proved to be an issue with cloud computing. The main issues related to cloud storage are reliability and security. Clients aren't likely to entrust their data to another company without a guarantee that they'll be able to access their information whenever they want and no one else will be able to get it. The opportunity is to create a storage system that would not only meet these needs but combine them with the cloud advantages of scaling arbitrarily up and down on demand, as well as meeting programmer expectations in regard to resource management for scalability, data durability and high availability.

2.3.3.8 Technologies that make Cloud Computing Work

This sub section provides a review of the technologies that make cloud computing work. There are quite a number of technologies that are employed to realize the full potential of cloud computing [56][57][61][69].

Data center architectural design – A data center is the hub of cloud computing that contains thousands of devices like servers, switches and routers. Proper planning of a data center is very important as it heavily influences applications performance throughput of a cloud computing system. Presently, the network architecture design uses the layered approach and has been tested in some of the largest data centers. The basic architecture of a data canter consists of core, aggregation and access layers. Access layer is where the servers in racks physically connect to the network. The aggregation layer renders functions such as domain service, location service, server load balancing etc. The core layer provides connectivity to multiple aggregation switches and provides resilient fabric with no single point of failure. The core routes message traffic into and out of the data center. Usually the design of data center network architecture has to meet uniform high capacity, free Virtual Machine (VM) migration as well as resiliency.

Virtualization – This is a technology that abstracts away the details of physical hardware and provides virtualized resources for high level applications. This is the underlying technology of cloud computing as it provides the capability of pooling computing resources from clusters of servers and dynamically assigning or reassigning virtual resources to applications on demand. It

enables consolidation of servers and do more with less hardware and also supports more users per piece of hardware. With virtualization, if one server fails it will be restarted on the other virtualized server in resource pool restoring the required services with minimum service interruption. All these attributes of virtualization make it possible for cloud computing systems to achieve their key characteristics of multi-tenancy, massive scalability, rapid elasticity and measured service. With virtualization, the emulated computing platform for all practical purposes behaves like an independent system, but unlike a physical system, can be configured on demand, and maintained and replaced very easily.

Distributed file system – Distributed file systems are specifically designed to provide efficient, reliable access to data using large clusters of servers. They run on data centers to provide extremely high data throughputs, low latency and survive individual server failures.

Distributed applications framework – Since cloud computing uses web based applications, some HTTP-based applications conform to certain web application frameworks like Java EE. An example of software framework, MapReduce was introduced by Google to support distributed computing on large data sets on clusters of computers. It consists of a Master to which client applications submit their jobs. The Master then assigns work to available task nodes in the data center. It also knows which node contains the data and which other node hosts are nearby. If the task cannot be hosted on the node where the data is stored, priority is given to nodes in the same rack so as to reduce network traffic on the main backbone which also helps to improve throughput since the backbone is always the bottleneck.

Web services – A Web service is defined by the W3C as a software system designed to support interoperable machine-to-machine interaction over a network. Web services work with many different systems but in common usage the term refers to clients and servers that communicate over the HTTP protocol. Web services help to standardize the interfaces between applications, making it easier for a software client i.e. web browser to access server applications over a network.

2.3.3.9 Cloud security threats

Web applications are becoming increasingly prevalent because they allow users to access their data from any computer and to interact and elaborate with each other. However, exposing these

rich interfaces to anyone on the internet makes web applications an appealing target for attackers who want to gain access to other users' data or resources [35]. Many industries such as banking, healthcare, commerce etc. are extending their business operations to operate over the web. In healthcare, a more integrated system that crosses the various healthcare boundaries would clearly be an advantage to the patient [36]. This would contribute to the economy of effort for the patient if he/she could schedule an appointment, receive the results of diagnosis test, refill a prescription and file an insurance claim from a single, integrated portal, rather than making four separate logins on four separate websites to conduct four separate transactions with four different entities. A web services approach has the potential to enable this single scenario, but only if we can ensure the privacy and security of patient data throughout the medical enterprise [36].

Although there are many benefits to adopting cloud computing, there are also some significant barriers to adoption. One of the most significant barriers to adoption is security, followed by issues regarding compliance, privacy and legal matters [37]. According to the ISO 7498-z standard produced by The International Standards Organisation (ISO), Information Security should cover a number of suggested themes. Cloud computing should also be guided in this regard in order to become an effective and secure technology solution [38]. Therefore by exploiting the information security requirements at each of the various cloud deployment and delivery models set out by the ISO, vendors and organizations can become confident in promoting a highly protected, safe and sound cloud framework. The security requirements of web applications in the context of cloud computing can be attained by meeting a number of security measures some of which are:

Identification and authentication: This is the first step to protect sensitive records in web applications that employs a number of techniques i.e. fingerprint, iris scan, signature and voice recognition as well as other digital techniques like e-tokens, RFID, key fobs etc [36]. Each authentication technology is assigned a trust level, T() based upon its perceived reliability. However, in practice, the trust level of any particular product must be determined by experimentation to quantify its false acceptance and false rejection rates (the false acceptance rate is the percentage of authentication attempts by a person other than the enrolled individual which are nevertheless successful while false rejection rate is the percentage of authentication attempts by the enrolled individual which are nevertheless rejected) [36].

Authorization: Authorization ensures referential integrity is maintained. To prevent unauthorized access in web applications, most systems use combination of user authentication information with authorization policies provided by the application or administrator in the form of access control rules for various resources in the application such as files, directories, and database entities [35].

Confidentiality: At the center of confidentiality are control systems. Cloud computing utilizes the virtual computing technology. Users' personal data may be scattered in various virtual data centers rather than stay in the same physical location, even across the national borders. Hence data privacy protection will face the controversy of different legal systems. On the other hand, users may leak hidden information when they are accessing cloud computing services [39].

Integrity: One of most critical elements in any system. Integrity is easily achieved in systems when transactions follow the ACID (Atomicity, Consistency, Isolation and Durability) properties. Thus, the ACID properties of cloud's data should without doubt be robustly imposed across all cloud computing delivery models [40].

Non repudiation: In cloud computing, non-repudiation can be obtained by applying the traditional e-commerce security protocols and token provisioning to data transmission with cloud applications such as digital signatures, timestamps, and confirmation receipts services [38].

Availability: Web applications unavailability can be due to a number of reasons that may include security breaches at the physical location of data centers, failure of equipment at data centers, consumer site equipment failure, connectivity failure (major problem in Africa). Of much concern is the Denial of Service (DoS) which prevents legitimate transactions to take place [41][47].

2.3.4 Mobile Cloud Computing (MCC)

The advances in information and communication technology and the invention of modern communicational and information devices in today's world have created new forms of doing things and giving services, thus the accuracy, speed and transparency have been increased [24]. Globalization makes governments establish e-government, a hype that has attracted many businesses, organizations and institutions that require collaborative, flexible, scalable and cost

effective computational infrastructure [25]. With the explosion of mobile applications and the support of cloud computing for a variety of services for mobile users, mobile cloud computing (MCC) is introduced as an integration of cloud computing into the mobile environment. Mobile cloud computing brings new types of services and facilities for mobile users to take full advantages of cloud computing [26].

Although the predictions that mobile devices will be dominating the future computing devices, they along with their applications are still restricted by some limitations such as the battery life, processor potential, and the memory capacity of Smart Mobile Devices (SMDs). Nowadays modern mobile devices have sufficient resources such as fast processors, large memory, and sharp screens. However, it still is not enough to help with computing intensive tasks such as natural language processing, image recognition and decision making [62]. Mobile cloud computing is an integration of cloud computing technology with mobile devices to make the mobile devices resource-full in terms of computational power, memory, storage, energy and context awareness [63]. Mobile applications are becoming an integral part of society in various domains and disciplines. However, the realization of these applications at scale is challenging. Developers and stakeholders are faced with constraints that arise from multiple factors including limited resources on mobile phones, lack of consistent communication bandwidth, security and privacy etc. [64]. MCC provides business opportunities for mobile network operators as well as cloud providers. More comprehensively, MCC can be defined as a rich mobile computing technology that leverages unified elastic resources of varied clouds and network technologies toward unrestricted functionality, storage, and mobility to serve a multitude of mobile devices anywhere, anytime through the channel of Ethernet or Internet regardless of heterogeneous environments and platforms based on the pay-as-you-use principle [65]. The mobile devices in MCC can be laptops, PDAs, smart phones, mobile phones, and so on which connect with a hotspot or base station by 3G/4G, WiFi, or GPRS [66].

In the past, all services on the internet were available only to computer users. Mobile phones are greatly expanding the market for the electronic delivery of services available on the internet [29]. Mobile data communication is already extending the internet to people on the move. Facilitating this will be a new technology called Wireless Application Protocol (WAP), which will, to put it simply, bring the internet to a mobile phone. The latest web computing-related technologies

(including WAP, WML, Script and CGI programming) are gaining interest for applications in software technology research and education. Implementing a practical internet application system to effectively utilize and evaluate these technologies can actually be combined for substantial improvement of productivity to end users as well as providers [29].

The main operation in any mobile cloud world is the offloading of jobs that takes place from the resource constrained mobile device to the cloud. Current research discusses offloading methods in three main directions. Client –server communication, Virtualization, and Mobile agents [67].

Client-server communication is done across the mobile device (off loader) and surrogate device via protocols such as Remote Procedure Calls (RPC), Remote Method Invocation (RMI) and Sockets. Both RPC and RMI have well supported APIs and are considered stable by developers. However, offloading through these two methods means that services need to have been pre-installed in the participating devices. This is a disadvantage when considering the ad hoc and mobile nature of a mobile cloud and restricts the mobility of users if in the vicinity of devices that do not support the needed services [67].

Virtual Machine (VM) migration refers to transferring the memory image of a VM from a source server to the destination server without stopping its execution. The memory pages of the VM are pre-copied without interrupting the OS or any of its applications, thereby providing an illusion of seamless migration. This method ensures that no code changes are needed when programs are offloaded, and provides a relatively secure execution, since the VM boundary insulates the surrogate device. However, VM migration is somewhat time consuming and the work load could prove to be heavy for mobile devices [67].

Scavenger is an instance of framework that employs cyber-foraging using WiFi for connectivity, and uses a *mobile method*, code approach to partition and distribute jobs. It also introduces a scheduler for cost assessment. The method of cost assessment is based on the speed of the surrogate server and it uses a benchmarking method to do this. Using its framework, it is possible for a mobile device to offload to one or more surrogates. However, it does not discuss fault tolerance mechanisms and since its method is strictly about offloading on surrogates and not sharing, it is not really dynamic. Also all its surrogates are desktops and it is unclear if Scavenger is too heavy to run on mobile phones [67][68].

2.3.4.1 Mobile Cloud Computing Applications

Some well-known applications of MCC include Google's Gmail drive, Maps and Navigation systems for mobile, I-cloud from Apple, Moto Blur from Motorola, Amazon's new "cloud-accelerated" Web browser Silk etc. Below are some application areas of MCC [64][65].

Mobile Commerce - Buying and selling of products using mobile devices. M-commerce applications are normally used to achieve some tasks that necessitate mobility i.e. transactions and payments, mobile messaging, and mobile ticketing through messaging services (SMS or MMS messages).

Mobile Learning – By orchestrating mobile computing and cloud computing, we project a paradigm shift in delivery of education that can impact learning behaviors and accessibility of educational opportunities. Cloud based m-learning applications are presented to solve limitations of traditional m-learning applications i.e. utilizing a cloud with the large storage capacity and powerful processing ability, the applications offer learners with much comfortable services in terms of information size, processing speed.

Mobile Healthcare – The treatment for chronic illnesses heavily depends on patient continuous reports of symptoms and side effects. M-health platforms make it feasible for patients to collect and share relevant data with physicians, anywhere anytime for effective treatment. Cloud m-health helps to realize applications that provide real time processing and storing of huge volumes of patients data. However, the major challenge is the privacy/security of medical information [50].

Mobile Banking – This is an uprising in traditional banking services, where users can avail the bank services provided to them through their mobile despite of location and time. Transaction can be done even if user is busy in his routine work via SMS or with mobile internet but can also use special programs, called mobile applications, downloaded to the mobile device.

Mobile Game – M-game can completely offload game engine requiring large computing resource i.e. graphic rendering to server in the cloud, and games only interact with the screen interface on their devices. This demonstrates that offloading (offloading code) can save energy for mobile devices, thereby increasing game playing time on mobile devices.

Mobile Social Media – Today, mobile applications are often built based on social networks such as Facebook. These social networks save as de-facto means of entry login into many mobile services which bridge the gap between virtual social communities and physical world information and services. By using Location Based Services (LBSs) mobile users could get localized information like maps, driving directions, search of points of interests, sharing data or socializing with friends and families.

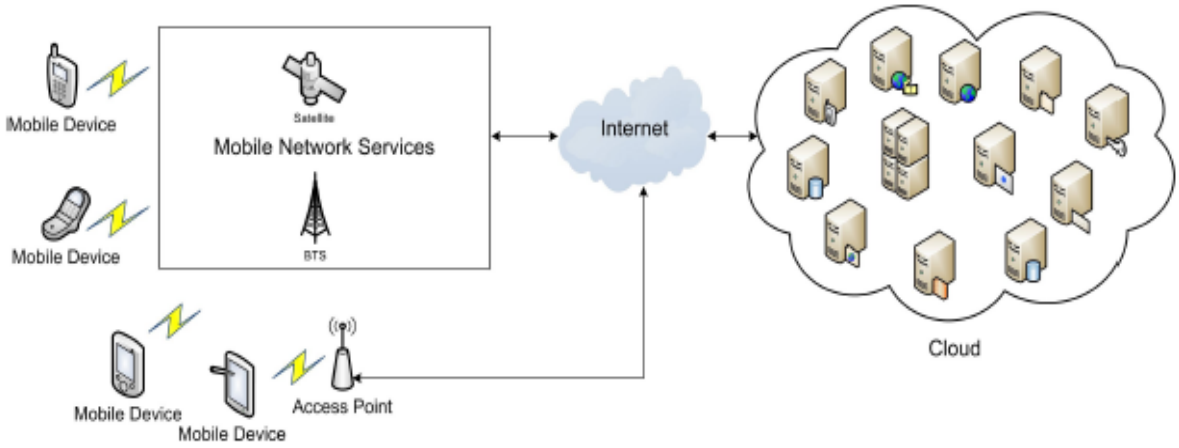


Figure 2.2: Mobile Cloud Architecture [63]

2.3.5 Short Message Service (SMS)

Although it is a widely used communication mechanism for cell phones, SMS is far more than just a technology for teenage chat [70]. SMS technology evolved out of the Global System for Mobile Communication (GSM) standard, an internationally accepted cell phone network specification the European Telecommunications Standards Institute created. The dramatic penetration of mobile phones all over the world, even in very remote areas, has created enormous opportunities for marketers and public administrators to be in touch with consumers with continuous interactivity so that citizens can find a satisfactory relationship to government [71]. Text messages are short alphanumeric communications sent from one mobile phone user to another with messaging applications on mobile handsets. They are frequently used for social coordination and personal communication because text messages are quick and cheap to send [72].

SMS gateway can be defined as a system or mechanism that facilitates SMS transition by transforming the messages from several types of communication media to mobile network traffic, and vice versa, allowing, receiving and transmitting the SMS messages with or without the use of a mobile phone. The typical working process of SMS gateway system is similar to the concept of regular email or SMS in terms of a system receives a message from sender client then conveys it to the receiver client [73].

2.3.5.1 How SMS Works

SMS messages are transmitted over the Common Channel Signaling System 7 (SS7) which is a global standard that defines the procedures and protocols for exchanging information among network elements of wire line and wireless telephone carriers. These network elements use the SS7 standard to exchange control information for all setup, routing, mobility management etc. [32].

SMS messages are handled via a Short Message Service Center (SMSC) that the cellular provider maintains for the end device. The SMSC can send SMS messages to the end device using a maximum payload of 140 octets meaning that the upper bound of an SMS message is 160 characters using 7 – bit encoding. Other schemes can be specified such as 8 – bit or 16 – bit encoding, which decreases the maximum message length to 140 and 70 characters respectively [70]. SMSCs operate in either a store – and – forward or a forward – and – forget paradigm. In the former paradigm, the system resends the message for some period of time until it is successfully received. In the latter paradigm, the system sends the message to the end device without assurance of receipt or an attempt to redeliver in the case of failure.

SMS applications can be built as two kinds of services i.e. Independent and Dependent services. [30]. Independent service involves using solely a mobile phone and the application server (system running SMS application). This option offers limited benefits but it is easy and fast to set. It does not require authorization of the service provider or connection to any third party SMS provider. The mobile phone uses a regular SIM card which has a normal phone number and messages that originate through the phone attract the standard cost or tariff. On the other hand, Dependent service involves having the application server connect to the service provider's SMS center (SMSC). It requires a constant connection to the internet as the application server does not

require any physical phone/modem with a SIM card connected to it; rather it connects to a SMSC. When users send their requests, they go to the SMSC which automatically forwards the message to the application server over the internet. This option provides added benefits as the service provider can provide a special tariff and a dedicated line for the application. Here the application usually runs on corporate servers that are connected to the SMS network through specialized connectors and gateway connected to the SMSC of mobile operators (Mavrakis, 2004). These servers are assigned short numbers instead of the traditional 10 -15 digits mobile numbers. These numbers, also known as short codes, are usually 4 -6 digits long and are operator specific.

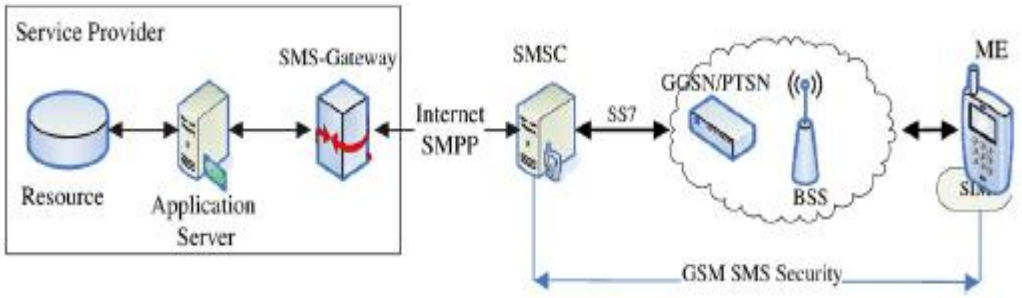


Figure 2.3: Short Message Service Architecture [75]

SMS communication happens between Mobile Equipment (ME) and the Application Server (AS). The Application Server deals with the content of SMS from the ME, and the SMS-Gateway is a gate way which receives the SMS from a ME or sends the SMS to a ME by the connection with SMSC. The AS and SMS-Gateway as well as resource database are located in local network environment of the Service Provider (SP) [75]. When a handset sends out an SMS (possibly a requesting message), it is firstly delivered from the handset (ME) to a SMSC through the base station (BSS). Then the SMSC gets the destination of the SMS and forwards the message to AS through the SMS-Gateway or SMS-Gateway Mobile switching Center (SMS-GMSC). The SMS-GMSC will then access the Home Location Register (HLR), search to locate the cellular phone address at the end point, and then route information to the Mobile Switching Center (MSC). After receiving the data, the MSC will determine which SMSC to contact for this end point. If the caller is on roaming mode, SMS-Internetworking Mobile Switching Center (SMS-IWMSC) will be the message's next stop [74]. On the contrary, when a SMS message

(possibly a response message) is sent to a mobile user by AS, it is firstly delivered from AS to the SMSC through the SMS-Gateway; the SMSC then broadcasts the message through the BSS to the destination ME. The connection between SMSC and the BSS is over the SS7 network and that between SMSC and the SMS-Gateway is facilitated by a TCP/IP connection over the Internet [75].

2.3.5.2 Notification Messaging

Generally, a message may be sent or received. A response from the message sent is feedback. The primary emphasis of today's messaging services practically rests in the notification function. Notification is an important up to date message delivered via some kind of mechanism. Notification and messaging services in general are going to affect everyone's life as all of us grow more and more dependent on consuming interesting updates on potable and/or smart devices anywhere anytime [76].

Several techniques exist that can deliver notification messages to the receivers. However, the most popular and widely used are polling and pushing (NewBay, 2011).

With polling, the receiver regularly checks for new notification updates with the data source such as the notification service provider. The receiver sends a request and gets a reply. This is a full duplex scenario where a user sends a request to the SMS application and the application replies with the information requested [31]. Polling is simpler to implement than the pushing counterpart technique. However, its characteristic of perpetually interacting with the data source tends to create a lot of header data that could adversely affect a mobile operator's network, and also it significantly deteriorates the battery life between charges of mobile devices [76]. Pushing is more emphatic on the core applications that reside on the server. The pushing technique, unlike polling, has the application's server deliver notification messages to the receivers upon learning of new updates. It relies upon the exchange channel between the application's server and receiver's application. It only pays attention to changes on the prescribed parameters that matter to the receivers and when such a change is detected, the server will automatically send a notification to each receiver that has subscribed to the external channel. It is a one way message and it is initiated by the SMS application [31].

Much research on existing notification messaging services has focused on push notification services in the market and they have been categorized into three as follows [76]:

Notification service platform providers – Here notifications are provided by the major mobile operating system vendors/providers and are accessible by a wider mobile user population typically via a function built into the mobile operating system. Apple Push Notification and Google Cloud Messaging are the more popular examples of the services in this class.

Notification service middleware providers – With the growing number of notification service providers on different platforms, developers could not keep up with such diversity since they will have to deal with multiple notification service APIs. This class of notification service providers addresses such an issue by furnishing the cross-platform messaging middleware layer that permits the application developers to deliver their notification payloads to multiple receiving platforms via common APIs. Examples are Azure Notification Hub, Amazon Push Service, Urban Airship, Pushwoosh, OpenPush, Helios etc.

Notification messaging application providers – In this group, the notification service happens at the application level. The notification messaging application is installed on a different platform that will allow cross-platform notification messages to be sent and received effortlessly. Instead of having several notifiable applications on each platform for the receiver to deal with individually, the application in this group can collect all receivers' subscribed notifications in one place for ease of access. Examples are PushOver and PushBullet.

2.3.5.3 Use of SMS in Education

Given its ubiquitous and low cost nature, mobile telecommunication may be able to break the digital divide and be used as an important means to improve education services. In many countries mobile applications have been designed and implemented to educational services such as applications that assist students and/or parents to easily access examination results immediately after being released. Till today, especially in developing countries, there exists a problem of checking students' registration details as well as examination results as students throng to notice boards. Although this information is put on websites in other countries, the level of internet availability in less developed countries is still low and quite expensive. In the case of result checking systems, they do not only allow students to request grades, they also provide the

results as soon as they become available. This is done by pushing the results to students or working on a request sent from a student to produce results [30].

Mobile technologies could facilitate collaboration and interaction, accessing, discovering, discussing, and sharing environmental information with use of SMS service. The 'push' model will allow the school or teacher to send out messages to learners enrolled in a specific lesson and a 'pull' system enables learners to receive information using a menu system, an interactive system which enables learners receive questions then answer, receive feedback [77]. Most other usage of mobile phones include short answering, ranking, matching, fill in blanks, true/false, multiple choice questions [78].

Mobile phones have the capacity of storing information and received texts in SIM cards that will allow students to review and edit information later. Because mobile phones give chance to receive information and feedback on real time and on demand, it is much more nonthreatening and private than other classroom technologies. Also use of mobile phone is very easy for many students so adaptation of the technology is fairly easier than use of any other unusual educational technologies such as Smart Board [79].

2.3.5.4 SMS security threats and vulnerabilities

SMS messages are delivered in a best effort manner to other cellular telephone users asynchronously through the cellular network. These networks operate separately from the Internet and are sometimes considered to be more secure, accessible and less open to misuse i.e. spam. However, the GSM network does not provide important security services such as mutual authentication, end-to-end security, non-repudiation or user anonymity [80]. When the SMS is used as a bearer for mobile business applications which need high security, e.g. payment, shopping or mobile betting, m-health etc. there is a possibility that an attacker might capture the message context which includes user privacy, or amend the message causing a fraudulent transaction [75]. This section summarizes the threats identified that occur within a mobile environment.

SMS disclosure

Nowadays, the transmission of SMS does not provide end-to-end protection of confidentiality and integrity. Thus, the SMS message can be snooped and intercepted during its transmission which results the privacy at the punt. Network operators can even access the content of SMS during transmission at SMSC since SMS messages are stored as plain text in the SMSC before they are successfully delivered to the intended recipient. Hence they can be viewed or amended by users in the SMSC who have access to the messaging system [81][75]. Although SMS messages are encrypted when sent across the air, the encryption algorithm chosen for SMS message encryption must be the network specific algorithms, such as A5 for GSM. These algorithms have been susceptible to cryptanalysis [75]. The SS7 network is physically protected but not under the control of a single entity hence the protection of the SS7 network against the injection of messages is thus only as effective as the weakest protection offered by any of the operators since messages can be injected into the weakest point of access [80].

SMS spoofing

The possibility exists that an attacker manages to inject SMS messages into the messaging network with a 'spoofed' originator IDs. The attack can be applied in both ways by impersonating the AS for a legitimate MS or impersonating the MS for a legitimate AS [80] with the possibility of spoofing very high in the former case as it is possible to send an SMS message from the Internet with the correct headers without the recipient being able to detect that it comes from the Internet. When a malicious user knows the secret authenticating information of a legitimate MS, he/she can perform the operation with legitimate AS [81].

Replay of messages

The malicious user maliciously or fraudulently repeated or delayed the conversation between the sender and the receiver and captures the authenticated information [81]. Here the passive eavesdropper will resend the previously sent messages by the sender to disturb the network traffic as a way to quickly deplete the resources of the energy constrained mobile station [82]. An attack on the reply of an authentication request message does not seem obvious; however, replaying an authentication response could be a more serious vulnerability [80]. If such a reply is

possible, it can be used to impersonate a legitimate user and hence authenticate a false transaction [75].

Man-in-the-middle attack

An attacker establishes an independent connection with both victim's MS. The malicious user may gain access into an existing connection to intercept the exchanged information and inject false information [81]. The attack involves an attacker invisibly receiving all the communications from the mobile phone of a sender and forwards them to the receiver and vice versa. It can occur when an MS tries to connect to a BTS/BSS [82].

Over the air modification in SMS transmission

The vital parameters sent through the SMS are modified when the message is in transit in the wireless medium [82]. SMS messages are sent Over the Air (OTA) interface between the MS and the BTS. In GSM network, all traffic and signaling data across the air interface are sent encrypted. The encryption algorithm is also network specific and earlier it was one of two GSM-specific algorithms known as A5/1 and A5/2. The A5 algorithm is a symmetric cipher [81].

SS7 transmission security issue

The SMS messages sent over the SS7 networks are unencrypted; moreover, most service providers communicate with the SMSC with Short Message Peer to Peer (SMPP) protocol over the internet. However, the cryptographic security protection is not available in SMPP protocol hence the malicious user can easily read, alter or delete the message content [81].

Other SMS transmission attacks

According to [81][82] a lot of other SMS protocol attacks have been discussed together with their impacts;

Signer and content verification attack, Source substitution attack, Time-memory trade off attack, Codebook attack, Key separation attack, Known key attacks, Denial of service attack, Distributed denial of service attack, Masquerading etc.

2.3.6 Bulk SMS

Bulk SMS service is used to send a mobile message to multiple mobiles through Internet. Its advantages include cost effective, time saving, instant delivery of messages and measurable response for the sent SMS from the recipients [33]. Large target audience and mass campaigning have become a necessity for business these days, hence a new concept has emerged called bulk messaging. With benefits of bulk SMS system, we can apply this system to enhance educational communication. In terms of education, the system can be applied to conduct a feedback system for a large class. Furthermore, it can be applied to send quizzes in forms of multiple choices, true/false, ranking and matching questions to multiple mobiles at one time. In terms of academic information and public relations, bulk SMS can provide a more flexible and effective way to reach the lecturers, students and other related receivers anytime anywhere [34].

Similar to email, bulk SMS is an entirely web-based application of messaging platform; however, bulk SMS offers a better solution to distribute information instantly to multiple cellular users without using complex computer devices [34]. The huge improvement of wireless services and the growth of web applications have drawn the attention of the advertising market. Business forms, producers, and service providers have continually sought to reach consumers in the community through advertising. Organizations and government institutions have also sought for effective ways to broad cast essential information to the public concerning emergencies, natural or manmade disasters and for public awareness [83]. SMS does have the potential to be used in location-based services if the wireless service provider uses other resources that provide information of geo-specific location. For instance, bulk SMS messages can be transmitted to specific mobile numbers when they have been identified to exist in designated area (s). The usability of SMS as a teaching tool has also been greatly enhanced by an additional tool that has been developed to ease the workload of teachers in sending bulk messages. For example, the Information Technology Services Center at The Chinese University of Hong Kong (CUHK) developed an online system to enable teachers to send batch messages to a single student or groups of students through a web based interface [84].

2.3.7 Unstructured Supplementary Service Data (USSD)

As Global System for Mobile Communication (GSM) companies have been increasing by each day, the rivalry of making more and more profits among the companies all over the world urges them to be creative and innovative in terms of the services provided by the network and related equipment. Voice Call, Short Message Service (SMS), Unstructured Supplementary Service Data (USSD), Voice Mail, Wireless Application Protocol (WAP) etc. were the services started respectively [87]. Unstructured Supplementary Service Data is a GSM service that allows high-speed interactive communication between the subscribers and applications across a GSM network [86]. USSD applications are accessed by user request, and make use of short codes or text strings to trigger certain services in a session-based communication. These codes could perform a function, request a snippet of information, or lead the user into a series of textual menus which are navigated through the corresponding menu numbers. Technically, USSD service allows the Mobile Station (MS) user and a Public Land Mobile Network (PLMN) operator defined application to communicate in a way which is transparent to the MS and to intermediate network entities [87].

2.3.7.1 USSD vs SMS

Although SMS and USSD are contextually different, they share some features. The following table lists the common and unique features of both of them.

Features	USSD	SMS
Out of band signaling channel	Yes	Yes
Communication characteristics	Real-time, Session-based	Store and Forward
Communication entities	Between MS and an USSD handler in a network entity	Among Mobile Originated MS, MSC, Mobile Terminated MS
Communication protocol	SS7	SS7
Payload length	182 characters	160 characters
Message storage in mobile	Just one-time cached to see message	Stored in either SIM card or MS memory

Analogy	Chat	Email
Operation costs	Less costly because of that the USSD communication happens between MS and handler	Much costly because of that SMS messages might need to be passed through different networks

Table 2.2: Common and Unique features of USSD and SMS [87]

2.3.7.2 USSD architecture and communication

USSD is a soft real time data communication protocol between MS and GSM network. It is an interactive data service defined by European Telecommunications Standards Institute and a supplementary data service based on GSM. It adopts a connection-oriented and interactive conversation mode. When mobile phone users conduct their query operation on an information query system based on USSD, they first dial a given number to access the system [85]. Then a conversation between the mobile phone of the users and the system transpires. Users may send their query request by inputting query parameters on their mobile phone. According to the query parameters, the system searches the requested information in its database. Finally, the system returns query results to the user [85]. While the data communication between MS and Switching System (SS) is fulfilled with Base Station System Application Part (BSSAP) messages, Mobile Application Part (MAP) messages are used among MSC, VLR, HLR and USSD Gateway. The data communication is transparent to MS and Base Station Subsystem (BSS). This is to say USSD messages are not modified while passing through these entities. The communication can be established during call or out of call because the communication channel for both is different [87].

2.3.8 Mobile payment

In a developing country, the financial infrastructure is not well developed, with a limited number of payment instruments and a larger unbanked population, because access to financial services is very costly. This results in a large percentage of the population operating on a cash only basis and outside the formal banking system. A growing number of people in remote areas are using new alternatives to traditional banking made possible by the rapid spread of mobile phones, as mobile penetration is expected to reach 100 % worldwide in the near future [137].

Mobile payments allowed customers to eliminate the need to use cash, offering convenience and speed, performance and transfer of secure information between devices, from single or individual transactions to environment with high volume of payments such as restaurants or large retailers [88]. Generally, mobile payment (m-payment) refers to the payment for goods, services, and bills with a mobile device such as mobile phone, smart phone, or personal device assistant by taking advantage of wireless and other communication technologies [89]. The innovation within m-payment has grown rapidly over the last decade with the introduction of various payment methods such as Wireless Application Protocol (WAP), Unstructured Supplementary Service Data (USSD), Short Message Service (SMS) and General Packet Radio Service (GPRS). Mobile payment systems show wide disparities in rates of penetration in different national markets. In general, they have been slow to diffuse in Europe, the United States and other countries where the credit card payment system is very popular [90]. The findings of a study in Malaysia showed that mobile users are beginning to accept m-payment system as a convenient and effective option to perform payment transactions. Hence, government bodies and business organizations can further utilize m-payment system to complement existing payment methods and augment customers' payment behavior [91].

2.3.8.1 Mobile payment characteristics for user adoption

The following conditions have to be met in order for mobile payment to become acceptable in the market[92][93]:

- Simplicity and usability: Technology Acceptance Model (TAM) states that perceived usefulness and ease of use are the two most important determinants of acceptance of new technology. The m-payment application must be user friendly with little or no learning curve to the customer. The customer must also be able to personalize the application to suit his or her convenience.
- Universality: M-payment service must provide for transacting between one customer to another customer (C2C), or from a business to a customer (B2C), or between businesses (B2B). The coverage should include domestic, regional and global environments. Payments must be possible in terms of both low value micro-payment and high value macro-payment.

- Interoperability: Development should be based on standards and open technologies that allow one implemented system to interact with other systems.
- Security, Privacy and Trust: The wireless and mobile environment adds additional complexity to these issues. Consumers are less likely to adopt m-payment if they are uneasy about its ability to ensure secure transactions and protect privacy. When these transactions become recorded, customer privacy should not be lost in the sense that the credit histories and spending patterns of the customer should not be openly available for public security. Mobile payments have to be as anonymous as cash transactions. Finally, the system should be foolproof, resistant to attacks from hackers and terrorists. This may be provided using public key infrastructure security, biometrics and passwords integrated into the mobile payment solution architectures.
- Cost: The m-payments should not be costlier that existing payment mechanisms to the extent possible. A m-payment solution should compete with other modes of payment in terms of cost convenience.
- Speed: The speed at which m-payments are executed must be acceptable to customers and merchants.
- Cross border payments: To become widely accepted the mobile payment application must be available globally, worldwide.

2.3.8.2 Mobile payment business models and players

The mobile payment value chain may include mobile operators, financial service providers (such as banks, financial unions etc), third party payment service providers (such as Alipay, Google Wallet and paypal), service providers (such as public transport companies, schools, public utilities), equipment providers (such as chip manufactures, mobile handset manufacturers and terminal equipment providers), system integrators, merchants and mobile phone consumers. All the three major participants, namely, mobile operators, banks and third party payment institutions want to control the market, and their competition and cooperation determine the operational models for mobile payments [90] hence current researchers have identified mainly four types of mobile payment operational models [90][92]:

Mobile operator-led operational model

Customers may make payment to merchant using their mobile phone and this may be charged to the mobile phone bills of the customer. In this model, mobile transaction charges are collected directly by mobile operators, with no involvement of banks. When making mobile payments, the mobile account connected to the user's telephone number is usually considered the payment account. Therefore, payments for consumer purchases of goods and services are deducted directly from the mobile account.

Bank-led operational model

The bank account is linked to the mobile phone number of the customer. When the customer makes a m-payment transaction with a merchant, the bank account of the customer is debited and the value is credited to the merchant account. In this model banks offer mobile payment services independently, while mobile phones are just (one of) the platforms of payment. Mobile operators are only responsible for providing the information access channel, but do not participate in operation and management of payment systems; therefore, banks are solely responsible for transactions and retain all profit.

Third-party payment platform-led operational model

In this model, third-party payment systems establish a trading support platform that contracts separately the banks. These payment systems have dependable economic strength and reliable reputation in the industry, and they are independent of other financial institutions, especially of banks. Here, the buyer purchases goods from vendors listed by the platform, and the platform informs the seller for delivery. The platform will transfer money from the buyer's bank account to the seller, but will not do so until the buyer has received and checked the goods, and approves payment. It connects consumers, banks, and merchants using the mobile operator as a platform. Payment platforms not only can serve consumers irrespective of which bank they do business with, which is difficult otherwise, but also protects buyers from fraudulent sellers.

Hybrid operational model

Here, mobile operators partner with one or a few selected banking institutions to provide mobile payment services. This model encourages mobile operators and banks to work together to dominate market, since their cooperation can take advantage of the former's network presence and customer relations, and the latter's expertise in electronic payment technology, security and credit management fields while eliminating each other's shortcomings.

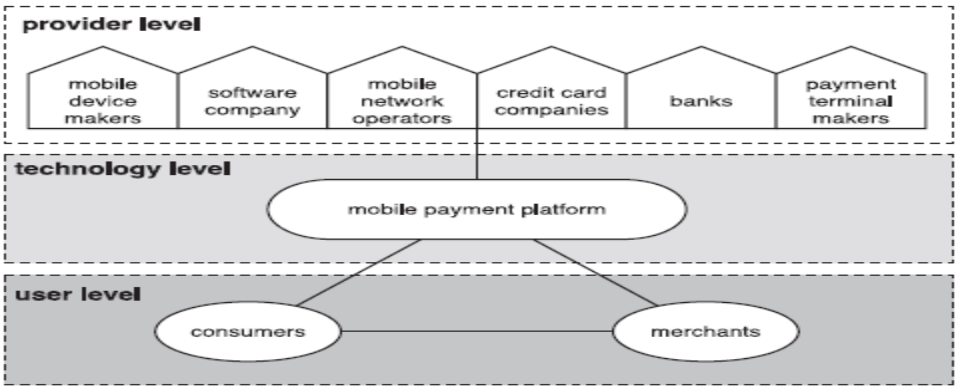


Figure 2.4: Multisided platform framework for mobile payments [94]

2.3.8.3 Challenges of Mobile payment

Standards: Mobile payments lack cohesive technology standards that can provide a universal mode of payment. The lack of standards will give rise to a lot of local and fragmented versions of m-payments offered by different stakeholders (network operator centric models and bank centric models) [92].

Business models: Since there are several stakeholders in the systems, a viable and sound business model needs to be developed that will provide a framework for revenue sharing [92].

Regulatory issues: Although m-payment may allow parties to make economic exchanges, it is not legal tender in the sense that it lacks the status of other payment instruments such as cash, which is the medium of exchange that is authorized, adopted and guaranteed by the government. The regulations for players in the financial industry are different from those governing the telecommunications industry, which means that each industry has its own particular standards body to comply [92].

2.3.8.4 Digital Financial Services Regulations

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, Information and Communication Technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is an organ of ITU responsible for studying technical, operating and tariff questions and issuing recommendations on them with a view of standardizing telecommunications on a worldwide basis. Regulations may enable or thwart a healthy digital financial services ecosystem and therefore the potential to realize the goals of financial inclusion. Moreover, given the complexity of the Digital Financial Services (DFS) regulatory environment, it remains imperative that the two sector authorities involved in these efforts – financial services and telecommunications, collaborate to address these issues [138].

According to [138], digital financial services and financial inclusion are split across six categories i.e. agents, consumer protection, market access, payment systems, risk management and others.

- Agents: Involves governing agent exclusivity. Exclusivity may create barriers to access, vis-à-vis non-interoperable networks. However, allowing exclusivity for a short period of time may serve as an incentive to first movers. Authorization of agents can be burdensome and may limit agent network development. However, guidelines may need to be issued for proper identification and notification of agents to the regulatory authority to help enable appropriate tracking and monitoring. If few limitations are placed on who can serve as an agent, it may allow greater access of services by the unbanked.
- Consumer Protection: This involves governing the ease of switching between alternative service providers, outlining end user privacy of payments and transactions, including governing the use of end user data by entities other than the end user as well as determining information transparency, including those related to fees.
- Market Access: Specifies the types of entities that can hold a mobile money license or offer digital financial services. It also looks at cross-border money transfer as well as outlining entry and exit controls of digital financial service providers and other entities participating in the scheme.
- Payment Systems: Payment systems regulations help identifying requirements for e-float to non-bank digital financial services providers, interest accrued on trust accounts,

defining or limiting service payment scheme interchange between providers and requiring interoperability of digital financial services providers and schemes.

- Risk Management: Specifies Know Your Customer (KYC) requirements for digital financial services providers, requiring Anti-Money Laundering (AML) / Combating the Financing of Terrorism (CFT), monitoring of suspicious activity, requiring AML/CFT reporting of suspicious activity and also the appropriate identification and registration of end users by agents.
- Others: Regulators have to see to it that end users do feel that digital financial services are as reliable and available as cash. High quality of service is likely to help meet that standard. Agents' critical role in supplying digital financial services particularly to those who may have previously been unbanked may not be commercially viable if the cost to serve becomes too high hence regulators should be aware of this balance and how it may intersect with labor laws. Furthermore, merchants may be dissuaded to use digital financial services if suddenly they are taxed on gains that when using cash, went unnoticed and untaxed. Therefore, regulators should be cautious of how to implement and message tax policies to merchants who serve lower income end users. Consideration should be given to creating new tax policies that actively encourage merchant participation in the DFS ecosystem [138].

2.3.9 Geographical Information Systems (GIS)

Nowadays, with the rapid development and widespread of information technologies integrated with lightweight mobile devices and terminals, pinpointing location on the move has become a common exercise. The technologies involve Geographical Information Systems (GIS), Global Positioning Systems (GPS), Radio Frequency Identification (RFID) and various other location sensing technologies with varying degrees of accuracy, coverage, and cost of installation and maintenance [95]. The purpose of mobile positioning is to provide Location-Based Services (LBS), including wireless emergency services. The increasing demand for commercial LBS has driven scientists to focus on more accurate positioning solutions. LBS employs accurate, real-time positioning to connect users to points of interest and advises them of the current conditions such as traffic and weather conditions, or provides routing and tracking information using wireless devices. It is important to integrate the mobile computing technology and the GIS

technology in order to meet the needs of LBS, which is considered one of the most promising applications of GIS [97].

Mobile positioning refers to determining the position of a mobile device while mobile location refers to the location estimate derived from the mobile positioning operation [96]. MS positioning plays a vital role in LBS. To fulfill this requirement, cellular network operators can use either network-based technique, handset-based technique or hybrid-based technique [98]. Due to the coarse description of individual's locations provided by the GSM cell-tower data, however, many existing studies of mobility patterns are incomplete and less than convincing. In GSM cell-tower data, a location is indicated by the cell tower that provides the connecting service, hence the resolution for the location is constrained by the service area of a cell tower whose size is in the order of hundreds of square meters to several square kilometers. And also the paths, often indicated by a series of discontinuous sudden jumps, are hardly observable in fine details between the destinations [99]. LBS systems aim at improving user-friendly info-mobile services for position determination by combining Wireless Communications (WCs), Global Navigation Satellite System (GNSS) and GIS based on mobile client/server architecture [97].

2.3.9.1 Mobile positioning categories

Network-based mobile positioning

The category is referred to as network-based because the mobile network, in conjunction with the network-based positioning determination equipment (PDE) is used to position the mobile device. Here the parameters used for computing location are measured at Base Station (BS) and transferred to a central facility for location determination. One of the easiest means of positioning the mobile user is to leverage the SS7 network to derive location [96][98].

Handset-based mobile positioning

This is referred to as handset based positioning because the handset itself is the primary means of positioning the user. The network can be used to provide assistance to the mobile device in making position estimate determination based on data measurement and handset based position determination algorithms. This requires handset modifications such as installation of GPS chipset in the MS. The STK allows for communication between the SIM (which may contain additional

algorithms for positioning) and a location server application (which may contain additional algorithms to assist in mobile positioning). [96][98]

Hybrid mobile positioning

This is the combination of network-based and handset-based techniques.

2.3.9.2 Wireless GIS platform

Currently, while the telecommunications industries are deploying 3G or better systems worldwide, emerging nations postulate enabling technologies like implementation of wireless position data transfer services. Wireless position data transfer involves two steps. The first step is to determine the location of the MS and the second step is relay the location information to a central place [98]. Many technologies currently exist for locating the MS such as GPS based one. GPS is the most popular radio navigational aid that provides three-dimensional position, time and velocity of users. Similarly, the GSM technology is an extremely successful digital cellular evolution and offers a family of voice, data and LBS services. The methods to connect client devices to the network vary according to the wireless system coverage. Tested systems are IEEE 802.11 at 11mbps, circuit-switched GSM and packet-switched GPRS. The client platform also requires a GPS receiver that can connect to the serial port or integrated into a PC card [98].

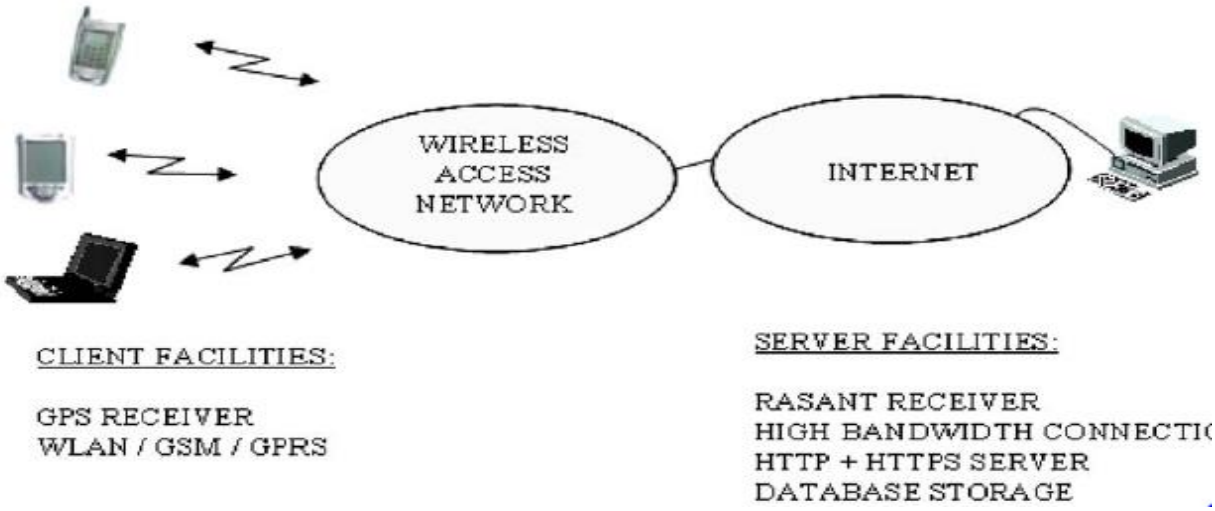


Figure 2.5: GIS application through PDA with wireless facilities architecture [100]

2.3.9.3 Location Based Service applications

According to [97], research divides applications of LBS in four main areas:

Information and navigation services

The services provide data directly to end users, in particular for destination location and criteria for trip optimization. Moving map displays guided by navigation GNSS (currently GPS) receivers are provided by the Automobile manufacturers as a new option in their modern vehicles. Many rental car companies have GPS equipped vehicles that give directions to drivers on display screens and through synthesized voice instructions.

Emergency assistance

This type of service provides the location of mobile users in case of distress and need for assistance. GIS capabilities are essential in such services.

Tracking services

In general, an AVL system consists of a GNSS receiver integrated with GSM/GPRS module mounted on the vehicle, communication link between the vehicle and the dispatcher, and PC-based tracking software for dispatching.

Network related services

Location can be achieved by integrating a GNSS receiver in the mobile phone (hand-held solution) or by using the communication network itself where knowledge of user's position improves communication services.

2.3.10 Biometrics

Traditional approaches to identification rely on the use of identification cards, passwords, or PINs to determine or verify one's identity. However, due to several challenges associated with traditional methods such as the ease to forge or forget, use of biometrics is gaining significant importance [101]. Biometrics is an authentication mechanism that relies on the automated identification or verification of an individual based on unique physiological or behavioral characteristics. Typical physiological features measured include an individual's fingerprints,

face, retina, iris, and hand while typical behavioral features that can be measured include voice patterns, handwriting and keystroke dynamics [102]. It seems to make sense that biometrics technology will be at the forefront of existing and new security measures in the world of information technology [42].

Biometric-based solutions are able to provide for confidential transactions and personal data privacy [43]. Because a biometric trait cannot be captured in precisely the same way twice, biometric matching is never exact. The matching is always a fuzzy comparison [103]. This feature makes computational intelligence (CI), primarily based on artificial intelligence, neural networks, fuzzy logic, evolutionary computing etc. an ideal approach for solving different biometric problems. The first commercial applications for automated biometrics were used to control physical access to buildings. This trend has continued with the increasing need to reduce fraud and limit physical and logical security breaches [103].

2.3.10.1 Verification vs identification

Verification is a one-to-one comparison used to confirm one's identity [103]. It confirms or denies a person's claimed identity by asking "is this person whom he/she claims to be?" The one-to-one comparison is against the reference template which is the enrolled and encoded biometric sample of record for a user. Identification is a one-to-many comparison search in a database. It is used to find one's identity [102]. It checks a biometric sample against all the reference templates on file. If any of the templates on file match the biometric sample, there is a good probability the individual has been identified [103].

2.3.10.2 Physiological and behavioral biometric features

Many different types of unique physiological or behavioral characteristics exist for humans. Some of the more traditional uses of the biometric methods for identification or verification are provided below:

Fingerprint recognition

Finger print scans have been used for many years by law enforcement and other government agencies. It is regarded as a reliable, unique identifier. Five steps are involved in finger scan technology for verification and identification. Fingerprint (FP) image acquisition, image

processing, and location of distinctive characteristics, template creation and template matching. The challenge of finger-scan technology is to acquire high-quality image of a fingerprint. The standard for forensic –quality fingerprinting is images of 500 dots per inch (DPI). Finger print recognition systems rely on the biometric device's ability to distinguish the unique impressions of ridges and valleys made by an individual's finger [43].

Hand geometry

Hand geometry solutions take more than 90 dimensional measurements to record an accurate spatial representation of an individual's hand.

Retina scanning

Retina scans have been used to confirm a person's identity by analyzing the arrangement of blood vessels in the retina or patterns of color in the iris while voice recognition uses a voice print that analyses how a person says a particular word or sequence of words unique to that individual. It involves an electronic scan of the retina, the innermost layer of the wall on the eye ball [42].

Facial recognition

Facial features scored the highest capability among the six biometric attributes in a machine readable travel documents (MRTD) system based on several evaluation factors including enrolment, renewal, machine requirements and public perception. This is largely due to the fact that compared to other popular biometric technologies; face recognition is non-intrusive and easy to use. In facial recognition the input facial images need to be normalized against variations which commonly occur, such as rotation, scaling, and dynamic range of pixel values. Facial recognition attempts to identify a subject based on facial characteristics such as eye socket position, space between cheekbones etc. [45].

Signature dynamics

Dynamic signature verification not only compares the signature itself, but also makes changes in speed, pressure and timing that occur during signing.

Keystroke dynamics

Keystroke dynamics technology measures dwell time (the length of time a person holds down each key) as well as flight time (the time it takes to move between keys). Taken over the course of several login sessions, the two metrics produce a measurement of rhythm unique to each other.

Voice recognition

Voice recognition biometrics digitizes a profile of a person's speech into a template voice print and stores it as a table of binary numbers. During authentication, the spoken passphrase is compared to the previously stored template.

2.3.10.3 Biometric system types

Unimodal systems: Unimodal systems are those that use a single biometric trait for user recognition.

Multimodal systems: Biometric systems can be combined to enhance security. Multimodal biometric systems are more robust to noise and alleviate the problem of non-universality and lack of distinctiveness hence they can achieve a higher recognition accuracy than unimodal systems [44]. A multimodal system allows for an even greater level of assurance of a proper match in verification and identification systems. They help overcome limitations of single biometric solutions such as when a user does not have a quality biometric sample to present to the system (e.g. an individual with a cold attempts to authenticate to a voice recognition system) and to reduce the ability for the system to be tricked fraudulently [102].

2.3.10.4 Biometric systems performance measures

Performance measures are used to create baselines to help organizations evaluate products. The performance of a biometric system is based on measures such as false rejection rate, false acceptance rate, crossover rate, verification time and failure to enroll rate.

False rejection rate (FRR): Also commonly referred to as a type I error, measures the percentage of times an individual who should be positively accepted is rejected. Biometrics vendors strive to have a low FRR.

False acceptance rate (FAR): Commonly known as type II error, measures the percentage of times an individual who should be rejected is positively matched by the biometric system. Biometrics vendors strive to have low FAR.

Crossover: It is also known as the equal error rate (ERR). It is the point on a graph where the lines representing the FAR and FRR intersect. A lower crossover rate indicates a system with a good level of sensitivity and generally means the system will perform well.

Failure to enroll rate (FTER): Used to determine the rate of failed enrollment attempts. Factors such as quality of the enrollment equipment ease of enrollment, environment surrounding enrollment and quality of the user's biometric influence FTER.

Verification time: It is the average time taken for the actual matching process to occur.

2.3.10.5 How biometrics work

All biometric approaches follow a similar operation. A digital template is created during an enrolment process; the template is stored in a database. On attempted verification, the relevant template is extracted and compared with the data input, say in the form of fingerprint, or an acquired iris image, for positive identification [104]. The first step is called enrollment in which each new user is registered into a database. Information about a certain characteristic of a person is captured. This information is usually passed through an algorithm that turns the information into a template that the database stores i.e. it is the template that is maintained in the system not the original biometric measurement and has a very small amount of information [103]. When a person needs to be recognized, the system will take the appropriate measurement, translate this information into a template using the same algorithm that the original template was computed with, and then compare the new template with the database to determine if there is a match and hence either an authentication or identification [103].

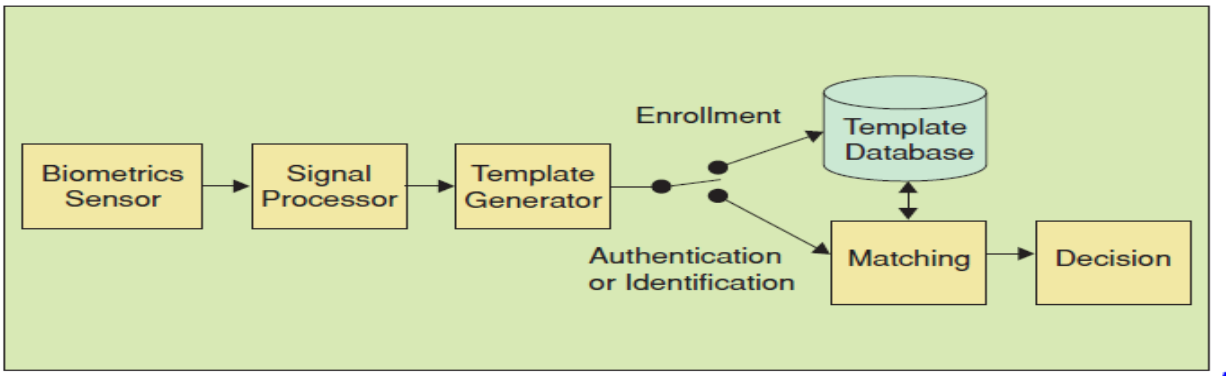


Figure 2.6: generic biometric system. [103]

2.3.10.6 Biometric applications

[103] outlines some of the applications of biometrics as follows:

Military: In 2004, Biometrics Management Office (BMO) in the US awarded Lockheed Martin a five year contract to design, build and maintain a new Automated Biometric Identification System (ABIS), an electronic database with its associated set of software applications to consolidate, store and search fingerprint data collected from persons of interest with respect to national security.

Biometric passport: The International Civil Aviation Organization has proposed using the face as the primary biometric with fingerprint or iris as an optional secondary measurement.

Airport security: Ben Gurion International Airport in Tel Aviv, Israel, one of the world's busiest air terminals uses a hand geometry system which is included in 21 automatic inspection kiosks throughout the airport to identify travelers. All passengers go through these kiosks.

Financial transactions: Bank United in the US first used iris recognition at Automated Teller Machines (ATMs) in 1999. Thousands of customers were able to withdraw cash from their account at the ATM just by looking at it. Japanese banks have used palm vein as well as finger vein authentication systems.

2.3.10.7 Biometric systems challenges

Just like other information systems, biometric systems are susceptible to some common attacks like denial of service, spoofing and man in the middle. They also experience a challenge of privacy protection that scares some users.

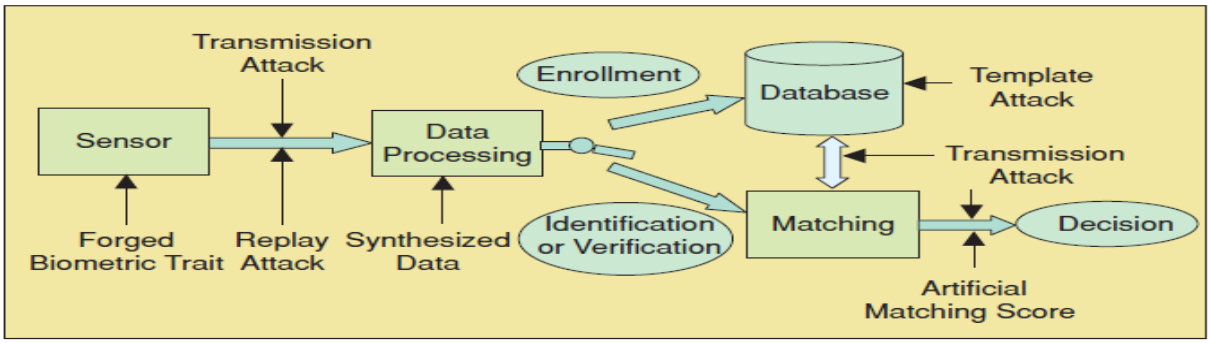


Figure 2.7: Attacks on biometric system. [103]

2.3.11 Barcodes

A barcode is an optical machine-readable representation of data, which shows information about the object on which it is found [105]. It is a series of bars and spaces arranged according to a set of rules that determines how data is to be represented. Different bars and space patterns are used to express different symbols which are readable only by a scanner. Barcode technology is an important identification tool that provides an accurate and timely support of the data requirement for proper management systems [106]. Barcoding, in conjunction with handheld personal digital assistants and computer-based tracking programs, has long been applied within industry for item tracking, inventory, and identification [107]. Traditionally, the barcodes used to be scanned by the specifically designed scanners in the various areas of application. However, since the general purposed camera phones started to install the barcode scanning software, the usage area of barcodes are expanded. It even became possible for the camera phones to enhance the scanning performance by adapting the image filtering and auto –focusing technologies when it reads the barcodes without using any other sensors except the camera hence the usages are rapidly extending due to the technological advances of barcode scanners [108]. Since barcodes can be easily stored, transferred, processed and validated in digital form, barcode identification provides

a simple and inexpensive way of encoding text information that is easily read using electronic readers [109].

Originally, barcodes represented data by varying the widths and spacings of parallel lines. These are referred to as linear or one-dimensional (1D) barcodes [110]. Since the earlier forms of linear barcodes were not capable of encoding letters, a new type of barcodes was invented to meet the needs of encoding alphanumeric data including letters, numbers and punctuation marks. These are known as 2D barcodes [109]. 2D type of barcodes has much higher capacity compared to the linear barcode. The information encoded in a 2D barcode can be scanned and encoded by mobile phones equipped with built-in cameras and the appropriate software. The encoded information can be URL, text, or series of alphanumeric characters such as a phone number or an SMS [110]. In general, there are two types of 2D barcodes; stacked 2D barcodes such as Code 49 and PDF 417, and Matrix 2D barcodes such as Data Matrix and QR Code[46] [111].

Figure 2.8: A sample linear (1D) barcode tag (left) and sample 2D barcode tag; QR (Quick Response) 2D barcode (middle), High Capacity Color Barcode (HCCB) 2D barcode (right)[110].

2.3.11.1 Applications of barcode technology in mobile commerce

Wireless advertising and marketing

Using a mobile camera phone, a customer can easily input a 2D barcode on a product advertisement; find more product information from the barcode. When the customer likes the product, only a very few clicks can lead to a trading transaction with the backbone m-commerce application system [111].

Wireless trading

Using 2D barcodes on products and goods, merchants and manufacturers allow mobile customers to find more detailed product information. This is also useful in post-sale, including product tracking, shipping, and delivery [111].

Mobile security

Most security solutions are developed based on some kinds of encoding and decoding cryptographic algorithms. Clearly, it is easy to use a 2D barcode technology to embed diverse security data (or code) into a 2D barcode by an encoding and a decoding process [111].

Mobile customer and product verification

Using 2D barcodes merchants can easily perform various verification using mobile scanner devices (or mobile devices) to scan 2D barcodes on a movie (or train/flight/sport) ticket, a coupon, a good, or an invoice [111].

Wireless payment

Most current electronic payment systems are account-based payment systems (using ATM/credit/cash cards and e-checks), micro-payment systems based on digital cashes, and e-wallets. 2D-barcode technology provides a new way to develop mobile e-card based payment systems that allow customers to make payments using mobile phone with 2D barcode technology. For example, 2D barcodes can be used to present different digital mobile cards. They can be stored in a wallet of mobile devices and used to make diverse types of wireless payment transactions anywhere and anytime [111].

2.3.12 Education Systems across the globe

As more children enroll in primary and secondary schools, education has received added attention from governments and development partners. With the expansion of primary and secondary education, new challenges emerge such as accommodating a greater diversity of aptitudes and societal needs and mobilizing the resources to fund additional infrastructure and teachers [114].

2.3.12.1 European System of Education

The national testing of pupils is becoming increasingly important across Europe as a means of measuring and monitoring the quality of education, and structuring European education systems. Tests standardization is done by the national education authorities or, in the case of Belgium, Spain and Germany, the top-level authorities for education referred to here as the central level [116]. In Europe significant variations are apparent from one country to the next, both in the frequency with which individual pupils take national tests and the precise cohorts or years of education that are tested. Some countries provide full time compulsory education within a single structure, while others clearly distinguish between primary and lower secondary education. For example, Denmark, Malta and the United Kingdom (Scotland) have developed national tests for almost every year of compulsory education.

The United Kingdom (England) and France may also be regarded as countries in which national testing is widely practiced, with seven and six national tests respectively. Countries that administer only one national test during International Standard (ISCED) levels 1 (primary education) and 2 (lower secondary education) include Belgium (Flemish Community), Germany, Spain, Cyprus, the Netherlands, Slovakia, and the United Kingdom (Northern Ireland). The majority of the remaining European countries administer national tests in two or three specific school years during the whole of compulsory education. This might thus be considered the predominant mode in Europe [116].

The education system in the United States is very diverse, with major differences in level, content and quality. None of the various phases of education conclude with a standardized final examination. For this reason, the concept of standardized entrance and outcome levels does not exist in the American system. The most common divisions are six plus three plus three (elementary plus junior high plus high school), six plus two plus four (elementary plus middle school plus high school). The divisions depend on the state or school district. Regardless of the division, secondary education begins in the seventh year [117].

Education in France is compulsory for children aged six to sixteen. Primary education lasts for 5 years which is followed by a four year lower secondary and a three year upper secondary education. After completion of lower secondary education, students are awarded the Diplome

National du Brevet des Colliges while upper secondary education leads to the award of the Diploma du Baccalaureat [118].

In Germany, education is compulsory between ages six and fifteen (sixteen for Berlin, Brandenburg and Bremen). Primary education in Germany is provided at a Grandschule (primary school, for children aged 6-10). No diploma is awarded upon completion. Secondary education is usually divided into two i.e. for pupils aged ten to sixteen and for pupils aged sixteen to nineteen. Upon completion of both levels, pupils are awarded certificates [119].

2.3.12.2 Education System in Asia

In Asia-Pacific, the first examination is typically taken at the end of primary school for the purpose of controlling access to secondary schools and particularly to more selective secondary schools. It may be a curricular-independent aptitude or ability test. The second is taken at the end of lower secondary education. This serves as an attainment test for those completing junior secondary education and may be used for purposes of entry into work for those leaving school. However, its main function is generally to control access to an upper secondary or 'sixth form' education. The third examination is taken at the end of a two or three year course of study at upper secondary school. It serves as an attainment test for those completing upper secondary education and for selection into higher education or recruitment into the workplace [114].

Figure 2.9: *Major national examinations in Asia-Pacific countries.[114]*

The Chinese education system has a total of nominal duration of primary and general secondary of twelve years with a national higher education entrance examination instituted. Primary education lasts six years and is intended for children aged six to twelve. Subsequently, pupils move on to the three year junior middle school, which marks the end of compulsory education. Then pupils go into three year middle school which concludes with examinations in nine subjects [120]. In China, the national examination is the university entrance taken by students at the end

of grade 12. All sit for Chinese language, mathematics, and a foreign language (usually English) and typically select one to three other subjects from around six options [114].

In India, the educations system falls into a number of segments: primary school which runs from first to fifth standards for six to ten year olds. The middle school or upper primary school for sixth to eighth standards and is targeted for eleven to fourteen year olds. It is of three years duration where education consists of the basic programs of primary school level, though teaching is more subject focused. Lower secondary education is for ninth and tenth standards for fourteen to sixteen year olds where admission requirement is the completion of upper primary school education. Instruction is more organized along specific subjects. Higher secondary education / pre-university education takes place from eleventh to twelfth standards and it is for sixteen to eighteen year olds and a student can choose particular subjects or vocations. In all the states and Union Territories, public examinations are conducted at the end of classes ten and twelve by the respective State Boards of Secondary and Higher Secondary Education. The Council for the Indian School Certificate Examinations (CISCE), Delhi, was established in 1958 by the University of Cambridge, Local Examinations Syndicate as a self-financing national examination board. The council conducts the Indian Certificate of Secondary Education (standard 10) and the Indian School Certificate (standard 12) examinations. CISCE affiliates schools using English as a medium of instruction [121][122].

Since 2003, the six years of primary education have been compulsory in Malaysia. Primary education lasts for six years and is intended for pupils aged seven to twelve. At the end of primary school, pupils take the Primary School Achievement Test. General secondary education lasts seven years and is divided into junior, senior and pre-university. Junior secondary education lasts three years, at the end of which pupils take the Junior Secondary School Test. At the end of senior secondary school, pupils take the Open Certificate Examination (Malaysian Certificate of Education). Following successful completion of Malaysian Certificate of Education, pupils take another two years of pre-university secondary education at a Sixth Form College, which upon completion; pupils are awarded the Malaysian Higher School Certificate [123].

2.3.12.3 African Education System

In most countries, three major examinations are administered by an agency outside the school (usually a national examinations authority in Anglophone countries and a ministry of education in francophone countries): at the end of primary schooling when students are examined in the major subjects of the curriculum; after two or three years in secondary school usually in a wider range of subjects; and at the end of secondary school [115]. With the slow economic growth and the increasing enrolment in most African countries, the choice for policy makers for the next couple of years will be between increased efficiency in the use of existing resources in provision of education to benefit the majority of the people or the acceptance of declining standards of access, equity and academic achievement [124].

Since the reforms introduced in 1987, the education system in Ghana has had a 6-3-3-4 structure which means six years of primary education, followed by two three-year stages of secondary education (junior secondary and senior secondary) and four years of higher education. No certificate is awarded upon completion of primary education. Secondary education consists of a junior phase and a senior phase, each lasting three years. Junior phase concludes the compulsory school-age years. At the end of the junior phase, pupils sit examinations to obtain the Basic Education Certificate. Senior secondary education is concluded with examinations for the West African Senior Secondary School Certificate (WASSCE), which has since 2007 replaced the Senior Secondary School Certificate (SSSCE). These examinations are held by the West African Examinations Council, Ghana National Office [125].

Kenya has official national examinations conducted by the Kenya National Examinations Council (KNEC), an official examinations body appointed by an act of parliament. The KNEC conducts several summative examinations mainly for grading purposes. The Kenya Certificate of Secondary Education (KCSE) examinations done at the end of every year by the final secondary school candidates is one of such examinations and is used to determine the candidate's next level in the education hierarchy including the intake to foreign universities [126]. The Kenyan education system consists of eight years of primary school, four years of secondary school and four years of higher education. Primary education lasts eight years (i.e. standards one to eight). At the end of their eighth year, pupils take examinations for the award of the Kenya Certificate of Primary Education (KCPE). Secondary education ordinarily takes four years. At the end of

their fourth year, pupils take examinations for the Kenya Certificate of Secondary Education (KCSE) administered by the National Examinations Council [127].

Uganda National Examinations Board (UNEB) has the responsibility for test development, administration, marking and the release of results. Uganda has a series of national examinations that include Primary Leaving Examination (PLE), Uganda Certificate of Education (UCE)-lower secondary leaving examination and Uganda Advanced Certificate of Education (UACE)-the upper secondary leaving examination [128]. Primary education lasts seven years and ends with the Primary School Leaving Certificate and it is mandatory. Secondary education comprises six years and consists of lower secondary for the first four years and upper secondary for the last two years. At the end of the fourth year the UCE is issued. After two years of upper secondary, students receive the UACE [129].

2.3.12.4 Education Structure in the SADC Region

In South African education system, no certificate is awarded upon completion of primary education. Secondary education consists of two phases as well: the senior phase (grades seven up to and including nine) and the further education and training phase (grades ten up to and including twelve). The senior phase concludes the so-called General Education and Training phase that comprises the foundation, intermediate and senior phase. No certificate is awarded upon completion of the General Education and Training phase. In the further education and training phase pupils take examinations for the National Senior Certificate (NSC) after completing grade twelve [130]. The NSC is a new qualification based on the National Curriculum Statement (NCS) that was introduced for the first time in grade ten in 2006. To qualify for the writing of the NSC examination, a candidate has to go through twelve years of schooling and must complete the programme requirements for grade ten, eleven and twelve separately [131].

A notable feature of Botswana's educational system is the supreme importance attached to performance in public examinations. It appears that the whole educational enterprise is geared to these examinations and that they dominate the educational thinking of parents, children, planners and the community at large [132]. Botswana provides a ten-year basic education, which is not compulsory. It consists of lower primary (grades one to four) and upper primary (grades five to

seven) with attainment and diagnostic examinations in grades four and seven respectively. Junior secondary education lasts three years and is followed by two years of senior secondary education. Terminal examinations are taken at the end of each level and serve as a basis for selection and placement as students progress to the next level [133]. A number of different public examinations are taken by various groups of students in Botswana but those that concern the largest numbers and which so clearly determine chances of further education are the Primary School Leavers Examinations (PSLE) taken at the end of standard seven, the Junior Certificate (JC) taken at the end of form three of secondary education, and the Cambridge Oversees School Certificate (COSC) taken at the end of form five. These are public examinations in the sense that all students at a given time sit the same examination papers which have been set and are marked by some authority other than the school the student attends [132].

In Namibia, as per revised National Curriculum Policy, three phases of education are recognized i.e. seven years of primary (grades one to seven), three years of junior secondary (grades eight to ten) and two years of secondary education (grades eleven to twelve) hence the education system provides for three terminal examinations. At the end of Primary schooling (grade seven), learners take Standardized Achievement under the Education, Training and Sector Improvement Programme (ETSIP) where schools set their own question papers. The Standardized Achievement examination outcomes are used for diagnosis rather than for promotional purposes. At the end of the junior secondary education, learners are required to write the Junior Secondary Certificate examination which in combination with the Continuous Assessment (CA) marks determines the learners' progression to senior secondary grades. During the last phase (senior secondary), the learners are required to write either the International General Certificate of Secondary Education (IGCSE) replaced by the Namibia Senior Secondary Certificate (NSSC) Ordinary or the Higher International General Certificate of Secondary Education (HIGCSE) replaced by the Namibia Senior Secondary Certificate (NSSC) Higher level [134].

2.3.12.5 Local Education System

Basic education in Malawi consists of eight years of primary education (standards one to eight) and four years of secondary education (form one to four). Students' performance in primary school is assessed based on the Primary School Leaving Certificate Examination (PSLCE). PSLCE qualifies pupils for secondary education. The secondary education consists of four years

of schooling divided into a two-year junior cycle and a two-year senior cycle. Junior Certificate Examination (JCE) is awarded after completing two years of secondary education while Malawi School Certificate Examination (MSCE) is awarded after completing four years of secondary education. The PSLCE, JCE, and MSCE are standardized national examinations set and marked by the Ministry of education and the Malawi National Examinations Board [135][136].

2.3.13 Related Works

This section of literature focuses on related research works that have been carried out in different parts of the world. It looks at how the technologies reviewed in the literature have been utilized in various fields i.e. agriculture, education, health, transport etc. to solve existing operational gaps.

2.3.13.1 Agricultural field data acquisition

This is a proposed solution to solve the problem of manual practice of collecting and managing farm field data by humans. The study uses GSM and SMS to conduct field data acquisition. It also includes an automatic field data collecting subsystem called the field monitoring platform (FMP) and a remote host control platform (HCP). The FMP consists of electric short sensing modules, GPS module, GSM module, environmental parameters sensing module and integration kernel module. The integration kernel module of FMP uses universal synchronous/asynchronous receiver-transmitter (USART) to connect with all environmental sensing modules and perform data assembly, processing and sequencing functions on the field data received [74].

With the help of GSM module, these data can be sent wirelessly across the field. When the host control platform receives the data that carry all the field information, the HCP will then decode these data and save them into the database for future long-term monitoring and statistical analysis to provide a reference framework for future farming improvement.

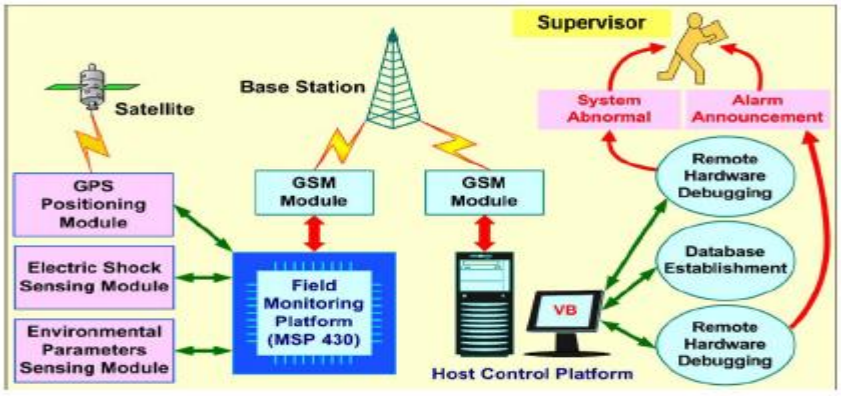


Figure 2.10: Architecture of the proposed agricultural data acquisition system.[74]

2.3.13.2 Pandora: An SMS-oriented m-informational system for educational realms

A fully functional SMS-oriented mobile informational system that was designed and developed from the onset to specifically support a plethora of services obtainable mainly by the students of University of the Aegean in Greece. Pandora services are in three categories namely administrative, informative (of general interest) and strictly academic.

Prior to obtaining Pandora's services candidates must subscribe to Pandora which is accomplished through the Pandora's web interface provided at http://pandora.samos.aegean.gr. Administrative services include subscribing and unsubscribing users etc and informative services include news, weather forecast etc while strictly academic services include register for courses, boarding, phonebook etc [112].

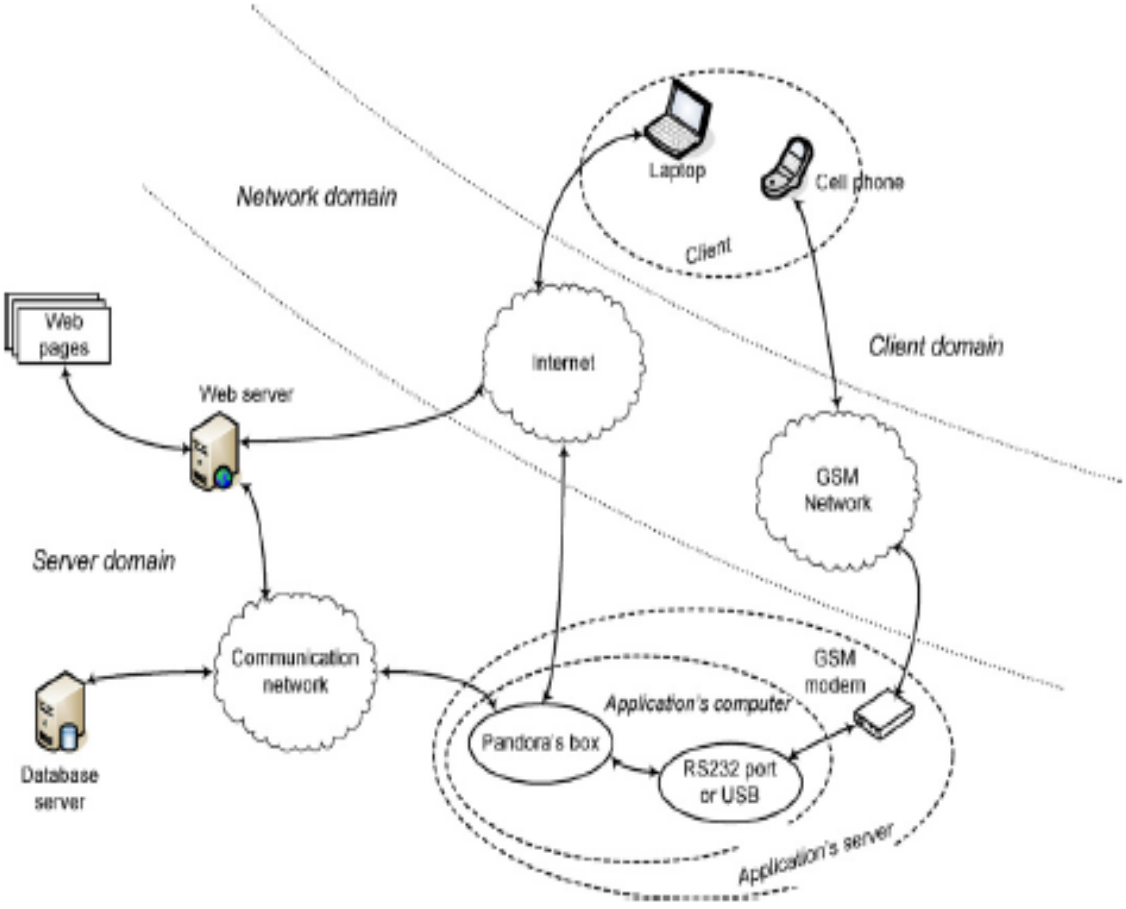


Figure 2.11: General overview of Pandora's system architecture.[112]

2.3.13.3 Bulk SMS to enhance educational communications

The advantages of bulk SMS can be applied in schools and universities to further develop classroom interactions and setup a virtual community as public relations system. Bulk SMS system, with its benefits, can be applied to enhance educational communication. In terms of education, the system can be applied to conduct a feedback system for a large class. Furthermore, it can be applied to send quizzes in forms of multiple choices, true/false, ranking and matching questions to multiple mobiles at one time. A system called B-SWU system, Srinakharinwirot University's dynamic bulk SMS system is proposed. It is used for two main purposes; Learning Enhancement i.e. asking questions, providing answers and providing feedback and Education Information and Public Relation Enhancement i.e. enrolment information, grade results etc [113].

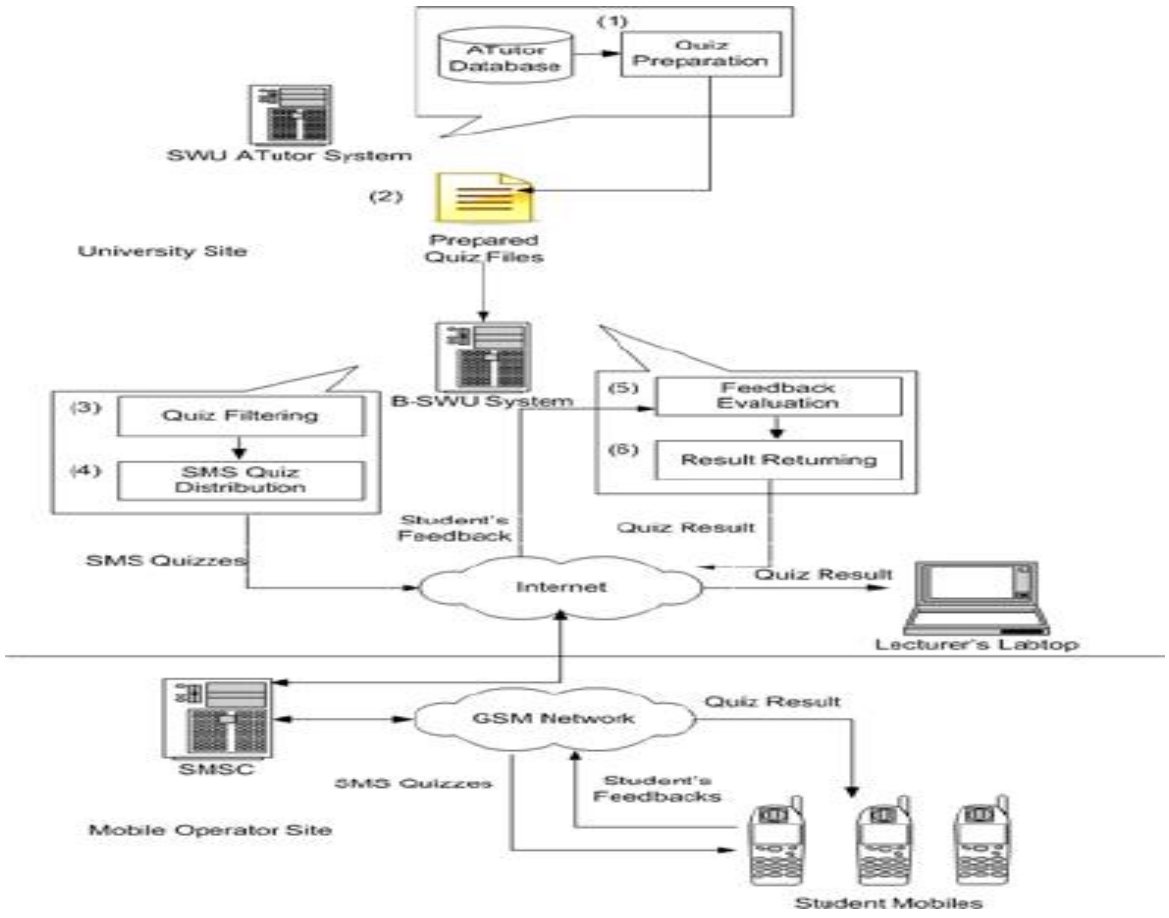


Figure 2.12: B-SWU System Architecture.[113]

2.3.13.4 Medical information query system based on USSD

Medical information systems were first paper-based, which consumes time and is expensive to maintain. With the development of network technology, medical information systems based on the Web have been developed. A user may search for information of interest via Web pages. Now, wireless communication technology increasingly appears to be widely applied in the medical field. Adopting USSD in an information query system does not need much investment and is also feasible to upgrade on many existing information systems.

The medical information query system being proposed is based on a USSD platform, and the system may be accessed by mobile phone users within China Mobile GSM network which covers 85% of all Chinese mobile phone users. The system is mainly composed of a USSD service application server and a database and a USSD platform. The USSD service application server realizes USSD service with the information provided by the USSD platform, including information query and fee charge. The medical information data of users is stored in the database. A signal processing platform included in the USSD platform connects to the mobile communication network via the No. 7 signal channel. The signal processing platform connects to a server-processing platform by high-speed LAN bus to access the USSD service. The USSD service application server connects to the USSD platform in a Client/Server mode [85].

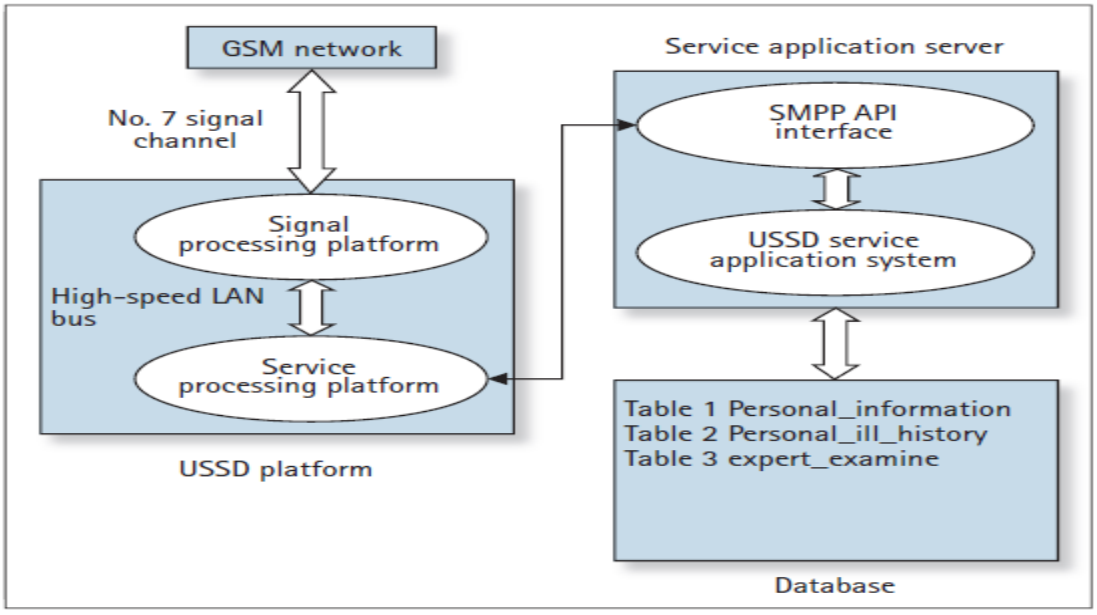


Figure 2.13: Structure of medical information query system based on USSD.[85]

If mobile phone users want to conduct a query by using the medical information query, they need to dial a given accessing number to connect to the USSD platform of the medical system and proceed according to instruction.

Figure 2.14: Screen display of an information query system.[85]

2.3.13.5 Agricultural information dissemination models in China

With the rapid development of ICTs, data and information can be effectively generated, stored, analysed, disseminated and used to support farmers and farming communities to improve agricultural productivity and sustainability. Information services for farmers at the national and regional level are a promising new field of research and application in the emerging field of e-agriculture. Research has shown that currently, the agricultural information dissemination models in China are classified into a number of types:

Web portal: a collection of relevant websites that provide for one stop center for users. China's Ministry of Agriculture (MOA) web portal has now contained a number of websites from different bureaus and different institutions under MOA administration. The portal has integrated abundant resources for agriculture-related departments, allowing the public to access agricultural news, agricultural market information, agricultural technologies, and rural life cultural information.

Text (SMS) based service: This is operated jointly by agricultural organizations and telecom operators (SP). One such service is the Human Agri-Telecom Platform (HATP). HATP's SMS service delivery page offers a range of functions and services in a very easy to use and user friendly interfaces.

Mobile internet-based service: This came into being due to the low penetration rate of computers in rural households and high usage of mobile phones in China. Users can be connected via handled devises anywhere at any time. Agricultural information is disseminated to farmers on the

move. This service model is expected to dominate the future information dissemination models. An instance of such a service model is the E-price App. E-Price App is developed to help farmers and agri-business managers to deal with the price volatility. It utilizes the internet, cloud computing and smart phone devices. The App releases agricultural products prices provided by a collaborated source from government agencies, agricultural producers, agri-business, consumers etc. It has functions like price puch, price comparison, real time inquiry, agricultural news, location identification, tailor made price reporting, and bidding and match making [48].

2.3.13.6 Improvement of vaccination coverage in hard-to-reach areas

In Bangladesh, web-based and mobile phone applications have been used for improving vaccination coverage among children living in rural hard-to-reach areas and urban streets of Bangladesh. A web database application named "mTika" was created by a research team working with the Bangladesh Ministry of Health and Family Welfare's (MOHFW) Management Information System Department. mTika works with Android smart phone application and it has numerous modules i.e. smart phone-based registration of pregnant women, short message service (SMS) birth notifications from mothers, automated SMS vaccination reminders to mothers, vaccination reminders for health workers and smart phone and web-based EPI monitoring by supervisors. Women in their trimester of pregnancy are registered by Health Assistants using smart phones. Their expected date of delivery is also captured. Upon registration, mothers are assigned a unique code and taught how to send SMS text messages from a regular mobile phone to mTika after child birth. This birth notification triggers an immediate, server-driven SMS reply as well as generation of a new born identification number, customized vaccination timetable and future vaccination reminders on appropriate dates [28][49].

2.3.13.7 Healthcare system using cloud computing

Online Healthcare systems have been researched over the years. One such research proposes an online healthcare system using the concept of cloud computing. The researchers believe that such a system will be helpful in dealing with all kinds of health related issues. It is an integrated system to have one's health check checkups done quickly and access reports anywhere anytime on the phone. Based on the reports, one gets symptoms and preventive measures on the phone. If in doubt, a patient can contact specialized doctors in his/her locality from the phone. Even if a

patient requires blood its just tap away; the patient makes the request to the system using the phone and the application will broadcast the request to people with same blood group in the locality. The proposed application will have an API that will be used for finding the location of the specific user Geo-location by identifying residual end points i.e. latitude and longitude of the area. The system integrates android application and cloud computing concepts. The Android application component is used by the user to easily access the data related to the path labs, hospitals, tests, offers etc. It provides user interface and increases the portability of the user [51].

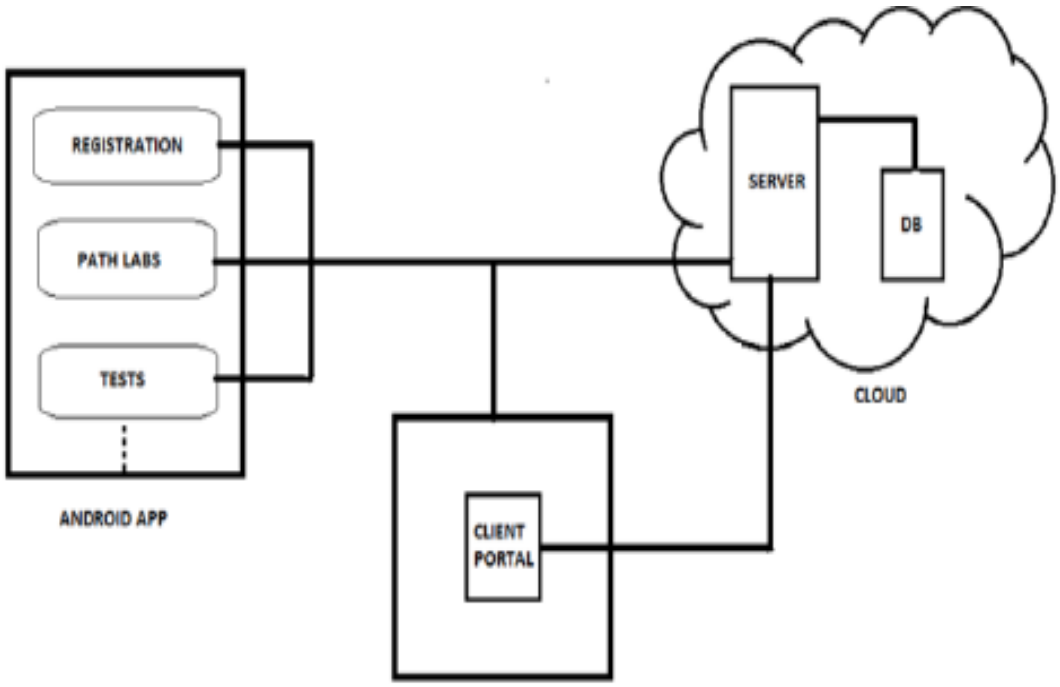


Figure 2.15: Cloud healthcare system tier-architecture.[51]

2.3.13.8 Students results checking system

O. Awodele et al proposed a system that uses the short messaging system which is dependent on the telecommunication infrastructure provided by GSM operators to provide a means of cheap and fast communication between the students and the university [30]. The system is to be used for results checking by university students. It works using client-server architecture and is deployed as a dependent service i.e. the server (with the SMS application) has a phone with a standard SIM card connected to it. The SMS server receives SMS messages from the users and processes the message by connecting to the database that holds the details and grades. It receives

all SMSs via the GSM terminal connected to the computer; it then connects to the database to authenticate the user and queries for the results via the appropriate database connector. The system uses a social interaction mechanism which involves the use of the surname provided by the user and then a generated password to be used with an ID to reduce the incidence of guess occurring in the checking system.

Figure 2.16: Operation of SMS result checking system.[30]

2.3.14 Summary

In this section relevant literature has been reviewed. The literature review mainly focused on the technologies that the proposed solution to the problem will use. It has also looked at the challenges that examinations bodies in other countries more especially within the African region face as far as the administration of national examinations is concerned and how they have managed to overcome the challenges. Some of the areas that the literature search has covered include cloud computing and its associated technologies, mobile cloud computing, short message service, unstructured supplementary service data, bulk SMS, mobile payment, geographical information systems and global positioning systems, biometrics, barcode technology as well education systems in some countries across the globe. A background narration of circumstances that prompted for this research has been thoroughly outlined which shows that examinations

administration systems contribute to the dropout and repetition of learners in schools. Finally, related research works on how the technologies reviewed have been put to use to solve similar problems in the fields of agriculture, education, health and transport have been given.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains the procedures as well as methods used in the implementation of the study. It describes the design, study population, sample selection criteria, research instruments and an outline of the methods used to collect and analyze the data. The chapter also illustrates the methodology that was used to design the models and implement the prototype.

3.2 Baseline Study

The baseline study was conducted to ascertain the challenges faced by MANEB, schools as well as students as regards the registration for national examinations and also accessing the examinations results. The study made use of both qualitative and quantitative approaches as it was deemed that the strengths of both approaches could provide the best understanding of the research problem. Descriptive survey design that involved asking questions in the form of questionnaires and interviews to a large group of individuals was employed. The design was recommended for this research because it involved a large group of students, teachers and parents hence had the advantage of providing a lot of information from a large sample of individuals.

3.2.1 Target Population

The target population for the study combined students who had previously sat for any of the national examinations, teachers who are responsible for registering candidates for national examinations in schools as well as parents with children who had previously sat for national examinations.

3.2.2 Sample Size and Sampling Procedure

A sample is termed as a smaller group obtained from the accessible population [139]. Each member or case in the sample is referred to as a subject or a respondent. The study was done in 2 of the 4 administrative regions in Malawi. 5 districts from each region were considered for the study and 2 schools from each of the 10 districts were chosen. The participants of the study were purposively sampled. Homogenous purposive (intentional) sampling was employed when choosing the participants. This was so because the researcher's focus was on particular characteristics of respondents that were of interest to enable the researcher answer the research questions i.e. those students who had sat any of the national examinations, teachers who are responsible for handling national examinations affairs in schools as well as parents who, at the time the study was being carried out had at least one child who had sat national examinations. The regions and the districts were selected using the Simple Random Sampling (SRS) method. The two schools within a district were selected in such a way that one was picked from urban and the other from rural locations. A total number of 80 questionnaires (80 respondents) were administered to 40 students, 20 teachers and 20 parents. Lilongwe, Dowa, Salima, Mchinji and Dedza districts were selected from the central region while Blantyre, Chiradzulu, Mwanza, Chikwawa and Neno were selected from the southern region.

3.2.3 Inclusion Criteria

The study population included MANEB staff in the examinations department as well as staff from the basic and secondary education departments in the ministry of Education, Science and Technology (MoEST).

3.2.4 Research Instruments

The research instruments were designed based on the objectives and research questions of the study. The following are the 4 types of instruments that were adopted for use in this study:

1. Questionnaire for students who had previously sat national examinations.
2. Questionnaire for teachers who register students for national examinations in schools.
3. Questionnaire for parents with children who had sat national examination.
4. Interview guide for MANEB and MoEST staff.

3.2.5 Data Collection

The researcher obtained authority to collect data from MoEST before embarking on the data collection exercise. After being authorized to collect the data, the researcher visited the sampled districts and schools where consent was also obtained from the school management to administer the instruments. Data collection was carried out over a period of one month (4 weeks) starting from mid-March to mid-April 2017. The self-administered questionnaires were distributed to the respondents in all the target locations in the central and southern regions. Respondents were given sufficient time to answer the questionnaires.

During the last week, the researcher conducted unstructured interviews with key personnel in the examination section of MANEB. These included the head of section, systems analysts as well as data entry clerks. During the same week, senior officers in basic and secondary education departments at MoEST headquarters were also interviewed. Qualitative data was collected from the interviews and the various documentations accessed from schools as well as MANEB. The records included excel templates used for registration, nominal rolls for verification, examinations results books, students' identity cards (IDs) and many other reports. These were studied to inform the design phase of the automated system.

3.2.6 Data Analysis

Data analysis refers to the search for patterns in data and for ideas that help explain the experience of those patterns [139]. Quantitative data was acquired using the questionnaires and properly coded. Descriptive statistics and frequency distribution were used to analyze the data. The outcome of the analysis and computations were presented in tabular form. Qualitative data were analysed by bringing out emerging themes that were categorized and interpreted. The quantitative data was analysed by use of descriptive statistics using computer based software called PSPP, a free program for statistical analysis of sampled data which comes as an alternative to the proprietary SPSS.

3.2.7 Staging of Findings

The data analysis results were summarized and presented in the form of tables, charts and graphs. This presentation of data made it easy for readers to understand.

3.2.8 Ethical Consideration

All respondents that took part in the study by answering the questionnaires were not required to reveal their identities or provide their personal information that would lead to revealing of their identities. Hence the respondents were assured of total confidentiality and non-persecution arising from their responses.

3.2.9 Limitations of the Baseline Study

During the study, the researcher encountered some challenges as is expected of any kind of research. First and foremost, the perfect scenario for this kind of research would be to collect data from all the regions and districts of the country and from as many schools as possible. This was hindered by time, logistics and financial limitations as it would require not less than five months to collect the data from all the districts. The researcher did not have enough money to cover all the districts. Another challenge is that since the study targeted schools, by the time the instruments were ready to be used for data collection, schools had closed for second term holiday meaning that the researcher had to wait for about three weeks for schools to open and start distributing the questionnaires. Finally, some respondents were reluctant to answer some questions more especially open ended questions as a result some questionnaires were not answered in complete.

3.3 System Automation

The interviews that were conducted during the baseline study helped to gather the system requirements and come up with a model design. The interviews were conducted with MANEB officials in the examinations section as well as officials from basic and secondary departments of MoEST. A number of documents that are used in the process of administering the national examinations were availed. The interviews and the documents provided a perspective of the current business processes MANEB employs and also helped to gather qualitative data needed to specify requirements for the system, design models and finally develop the system prototype.

The system model proposed makes use of the cloud environment and mobile applications to be used to register candidates for national examinations as well as accessing examinations results. From the baseline study, it showed that the current system is time consuming and too involving hence the proposed model will help reduce costs and time it takes to register candidates and also access results. The registration data as well as examinations results will be centrally kept in the cloud and accessed when needed by all the stakeholders i.e. MANEB, MoEST, DEM etc. Students or their parents will be able to register for examinations by simply sending an SMS or by completing a USSD transaction. Examinations results will also be accessed by simply reading an SMS or can be requested via USSD.

Unified Modeling Language (UML), a standard notation for the modeling of real-world objects as a first step in developing an Object-Oriented design methodology was used for the design modeling of the proposed system. UML uses the diagrammatic representation to visualize a system from various perspectives. Use cases, Sequence diagrams, Class diagram as well as Entry Relation diagram were used in the design model. The development cycle used iterative approach for systems development where several iterations were carried out and the system was gradually built in small modular increments.

3.3.1 Current MANEB Business Processes

This section of the chapter describes the current business processes that were alluded to during the interviews with examinations section officers from MANEB and officers in the basic and secondary education from MoEST. The research mainly focused on the registration, verification and results dissemination processes.

The registration process entails recognition of examinations centers, submission of registration details, payment of examinations fees, distribution and receiving of candidate registration templates, capturing of candidates' details at the center, gathering and consolidating registration templates by the DEM office from various centers, forwarding of consolidated templates to MANEB and finally cleaning and merging of the received data at MANEB.

The verification process involves printing of nominal rolls at MANEB, sending of nominal rolls to DEMs, forwarding of the nominal rolls to schools or centers and finally candidates check their registration details from their respective schools.

Rectification of errors involves identification of errors by candidates, reporting the errors to head teacher, forwarding the errors to MANEB together with covering letter and finally effecting of the changes by MANEB.

Examinations results dissemination process involves printing of results books, sending of examinations results books to DEMs and MoEST, distribution of the books to schools and finally checking of results by candidates or parents.

3.3.1.1 Recognition of Examination Centers

For a school to register candidates for examinations, it has to first of all be recognized as an examination center by MANEB. A school becomes a center when it is duly approved and allocated a center number. A school expresses its interest to be considered as an examination center to the District Education Manager. The DEM relays the request to the Education Division Manager (EDM) who finally forwards the request to MANEB. Upon receiving the expression of interest, MANEB's special team sets out to inspect the school. They look at things like enough room space to accommodate candidates when writing examinations, laboratories, sanitation etc. The inspection team hands over its findings to a special Board Committee that convenes to discuss the findings. If the committee is satisfied with the findings, the school is awarded the status of examination center and accordingly allocated examination center number. If the findings are not satisfactory, the school is not given the examination center status hence its candidates register using a nearby approved examination center.

3.3.1.2 Registration of Candidates, Verification of details and Dissemination of results

In Malawi, registration of candidates at all levels is done in schools. Before the introduction of computers in schools, candidates' entries were being captured manually and thereafter, files sent to the Board for data capture into a computer system by hired data entry personnel. As the number of candidates kept rising in number, it was taking longer for the Board to complete capturing the candidates' bio data into its computer system. As a way of eradicating the manual system of registering candidates, computers were introduced in schools. This led to the introduction of electronic registration of candidates currently being used to register candidates for national examinations.

Electronic Registration of Candidates

Currently, the Malawi National Examinations Board employs what is known as the electronic candidate registration system that makes use of spreadsheets and Microsoft Access database in the backend. This method of registration has been in use for a number of years to date.

For each level of examinations, i.e. PSLCE, JCE and MSCE, MANEB prepares a spreadsheet template containing three worksheets: one for the data entry and the other two for reference as data are being entered [54]. These spreadsheets are then burnt on a CD or DVD.

A	B	C	D	F	J	K	M	O	P	R	U	W	Y	AB	AC	AF	AJ	AK	AL
Seri	DistrictName	CentreNam	CentreNo	sex	YearofBirth	StudentName(Surname First)	AGR	BIB	BIO	CHI	ENG	GEO	HIS	LIF	MAT	PHY	Total	Fees	I Sign
1	LILONGWE CITY	MKWICHI	654	F	2001	BANDA JULLIANA		021	022	032	052	073		124	131	162	8	8400.00	
2	LILONGWE CITY	MKWICHI	654	F	1998	BENARD SYLVIA			022	032	052	073		124	131	162	8	8400.00	
3	LILONGWE CITY	MKWICHI	654	F	2000	CHIKHOLA JOSEPHINE	012	02		032	052			124	131	162	8	8400.00	
4	LILONGWE CITY	MKWICHI	654	F	1999	CHIKOLOSA VERONICA		021	022	032	052	073		124	131	162	8	8400.00	
5	LILONGWE CITY	MKWICHI	654	F	2001	CHIKOPA LINESS	012		022	032	052	073		124	131	162	8	8400.00	
6	LILONGWE CITY	MKWICHI	654	F	2001	CHINZU CYNTHIA		021	022	032	052	073		124	131	162	8	8400.00	
7	LILONGWE CITY	MKWICHI	654	F	1998	CHIPETA TOWERA		021	022	032	052			124	131	162	8	8400.00	
8	LILONGWE CITY	MKWICHI	654	F	2000	CHIUYE TAMANDANI	012	021	022	032	052				131	162	8	8400.00	

CODE
021

Figure 3.1: Candidate Registration Template [MANEB]

A copy of the CD for each of the examinations is given to each of the 34 education districts in Malawi. Once received, the DEM makes available copies of the templates to all relevant examination centers in the district. Each examination center is then responsible for registering its candidates on the spreadsheet, print a copy and let each candidate sign against their entry to show agreement that all details captured are correct. Prior to receiving the templates, the students registration details are compiled by the responsible teacher, students pay their examinations and Identity Card fees through the school's bursar or cashier, students' passport size photos for IDs are taken with details like name, date of birth and center number written at the back of the photos. The photos are then pinned on the identity submission forms which are then sent to MANEB after the head teacher has appended a signature for the production of IDs. The fees are then finally deposited into MANEB account.

A	B	C	D	E	F	G	H	I	J	K	L
		Running Total		**Exam Fees**		**IDs**					**858,600**
				657,600		**201,000**					
No.	Date		No of Subjects	Subject Fee	Total Subject Fees	Entry Fee	Admin Fee	Centre Fee	Sch Admn Fee	ID	Total Paid by Student
		CHARGES		**800**		**1,300**	**700**	**700**	**500**	**3,000**	
1	10/Oct/2016	Hope Mkwamba	9	800	7,200	1,300	700	700	500	3,000	**13,400**
2	13/Oct/2016	Grace Kandaya	8	800	6,400	1,300	700	700	500	3,000	**12,600**
3	18/Oct/2016	Ulemelero Chunga	8	800	6,400	1,300	700	700	500	3,000	**12,600**
4	20/Oct/2016	Sylivia Benard	8	800	6,400	1,300	700	700	500	3,000	**12,600**
5	21/Oct/2016	Mourice Benard	8	800	6,400	1,300	700	700	500	3,000	**12,600**
6	25/Oct/2016	John Robson	8	800	6,400	1,300	700	700	500	3,000	**12,600**
7	25/Oct/2016	Peter Palasila	9	800	7,200	1,300	700	700	500	3,000	**13,400**
8	25/Oct/2016	Thandeka Yiwombe	8	800	6,400	1,300	700	700	500	3,000	**12,600**
9	27/Oct/2016	Ashan Kalolo	9	800	7,200	1,300	700	700	500	3,000	**13,400**
10		Edna James	8	800	6,400	1,300	700	700	500	3,000	**12,600**
11		Francis Khaiya	9	800	7,200	1,300	700	700	500	3,000	**13,400**
12		Edwin Kachinga	9	800	7,200	1,300	700	700	500	3,000	**13,400**
13	31/Oct/2016	Liness Cjikopa	8	800	6,400	1,300	700	700	500	3,000	**12,600**
14		Innocent Thamangani	8	800	6,400	1,300	700	700	500	3,000	**12,600**
15		Hobby Mathews	8	800	6,400	1,300	700	700	500	3,000	**12,600**
16		Kereen Simunguzye	8	800	6,400	1,300	700	700	500	3,000	**12,600**
17		Vanessa Mankhwazi	8	800	6,400	1,300	700	700	500	3,000	**12,600**

Figure 3.2: Fees Payment Template [MANEB]

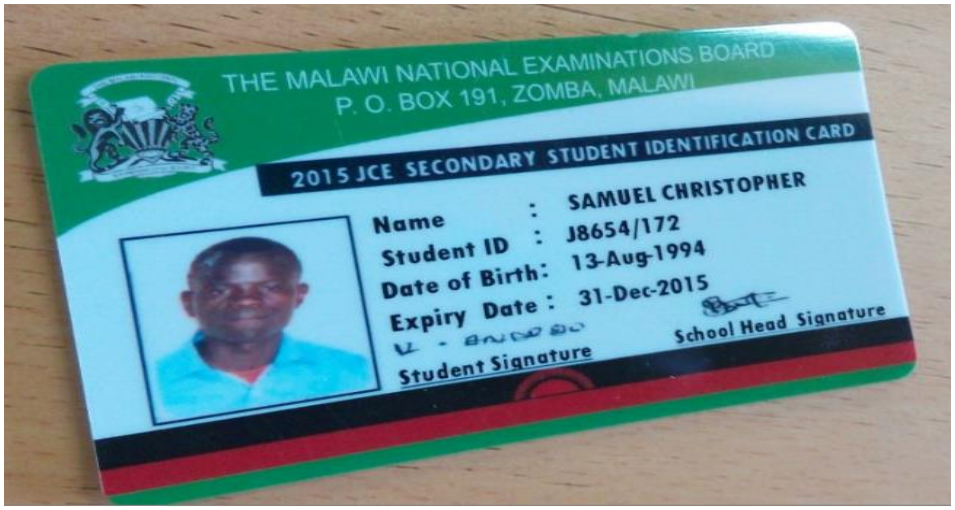
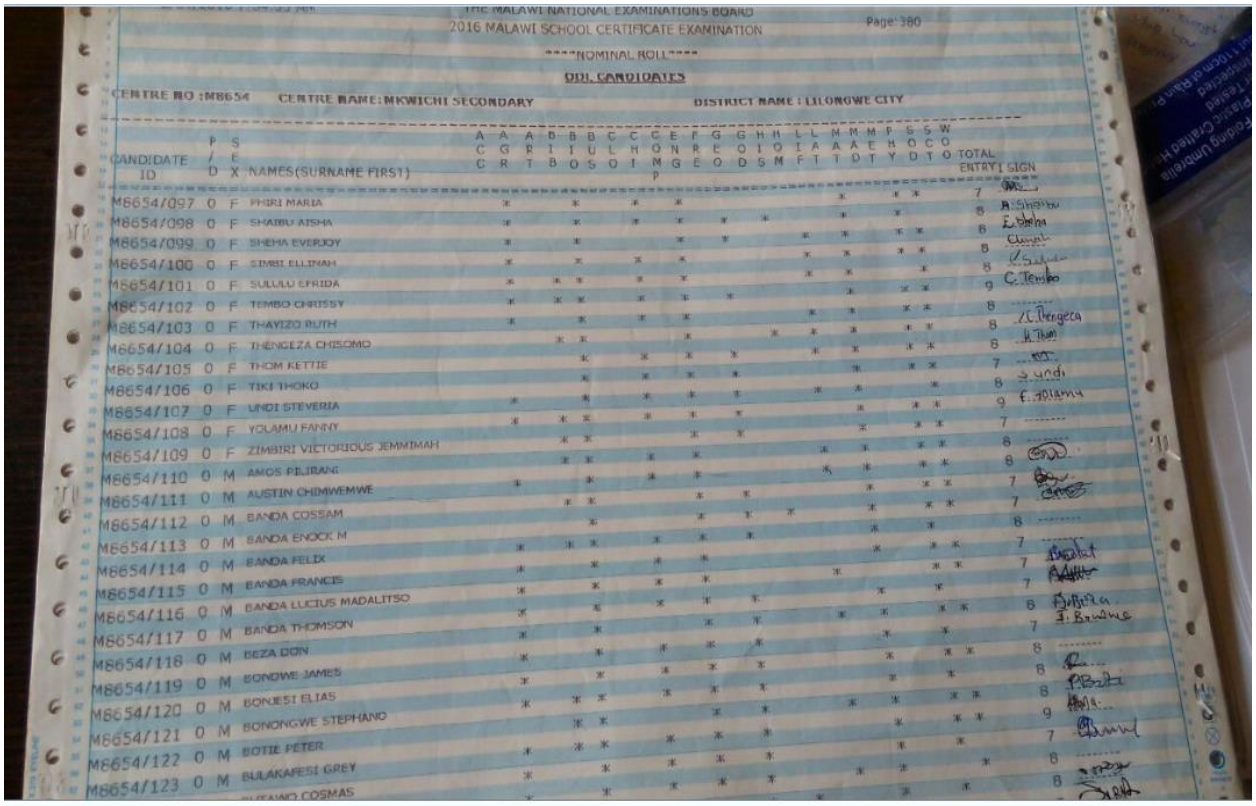


Figure 3.3: Candidate Identity Card [MANEB]

Where a center does not have ICT facilities as in many cases, the data on a hard copy are sent to the DEMs office where capturing into a spreadsheet occurs and likewise a printed copy is also sent back to the examination center for candidates to sign. When capturing of candidates' details is done, the DEMs office collects data on spreadsheets from all centers in the district with corresponding documentation i.e. the associated hard copies and submits the same to MANEB.

When data is received at MANEB from all the DEMs, it is cleaned, merged and converted into a standard database management system using Microsoft Access. Later, nominal rolls are printed and sent to all centers for verification of the accuracy of the captured data by candidates. Any queries are sent by center heads to MANEB through the DEM's office. This process of error rectification takes a period of at least one month. Common queries include missing subjects on entries, incorrect names and missing candidates. When querying period is over, registration is taken to have been completed and subsequent examination administration activities commence.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****NOMINAL ROLL****
ODL CANDIDATES
CENTRE NO :M8654 CENTRE NAME: MKWICHI SECONDARY DISTRICT NAME : LILONGWE CITY

CANDIDATE ID	P/D	SEX	NAMES(SURNAME FIRST)	TOTAL ENTRY	SIGN
M8654/097	0	F	PHIRI MARIA	7	
M8654/098	0	F	SHAIBU AISHA	8	
M8654/099	0	F	SHEHA EVERJOY	8	
M8654/100	0	F	SIMBI ELLINAH	8	
M8654/101	0	F	SULULU EFRIDA	9	
M8654/102	0	F	TEMBO CHRISSY	8	
M8654/103	0	F	THAYIZO RUTH	8	
M8654/104	0	F	THENGEZA CHISOMO	8	
M8654/105	0	F	THOM KETTIE	7	
M8654/106	0	F	TIKI THOKO	8	
M8654/107	0	F	UNDI STEVERIA	9	
M8654/108	0	F	YOUMU FANNY	7	
M8654/109	0	F	ZIMBIRI VICTORIOUS JEMIMAH	8	
M8654/110	0	M	AMOS FEJIRANI	8	
M8654/111	0	M	AUSTIN CHIMWEMWE	7	
M8654/112	0	M	BANDA COSSAM	7	
M8654/113	0	M	BANDA ENOCK M	8	
M8654/114	0	M	BANDA FELIX	7	
M8654/115	0	M	BANDA FRANCIS	7	
M8654/116	0	M	BANDA LUCIUS MADALITSO	8	
M8654/117	0	M	BANDA THOMSON	7	
M8654/118	0	M	BEZA DON	8	
M8654/119	0	M	BONDWE JAMES	8	
M8654/120	0	M	BONJESI ELIAS	8	
M8654/121	0	M	BONONGWE STEPHANO	9	
M8654/122	0	M	BOTIE PETER	7	
M8654/123	0	M	BULAKAFESI GREY	8	

Figure 3.4: Nominal Roll for Details Verification [MANEB]

Months after registration, examination question papers prepared by MANEB are circulated in all the centers in readiness for writing. Examinations are written for a period of two weeks to one month depending on the type of examination. When writing period is over, MANEB assembles teachers (examiners) from various schools to mark and grade the scripts. This exercise is done centrally by following some guiding principles. For PSLCE, the results are compiled in the form of books that are formatted and printed by some hired big print houses. For JCE and MSCE, the results are printed in a similar way as nominal rolls. After printing, the results are distributed to

various places i.e. MoEST headquarters, EDMs, DEMs as well schools where candidates or parents access the results from.

ASEYE GIRLS SECONDARY SCHOOL — SCH. NO. 04

Ser. No.	Pupil Number	Pupil Name	Sex	District of Origin	Status
1	002 14 025 083	MSUKWA ATUPERE WITNESS	F	CHITIPA	BOARDER
2	002 06 005 049	MTAMBO PRAISE			
3	002 06 020 003	CHOMBA LOSTINA		CHITIPA	
4	002 06 024 067	NAHOSI JENIPHER		LIKOMA	
5	002 14 072 040	MPANGALA MARTHA		KARONGA	
6	002 14 075 058	MWALILINO HILDA			
7	002 02 026 087	MWAMLIMA MATRIDA			
8	002 03 061 121	NYIRONGO THOKOZANI			
9	002 05 199 095	NYONDO ROSARIA			
10	002 16 143 008	CHILONGO JOSOPHINE		KASUNGU	
11	002 14 009 058	MBEWE DOROTHY			
12	002 06 037 027	MWALE TADALA			
13	002 25 039 097	NDALAMA WEZZIE G			
14	002 03 006 011	GONDWE RACHEAL		RUMPHI	
15	002 06 037 021	MHANGO WEZZIE			
16	002 06 002 095	MKANDAWIRE GLORY			
17	002 25 093 016	MKANDAWIRE UCHINDAMI GLORY			
18	002 06 035 071	MSISKA PRISCA		MZIMBA NORTH	
19	002 16 047 077	CHIUMIA WEZI			
20	002 06 018 007	HLONGO CHITEMWA			
21	002 04 008 008	KALAGHO SARA			
22	002 06 037 018	MAKWAKWA ALINAFE			
23	002 04 031 025	MDUMUKA FLORENCE			
24	002 04 008 012	MSISKA TEMWA			
25	002 14 028 109	MTAWALE TRYNESS			
	002 04 092 026	NKUNIKA KETTIE			
		RACHAEL		MZIMBA SOUTH	

MWANZA
CHIKHWAWA
NSANJE
NENO

Figure 3.5: PSLCE Examinations Results Book [MANEB]

CONFIDENTIAL

THE MALAWI NATIONAL EXAMINATIONS BOARD

SCHOOL CERTIFICATE EXAMINATIONS : 2012

LIST OF GRADES AND AWARDS FOR CANDIDATES

INTERNALS

CENTRE NO M0654 CENTRE NAME: MKWICHI DISTRICT NAME: LILONGWE CITY

ID	SEX	CANDIDATE'S NAMES
M0654 / 027	M	CHINGANYAMA MARTIN
M0654 / 028	M	CHIRWA SILENCE
M0654 / 029	M	CHITALO BILLY
M0654 / 030	M	CHUNGA ROBERT
M0654 / 031	M	GAMA BUSY
M0654 / 032	M	GAMA CHIYANJANO A
M0654 / 033	M	GAMA LAWRENCE
M0654 / 034	M	KABAGHE ALBERT GI
M0654 / 035	M	KACHIWAYA MIKE
M0654 / 036	M	KALEKENI JOSEPH
M0654 / 037	M	KALIATI JONATHAN
M0654 / 038	M	KALIRANI NASONI SATO
M0654 / 039	M	KALOLO AMOS
M0654 / 040	M	KAMENYA STEPHEN
M0654 / 041	M	KAMWAMBENI FRANCIS
M0654 / 042	M	KASAMBAH WITNESS
M0654 / 043	M	LIMULA JOLEX M
M0654 / 044	M	MAJAWA FRANK
M0654 / 045	M	MALENGA KENNEDY B
M0654 / 046	M	MANDA COSMAS
M0654 / 047	M	MBALANJE SIMEON
M0654 / 048	M	MBEWE JOSHUA K
M0654 / 049	M	MNDALA TIMOTHY
	M	MONTERSINO DAVIE

Figure 3.6: MSCE Examinations Results Sheet [MANEB]

3.3.1.3 Challenges with the Current System

The current system described in the previous section used by MANEB to register candidates, verify candidates' registration details and disseminate examinations results faces a number of challenges as revealed by the baseline study.

Capturing of candidates' details at the examination center during registration is done by ordinary teachers that are not conversant with computers, a thing which definitely leads to capturing incorrect data or unknowingly deleting some already captured data. Burning and forwarding of spreadsheets on CDs/DVDs at various levels of the process can undoubtedly lead to some files missing and others even get corrupt. The merging of these spreadsheet files into a single database file can also result in some data missing. Over and above all these, the registration process proves to be time consuming and very costly as it takes not less than a month to complete the registration of candidates. The use of CDs/DVDs, extensive paper work and involvement of hired data entry clerks renders the whole process to be expensive.

The printing of nominal rolls for verification of details by candidates uses a specialized type of paper and ink which are expensive thereby making the whole process costly. The nominal rolls in some cases are not clearly printed due to shortages of printing cartilage as a result candidates hardly manage to read their details. Some candidates reside very far away from their schools such that they do not go to their schools to verify their details. The procedure of rectifying errors found on the nominal rolls is too long and as a result candidates reach the day of writing examinations without their errors being reversed.

Dissemination of results using printed books and rolls is also expensive as printing agencies demand a lot of money from MANEB to have the books printed. Besides, the production of books and rolls for results dissemination delays the release of examinations and subsequently has an effect on the education calendar.

Another serious challenge associated with the current system is to do with the payment of examinations fees and it is perpetrated by owners of private schools. By virtue of candidates paying their fees through the school cashier or bursar, proprietors of some schools collect money from candidates and use the money for their own businesses without registering the candidates

thereby rendering the candidates unable to sit for examinations since fees payment forms part of the registration requirements.

Figure 3.7 below depicts current processes for registration, verification and results dissemination for MANEB.

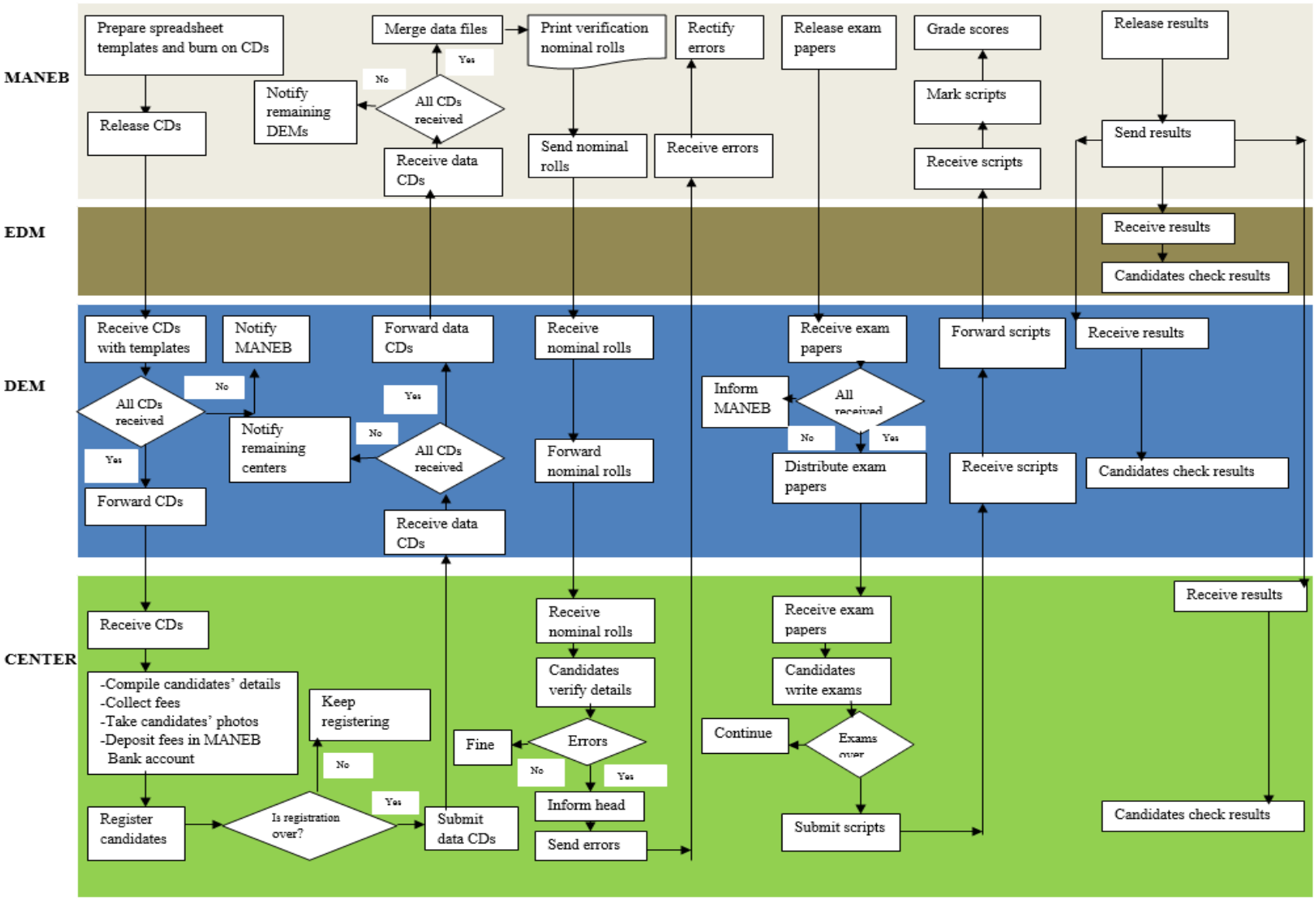


Figure 3.7: Current System Business Process

3.3.2 Proposed SMS/USSD based System Using Cloud Model

In this study, optional business process models based on the current business activities that are being used by MANEB were proposed. The study, in this section proposed a change by automating the current business processes that are being used by MANEB which are mostly paper based.

Although the current process described in the previous section is termed as electronic, the baseline study revealed that there are a lot of inefficiencies and manual processes that are done that contribute to the challenges the current system is having. A large percentage of respondents during the baseline study recommended the introduction of the proposed system to be used for registration, verification as well as accessing of examinations results.

The system will enable candidates or their parents to register for examinations by providing their details e.g. name, candidate number, center number, sex, list of subjects etc. At some point, when registration period closes, the system will push SMSs to all registered candidates with their registration details for verification. These details can also be requested through USSD. For any anomalies observed, concerned candidates will have to consult the responsible teacher at their school to do the amendments using the USSD functionality of the system. This error correction process will also have a specified period of time so that when it elapses the system shall allow no more changes. The system will be capable of generating candidates' registration cards which will be barcoded. The barcodes will have examination numbers embedded in them. The cards will be used for identification of candidates on the day of writing examinations by scanning them using a barcode reader machine. When examinations results are released, the system will also push SMSs with results to all candidates or parents. Similarly, the results will be requested through USSD. The system will incorporate a mobile payment facility so that all the fees pertaining to examinations are paid to MANEB using mobile payment.

The system will have web interface for the system administrator and other users. The web interface will be used for a number of operations i.e. viewing registered records, importing examinations results, generating registration cards etc.

3.3.2.1 Proposed Security Features for the System

Security remains one of the major concerns in today's systems. The rapid growth of cloud computing has also contributed to the security concerns for many systems users or clients as the data remain in the cloud which is susceptible to various attacks.

Use of Unique School Codes and Passwords

In the proposed system, each examination center will have a unique code that will be known by the teacher responsible for registration of candidates. These center codes will be given to the DEM through the bulk SMS notification and the DEM will then give the codes to the responsible teacher. Whenever a candidate wants their registration details amended after receiving registration details notification, the teacher at the examination center will be asked to supply the unique code for the center in order to proceed with the process of amending the details. This is to make sure that no any individual does the rectification task other than the teacher responsible. The web interfaces will have to be accessed by the administrator and other authorized users hence passwords and access levels will be used to access the system.

Use of Barcodes

Barcodes have for a long time been used for unique identification of items. As pointed out already, the candidate registration card will have a barcode that will keep registration number of a candidate. Before given access to the examination room, the candidate's card will have to be scanned to ascertain that the candidate really registered.

Use of Biometrics

The system will be designed in such a way that when a candidate is registering using a mobile phone, some biometric feature i.e. face or voice be captured. For the web interface, the system will use fingerprints or face recognition when logging in so that no any officer other than the designated one logs in and retrieve information.

Use of Location Based Security Feature

The proposed system will employ location based security feature to make sure that only those individuals within recognized locations are allowed to use the system i.e. by restricting people

outside the borders of Malawi from registering for examinations. This will be complimented by the current country mapping project that the government of Malawi is undertaking to have coordinates of various school locations across the country. The coordinates will be captured in the system so that if anyone is trying to register from a location not recognized by the system, the system will reject. Phones these days are made with GPS receivers that will be used to locate the position of any user of the system.

3.3.3 System Architecture

The proposed system for candidates' registration, verification and results dissemination using cloud infrastructure is depicted in the figure below. It has a number of components that work together to accomplish the intended goal of the entire system. It has the cloud service component that constitutes storage facilities, web servers, file servers and user applications. The other component is the MANEB internal network that is monitored and administered by the administrator of the entire system. The MANEB network connects directly to the cloud to have access to all the registration as well as examinations data. The administrator, employed by MANEB, will be responsible for all the administrative tasks throughout the process of administering national examinations. Among other tasks, the administrator will be required to manage users, make data backups, printing of reports, sending of bulk SMSs to the DEMs and EDMs and also pushing SMSs to candidates for verification after registration as well as results after release. The MANEB network will have redundant database storage and the user application as a fail-safe measure. There will be constant synchronization between the cloud and MANEB databases to maintain up to date data in the local storage.

Another component is that of mobile service provider (MSP). This will be any telecommunication operator that will facilitate the sending and receiving of SMSs and USSDs between the application and the users using their SMS and USSD gateways.

Users, in this case candidates or their parents, will also be part of the system. When registration period opens, the users will be registering for examinations using their mobile phones through the MSP and their details get to the cloud for storage. These candidates will be registering using a short code that MANEB will acquire through the Malawi Communications Regulatory Authority (MACRA).

Examinations centers form another component of the proposed system. Since candidates will be registering on their own, the centers will be involved when candidates would like to amend their details after verification stage. The candidate will have to get in touch with the responsible teacher and suggest the changes they would want to make. The teacher will do the amendments using a USSD facility by providing a unique code for the center. Centers will also be involved on the day of writing examinations to authenticate the candidates before granted access into the examinations room.

The DEM and EDM components of the system will be responsible for accessing their web interfaces of the system to produce reports specific to their respective districts and education divisions.

The last component of the proposed system is that of mobile money agent. When registration opens, candidates will be required to send all the examinations fees directly into MANEB's account using these agents. This is to avert the phenomenon of having some schools' proprietors mismanaging monies paid by candidates meant for examinations fees.

Figure 3.8 below shows the architecture for the proposed system.

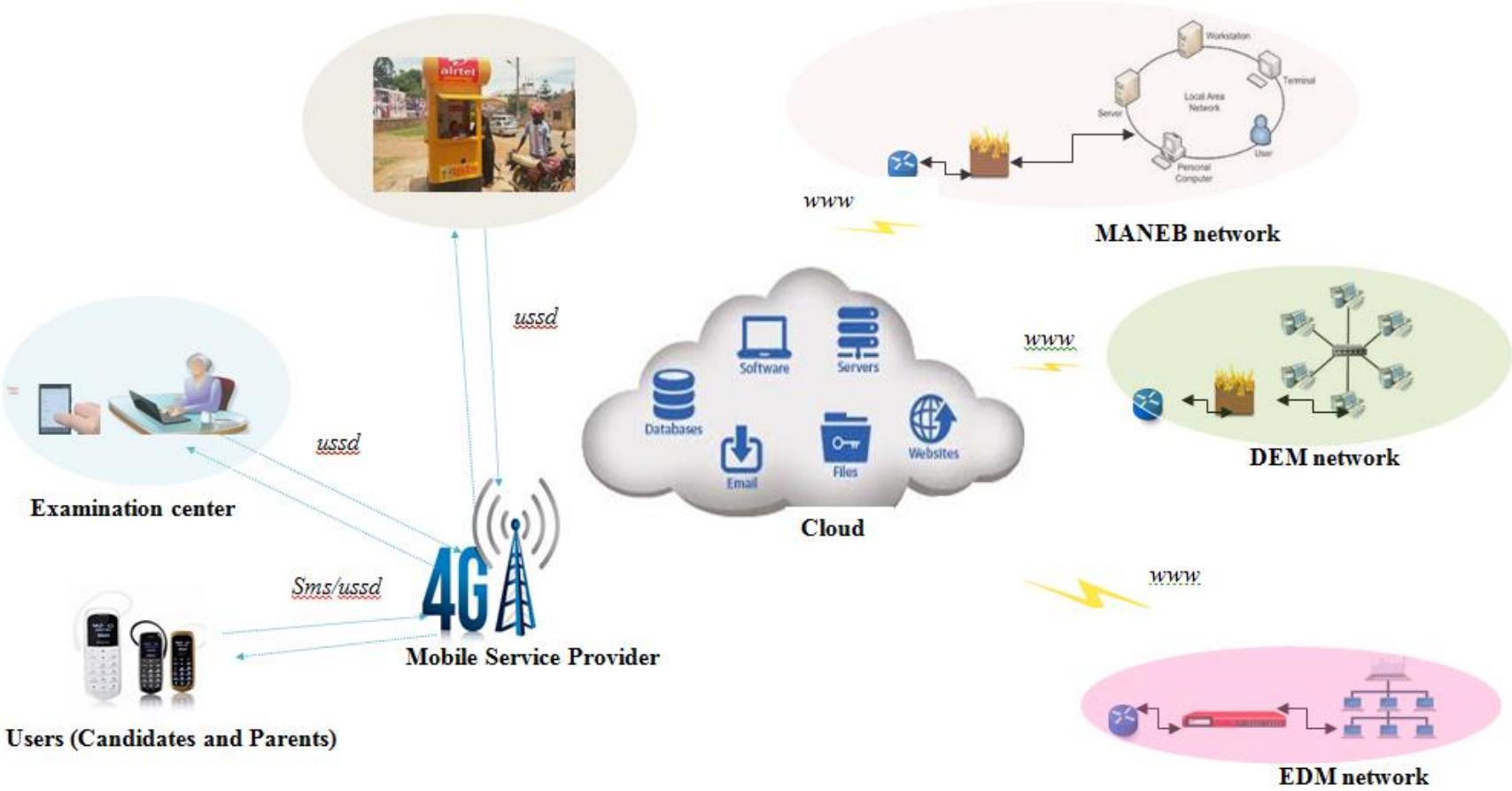


Figure 3.8: Proposed System Architecture

3.3.4 Requirements Specification for the Proposed System

System requirements are a description of what an envisaged system will have to do, what services the system offers as well as constraints on its operation. A requirement is referred to as a high-level abstract statement of a service that a system should provide or a constraint on the system. It reflects needs of a user for a system that serve a certain purpose [140]. Requirements for software applications are grouped into functional and non-functional requirements. According to [140], functional requirements are statements of service the system should provide and they do drive the application architecture of a system whereas non-functional requirements are constraints on the services or function delivered by the system and they do drive the technical architecture of a system.

The requirements specification section, therefore, provides a detailed depiction of the major functionalities and specifications of MANEB's registration, verification and results dissemination system.

3.3.4.1 Functional Requirements

Table 3.1 provides the functional requirements for the proposed system.

FR1	*The administrator of the system will be able to create users with different privileges*
FR2	*The system will be able to persist bulk data in the cloud storage*
FR3	*All users of the system will have to be authenticated before accessing the system*
FR4	*System administrator will be able to delete users from the system*
FR5	*System administrator will be able to view all the system users*
FR6	*System administrator will be capable of updating any user's account*
FR7	*Candidates will be able to register their details using simple SMS or USSD*
FR8	*The system will be able to send registration and examinations data to candidates*
FR9	*The system shall be able to acknowledge completion of a transaction* i.e. after successful registration of rectification.
FR10	*The system will be capable to send alerts and/or notifications to users' mobile phones* i.e. examinations dates etc.
FR11	*The system will have the ability to flash warnings with regards to any violations*

FR12	*Ability to match/tally registered candidates against those that have paid examinations fees by the system*
FR13	*Users with necessary privileges will be able to print registration cards from the system*
FR14	*The system will include barcode facility that will contain candidates' examination numbers.*
FR15	*The system will contain a bulk SMS facility for internal communication between MANEB, EDM and DEM.*
FR16	*There will be data archiving facility for future queries*
FR17	*The system administrator will be able to open and close sessions for each activity* i.e. registration, verification and results dissemination.
FR18	*Candidates will be able to view their registration details using particular code*
FR19	*The system administrator will be able to monitor activities of the system and block all malicious activities*
FR20	*Teacher responsible for examinations will be able to make registration amendments on behalf of candidates*
FR21	*Different users will produce different reports according to their privileges*

Table 3.1: Functional Requirements for the Proposed System

3.3.4.2 Non-Functional Requirements

Table 3.2 provides non-functional requirements for the proposed system

NFR1	*The system will have a parallel web based application to be used when there is network problem with the mobile based system*
NFR2	*The system will be user friendly with help screens, prompts and meaningful error messages*
NFR3	*The system will require both telecommunication and internet services for its operations*

NFR4	*The user application will run on a variety of operating systems*
NFR5	*The mobile application of the system will be purely SMS and USSD based to carter for all users including those who cannot afford smart phones*
NFR6	*Constant synchronization of data between the cloud storage and local storage for data availability*
NFR7	*The system will be self-monitoring to detect and report on any failures, warnings or errors.*
NFR8	*The system shall be able to sit idle and resume operations with minimal delay*
NFR9	*The system shall use cloud infrastructure to be able to smoothly handle candidates' bulk data*
NFR10	*The system failure shall not compromise data integrity*
NFR11	*All software processes shall be killable, able to restart, be debugged and testable without affecting normal operations*
NFR12	*The software shall take optimal advantages of all language, compiler, and system computational features and resources to reduce run times to the minimum practical level*
NFR13	*User documentation and operational manual for the system shall be provided*
NFR14	*Access to the system that will result in the manipulation or amendment of data shall require credentials for identification*

NFR15	*An audit trail and system logs will be made available for activity tracking within the system*
NFR16	*Encryption shall be ensured at all interfaces where data could be intercepted or transmitted.* This may be during transmission of data over the mobile network or the internet
NFR17	*Each user will have a set of system access properties that define the user's privileges within the system*
NFR18	*The system shall continue operations, but with reduced capacity on all unaffected resources during partial shutdowns for maintenance, repair and upgrade*
NFR19	*Non-real time operations will be handled by the system transparently*
NFR20	*Software system and application code shall be well documented and written in a generally familiar language that is easily readable and using practices that call for minimal confusion*

Table 3.2: Non Functional Requirements for the proposed System

3.3.5 System Modeling and Design

To design the proposed system, Object Oriented Design (OOD) methodology was used. OOD is a process of using an object oriented methodology to design a computing system or application. It enables the implementation of a software solution based on the concepts of objects. It serves as part of the object oriented programming (OOP) process or lifecycle [141]. Unified Modeling Language (UML) was used to model the system. UML includes a set of graphical notation techniques to create visual models of software intensive systems. Selected UML diagrams i.e. Use Cases, Sequence Diagrams Entity Relation Diagrams and Class Diagrams were used in the proposed system.

3.3.5.1 Use Cases

In the UML, a use case diagram can summarize the details of a system's users (actors) and their interactions with the system. The purpose of a use case diagram is to demonstrate the different ways that a user might interact with a system. Use case modeling is used to model interactions between a system and external actors which may be users and other systems. Actors are a representation of the roles that people, other systems or devices take on when communicating with particular use cases in the system [140]. With a use case diagram, the use cases are symbolized with a labeled oval shape. Lines represent actors in the process, and the actors' participation in the system is modeled with a line between the actors and the use cases.

The main actors in the registration, verification and results dissemination system are the system administrator, candidates, teacher responsible for registration of candidates, District Education Manager (DEM) and Education Division Manager (EDM). The system has three main modules namely registration, verification and results dissemination with their use cases as follows:

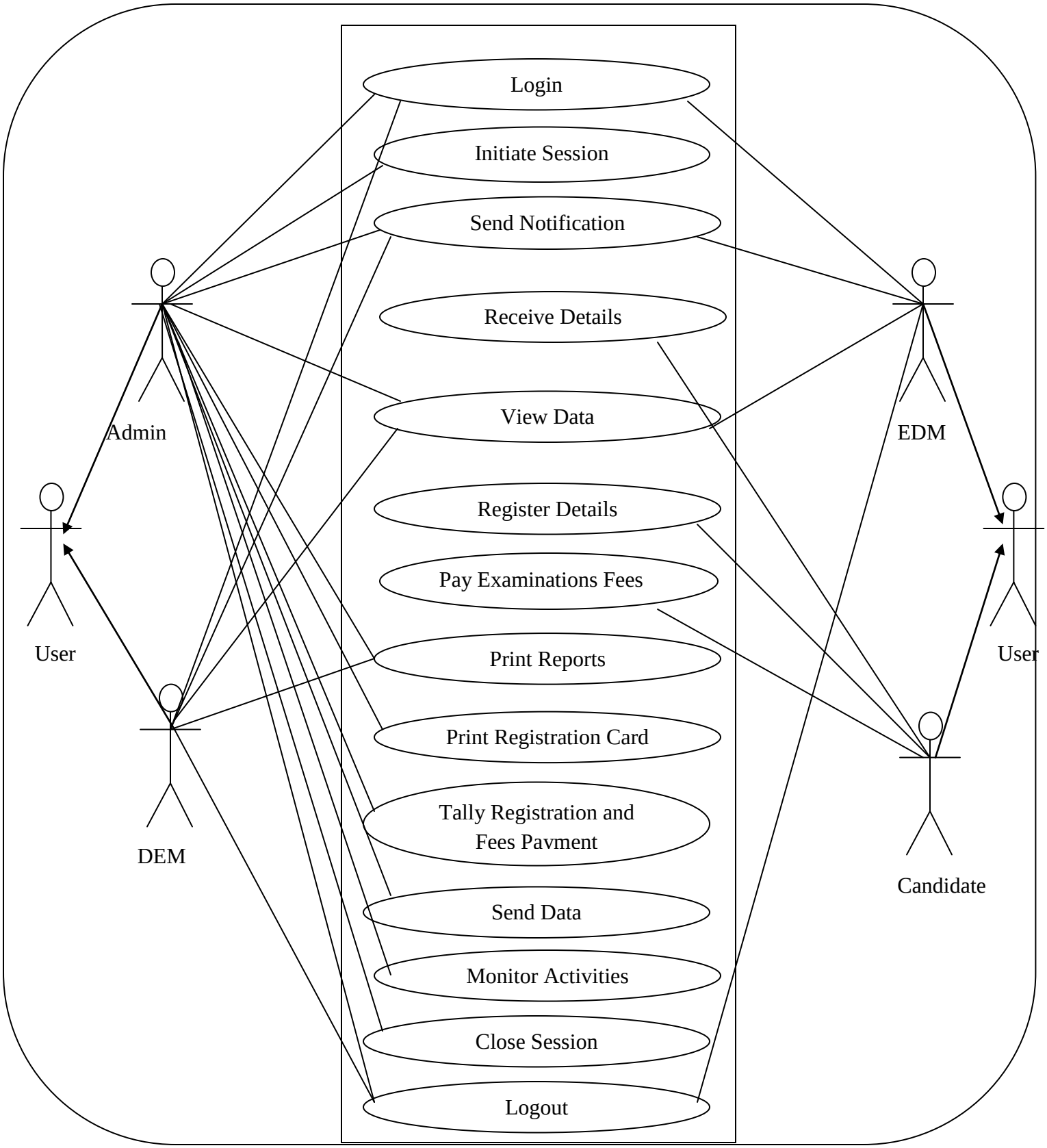


Figure 3.9: Registration Process Use Case

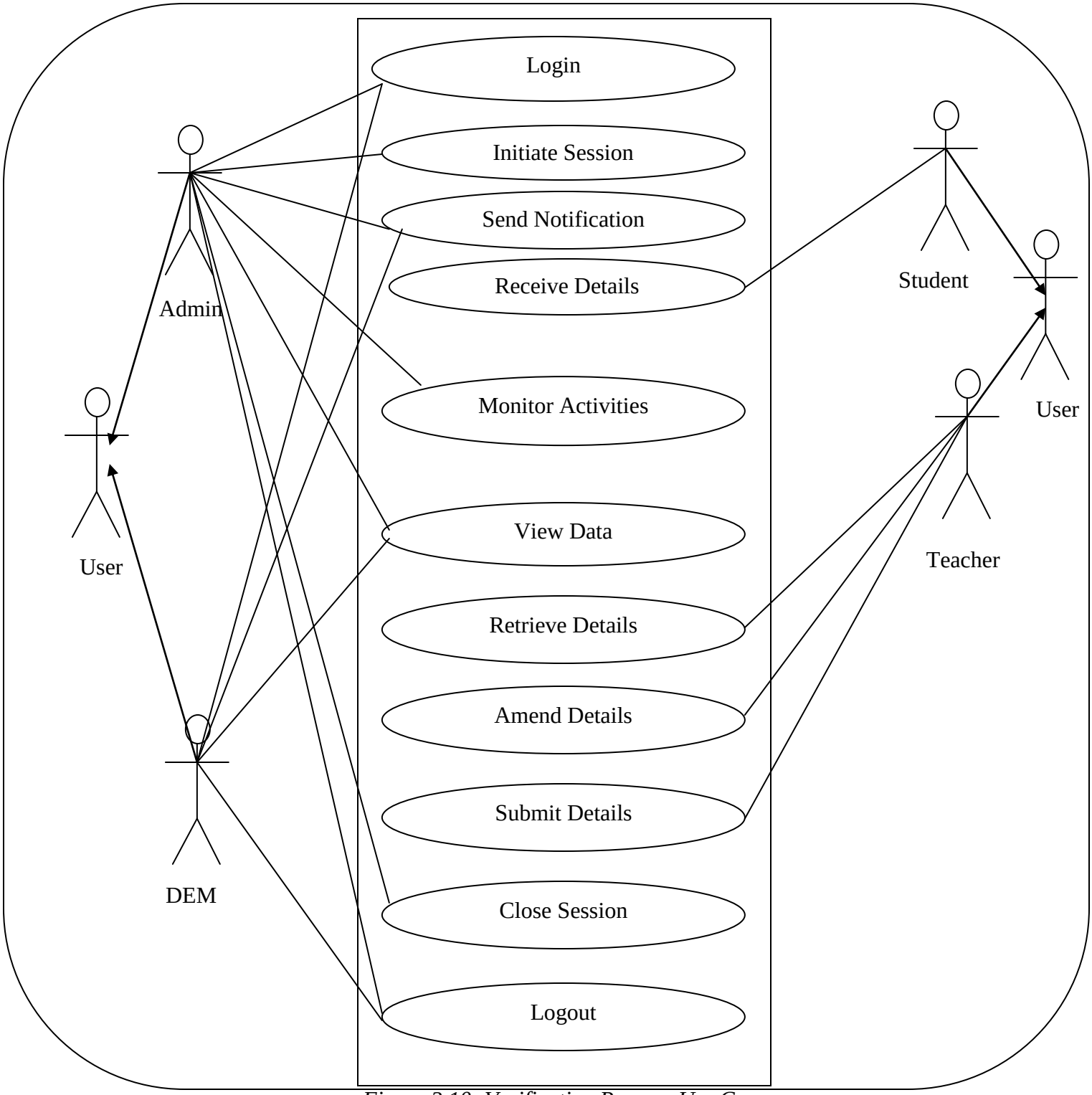


Figure 3.10: Verification Process Use Case

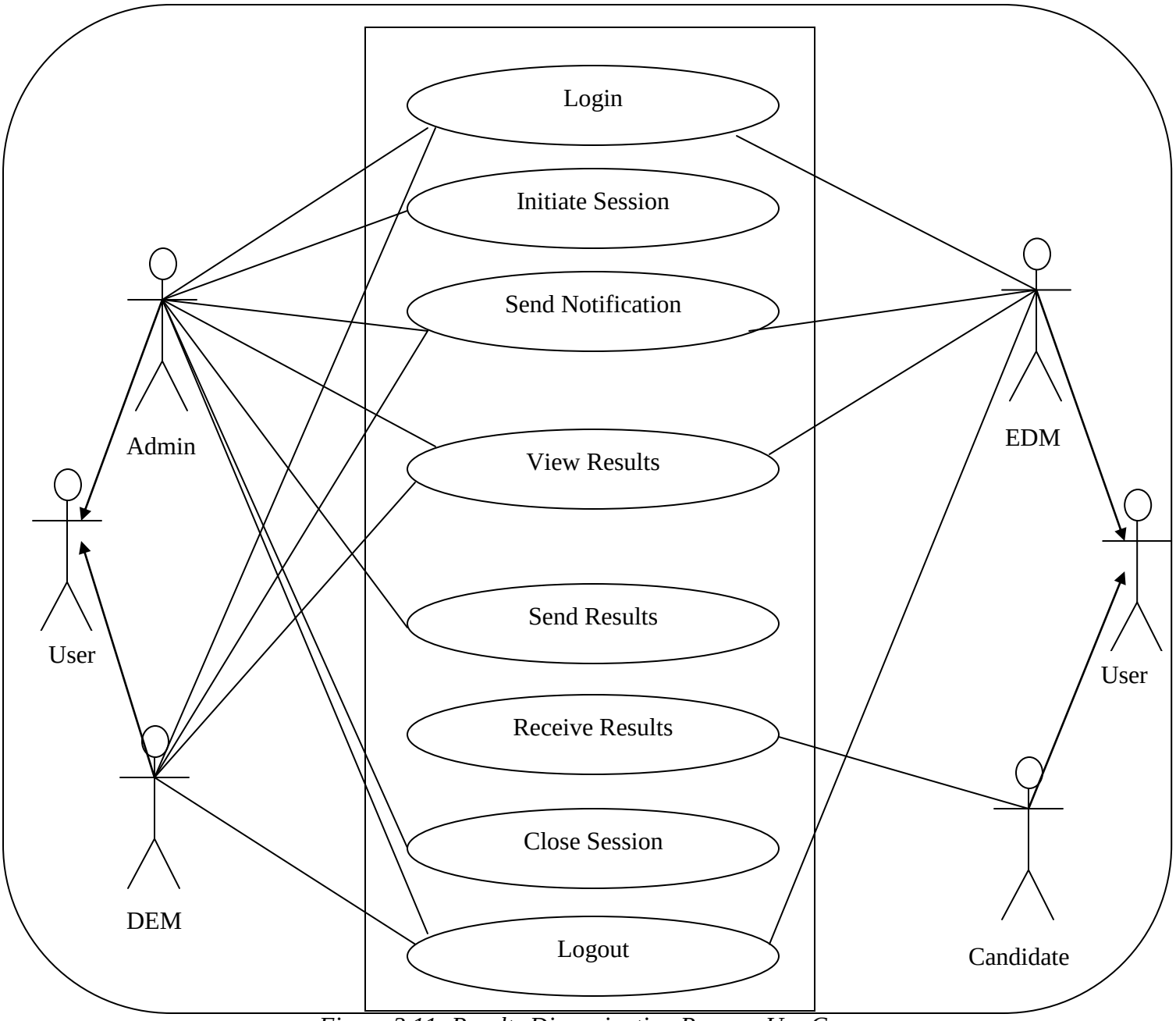


Figure 3.11: Results Dissemination Process Use Case

The system administrator will also have other tasks to perform apart from those outlined in the above use cases. The following use case shows the extra activities that the administrator for the proposed system will have.

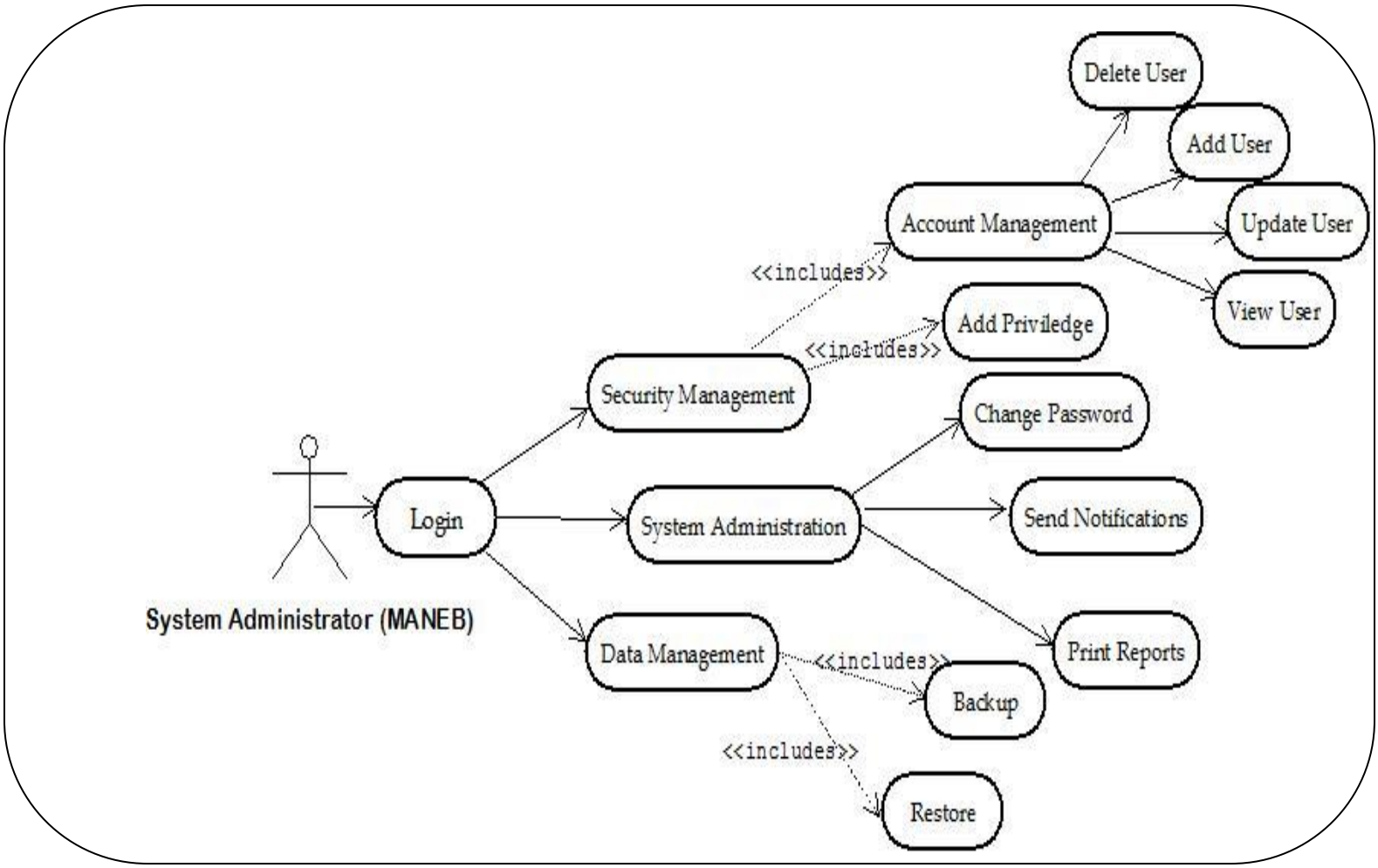


Figure 3.12: System Administrator use case

Different actors play in different modules within the system according to the level of accessibility that they have. The following are some of the use cases explained.

Use Case ID:	**1**
Use Case Name:	**Login Page access**
Actor:	Users (DEM, EDM, Admin)
Description:	This use case describes how to gain access to the web system component.
Trigger:	Login credentials will be required to login to the examinations data management system

Flow:	User enters username and the password. The username and password are assigned and given to the users earlier. If user is the administrator, he will be connected to the admin page and will have access to the admin links.
Exceptions:	Invalid data entry needs to be reported in the error logs with the Error Messages.
Priority:	High
Frequency of Use:	High
Special Requirements:	Login credentials are valid and confirmed before the entry.
Assumptions:	Username and password are given to the users earlier.

Table 3.3: Login Use Case

Use Case ID:	**2**
Use Case Name:	**Access to Admin Page**
Actor:	Administrator
Description:	This use case describes how to gain access to the Admin page.
Purpose:	Administrator requires managing administrative tasks i.e. user management, data management etc.
Flow:	Administrator logs in and connects to the Administrator page where he will have access to initiate sessions, send notifications, push data, close sessions etc. Will also connect to the network and the database.
Exceptions:	When there is a network problem create an error and report it. When there is a database connectivity problem report the problem via

	Error Messaging Technique.
Priority:	High
Frequency of Use:	High
Special Requirements:	Only certain users can have access to this page. It will require administrator privileges to open it.

Table 3.4: Access to Admin Page Use Case

Use Case ID:	**3**
Use Case Name:	**User Accounts Management**
Actor:	Administrator
Description:	This use case describes how to manage user accounts from the Admin page.
Purpose:	Administrator requires managing the users for security reasons.
Flow:	Administrator logs in and connects to the Administrator page where he will have access to user management page. In the user management page he will have the options to add users, delete users, update users, view users, change user privileges. Connect to the network via actor network. Connect to the database via actor database.
Exceptions:	When there is a network problem create an error and report it. When there is a permissions issue or other issues to assign the certificates for the users, report the issue with an error message.
Priority:	High
Frequency of Use:	High

Special Requirements:	Only certain users can have access to this page. It will require administrator privileges to open it.

Table 3.5: User Accounts Management Use Case

Use Case ID:	**4**
Use Case Name:	**Data Management**
Actor:	Administrator
Description:	This use case describes how to manage user data from the Admin page.
Purpose:	Administrator requires managing the user data for security reasons.
Flow:	Administrator logs in and connects to the Administrator page where he will have access to user data management page. In the user data management page he will have the options to backup data, restore data. Connect to the network via actor network. Connect to the database via actor database.
Exceptions:	When there is a network problem create an error and report it.
Priority:	High
Frequency of Use:	High
Special Requirements:	Only certain users can have access to this page. It will require administrator privileges to open it.

Table 3.6: Data Management Use Case

Use Case ID:	**5**
Use Case Name:	**Receive Registration and Results Details**
Actor:	Candidates
Description:	This use case describes the receiving of registration details for verification and examinations results details by candidates.
Purpose:	Candidates require to be sent their details for verification before writing examinations and also examinations results when out.
Flow:	Candidates receive their details through their mobile phones.
Priority:	High
Frequency of Use:	Medium
Special Requirements:	Only those candidates who supplied their mobile phone numbers during registration receive their details.

Table 3.7: Receive Registration and Results Details Use Case

Use Case ID:	**6**
Use Case Name:	**View Data**
Actor:	Admin, DEM, EDM
Description:	The use case describes viewing of candidates' data.
Purpose:	Admin requires checking registration progess and the results nationwide. The EDM and DEM will need to be checking the registration data as well as results per division and district respectively.
Flow:	Administrator, EDM and DEM log in, access their web interfaces and connect to the database through the view data link. The data will be made

	available in accordance with the level of privileges.
Exceptions:	When there is a network problem create an error and report it.
Priority:	High
Frequency of Use:	High
Special Requirements:	Not every user will be able to view the data.

Table 3.8: View Registration and Results Details Use Case

Use Case ID:	**7**
Use Case Name:	**Register Details**
Actor:	Candidate
Description:	The use case describes registration of candidates' details for examinations.
Purpose:	Candidates require registering their details so that they are eligible to write examinations.
Flow:	Candidates send their registration details using their mobile phones. The details are kept in the cloud.
Exceptions:	When there is a network problem create an error and report it.
Priority:	High
Frequency of Use:	High
Special Requirements:	Only eligible candidates will register.

Table 3.9: Register Details Use Case

Use Case ID:	**8**
Use Case Name:	**Print Report**
Actor:	Admin, DEM, EDM
Description:	The use case describes printing of various reports from the system.
Purpose:	Admin requires production of reports on candidates' data including payment of fees nationwide. The EDM and DEM will have access to reports per division and district respectively.
Flow:	Administrator, EDM and DEM log in, access their web interfaces. Required reports will be selected using menus. The reports will be made available in accordance with the level of privileges.
Exceptions:	When there is a network problem create an error and report it.
Priority:	High
Frequency of Use:	High
Special Requirements:	Not every user will be able to view the data.

Table 3.10: Print Report Use Case

Use Case ID:	**9**
Use Case Name:	**Print Registration Card**
Actor:	Admin
Description:	The use case describes production of candidates' registration cards to be used for identification on the day of writing examinations.

Purpose:	The admin requires producing registration card for each registered candidate prior to writing of examinations.
Flow:	Admin logs in to web interface. Retrieves candidates' records with barcodes and prints them.
Exceptions:	When there is a network problem create an error and report it.
Priority:	High
Frequency of Use:	High
Special Requirements:	Only a user with administrative rights will be able to produce the cards.

Table 3.11: Print Registration Card Use Case

Use Case ID:	**10**
Use Case Name:	**Monitor Activities**
Actor:	Administrator
Description:	The use case describes the monitoring of activities within the system.
Purpose:	Administrator requires monitoring of all activities happening within the system.
Flow:	Administrator logs into the system using some special monitoring tool and gets a log of any activity happening in the system at a given point in time.
Exceptions:	When there is a network problem create an error and report it.
Priority:	High

Frequency of Use:	High
Special Requirements:	Only certain users can have access to this page. It will require administrator privileges to open it.

Table 3.12: Monitor Activities Use Case

Use Case ID:	**11**
Use Case Name:	**Retrieve Details**
Actor:	Teacher, Candidate
Description:	This use case describes the retrieving of data by a teacher or candidate.
Purpose:	Teacher has the responsibility of amending candidates' details when there are errors during verification. Candidates want to check details.
Flow:	The user initiates a USSD session by dialing a unique code, sends the candidate's examination number and accesses the particular candidate's details.
Exceptions:	When there is a network problem create an error and report it. When there is a permissions issues report via logs.
Priority:	High
Frequency of Use:	High
Special Requirements:	Only the teacher responsible for registration of candidates can change the details.

Table 3.13: Retrieve Details Use Case

Use Case ID:	**12**
Use Case Name:	**Amend and Submit Details**
Actor:	Teacher
Description:	This use case describes the amending of candidates' registration details by a teacher.
Purpose:	Teacher has the responsibility of amending candidates' details when there are errors during verification.
Flow:	The teacher initiates a USSD session by dialing a unique code. Retrieves details of a candidate, changes the details and submit.
Exceptions:	When there is a network problem create an error and report it. When there is a permissions issues report via logs.
Priority:	High
Frequency of Use:	High
Special Requirements:	Only the teacher responsible for registration of candidates can change the details.

Table 3.14: Amend and Submit Details Use Case

Use Case ID:	**13**
Use Case Name:	**Logout**
Actor:	Users (DEM, EDM, Admin)
Description:	This use case describes how to logout from the system.
Flow:	User clicks on the logout button and exits the system.

Priority:	High
Frequency of Use:	High
Assumptions:	The user is using the system before logging out.

Table 3.15: Logout Use Case

3.3.5.2 Sequence Diagrams

Sequence diagrams are a popular dynamic modeling solution. Dynamic modeling focuses on the interactions occurring within the system. Sequence diagrams specifically focus on the lifelines of an object and how they communicate with other objects to perform a function before the lifeline ends. To understand what a sequence diagram is, one should be familiar with its components. The table below shows the elements that make up sequence diagrams.

Object	A box shape that represents a class or object on UML. It demonstrates how an object will behave in the context of the system. Class attributes are not listed in this shape.
Activation boxes	Symbolized by a rectangle shape, an activation box represents the time needed for an object to complete a task. The longer the task will take, the longer the activation box becomes.
Actors	Represented by a stick figure, actors are entities that are both interactive with and external to the system.
Package	Also known as a frame, it is a rectangle shape that is used in UML notation to contain interactive elements of the diagram. It has a small inner rectangle for labeling.
Lifeline	A dashed vertical line that represents the passage of time as it extends downward. Along with time, they represent the sequence events that occur to an object during the charted process. May begin with labeled rectangle shape or an actor symbol.
Messages	Packets of information that are transmitted between objects. They may reflect the start and execution of an operation, or the sending and reception of a signal.

	✓ Synchronous messages – Represented by a solid line with a solid arrowhead. Used when sender must wait for a response to a message before it continues. Both the call and reply should be included in the diagram. ✓ Asynchronous messages – Represented by a solid line with lined arrowhead. Don't require a response before the sender continues. Only the call to be included in the diagram. ✓ Create messages – Represented by a dashed line with a lined arrowhead. These messages are sent to lifelines in order to create themselves. ✓ Reply messages – Represented by a dashed line with a lined arrowhead, the messages are replies to calls. ✓ Delete messages – Represented by a solid line with a solid arrowhead, followed by an X symbol. The messages indicate the destruction of an object and are placed in its path on the lifeline.

Table 3.16: Components of a sequence diagram

Objects are also put into three categories as shown below.

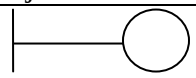
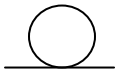
Object name	Description
	Boundary object. It models interaction between a system and its actors.
	Control object. Shows the coordination and sequencing of other objects.
	Entity object. Models information and associated behavior of some scenario such as a real-life object.

Table 3.17: Object types

Login

In the login sequence diagram, the login user interface (UI) is started and then the control object is instantiated. The control object then asks the user for login credentials and authenticates the user when correct credentials are supplied. The user entity object then gets the user account from the database. Finally, the application entity object displays the start page.

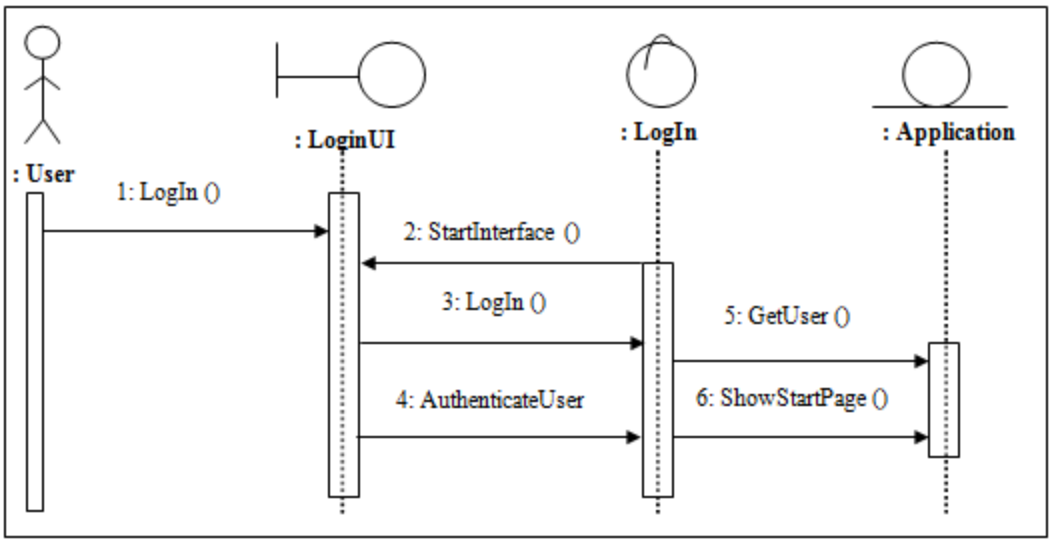


Figure 3.13: Login Sequence Diagram

Manage User

In the manage user sequence diagram, the system administrator logs into the system using administrative credentials. Then the manage user interface is started. The control object gets the user record if it exists or lets the administrator create a new record if it doesn't exist. User record can also be deleted. The administrator adds a new user accounts or updates an existing account and then the control object executes the save to or delete from database action.

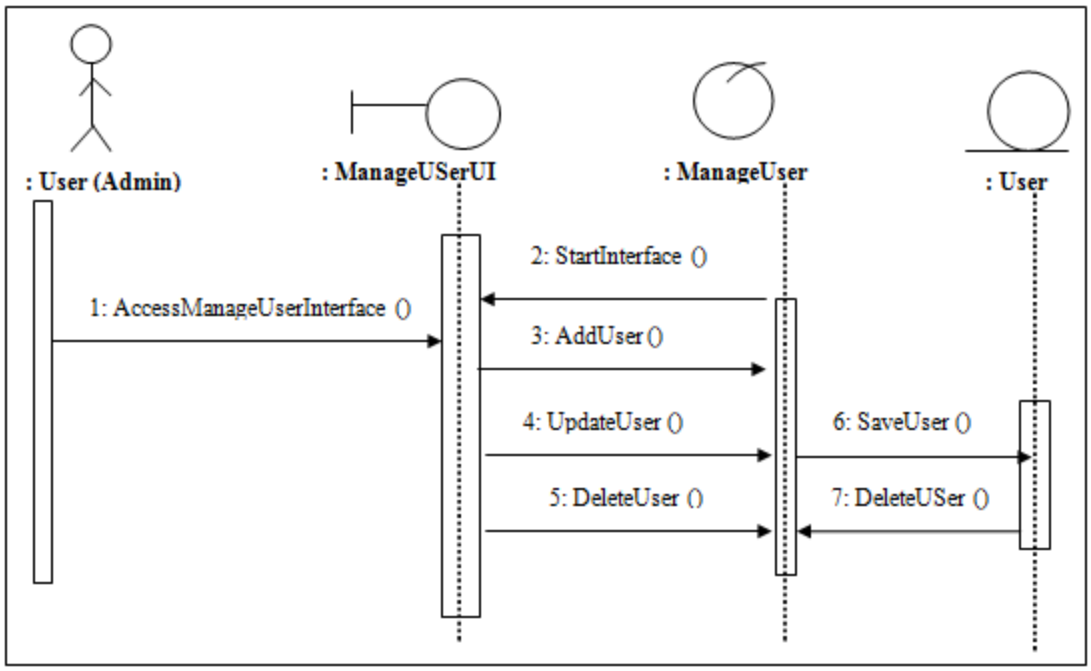


Figure 3.14: Manage User Sequence Diagram

Notifications

Notifications in the proposed system will be exchanged between users. The sequence of events in the exchange of the notifications is shown by the interactions between the objects indicated by the annotated arrows in fig. 35 below.

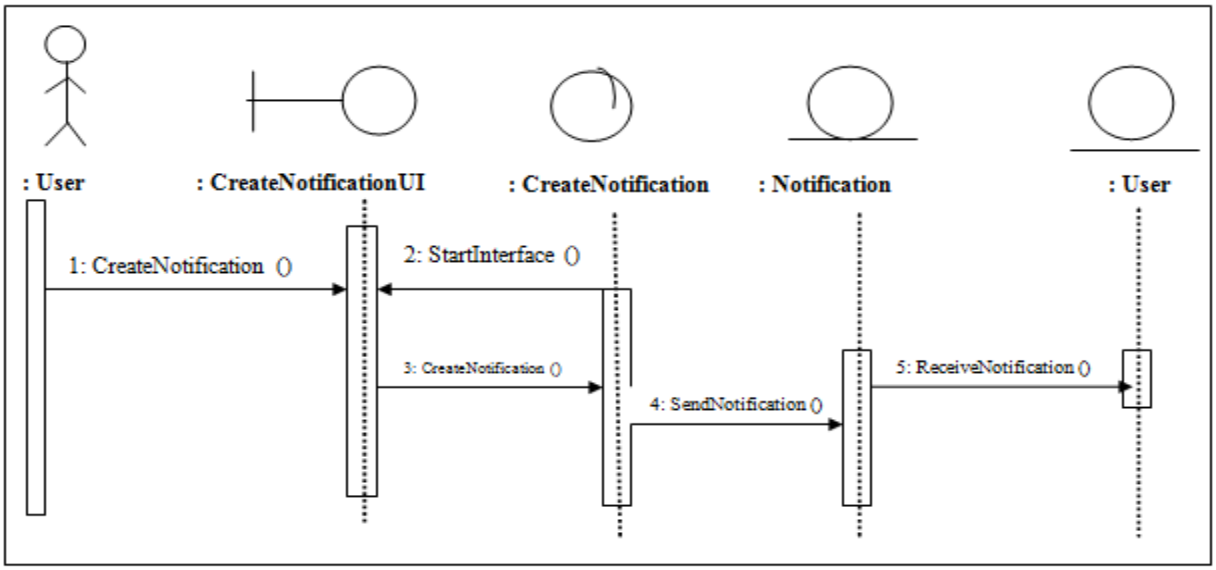


Figure 3.15: Notifications Sequence Diagram

View Data

Various users of the system will be required to view the data i.e. registration details and examinations results at various levels. In the view data sequence diagram, the user gets into the system and starts the view data user interface. The control object lets the user select and view the required data. The user selects the data to be viewed according to the privileges assigned to them i.e. the system administrator can view all the data in the system nationwide while the EDM can view the data within the education division that he/she belongs to. Likewise the DEM can only view data within their district.

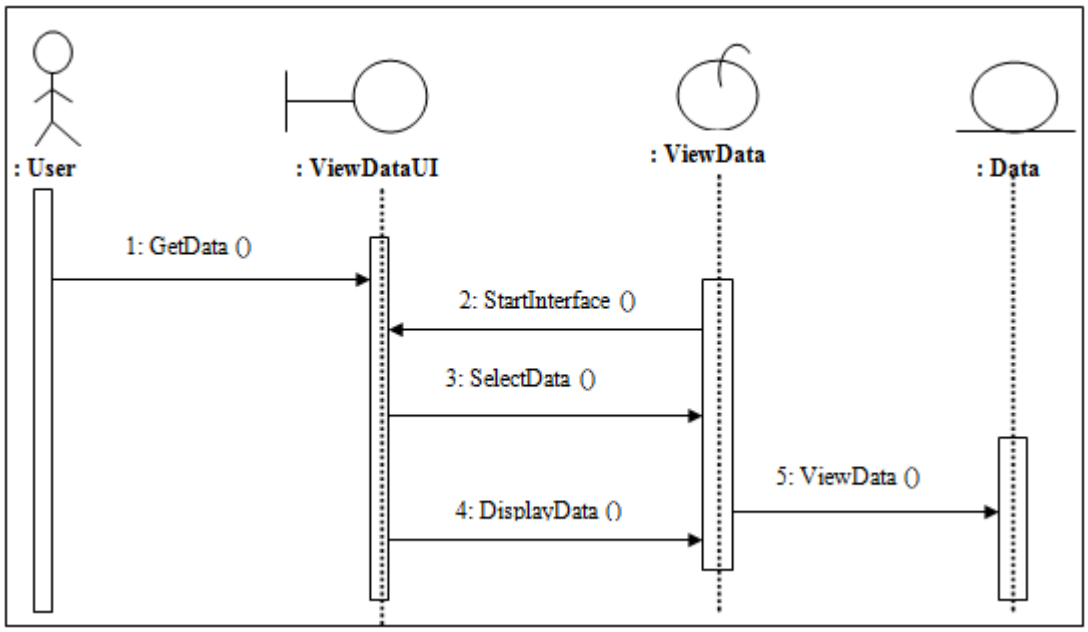


Figure 3.16: View Data Sequence Diagram

Register Details

Candidates will be registering for examinations using mobile SMS or USSD. The registration details will be saved in the database deployed within the cloud. The control object enables the candidate compose and sends the SMS using the mobile registration interface. The SMSs go through the mobile service operator's gateway to the cloud database.

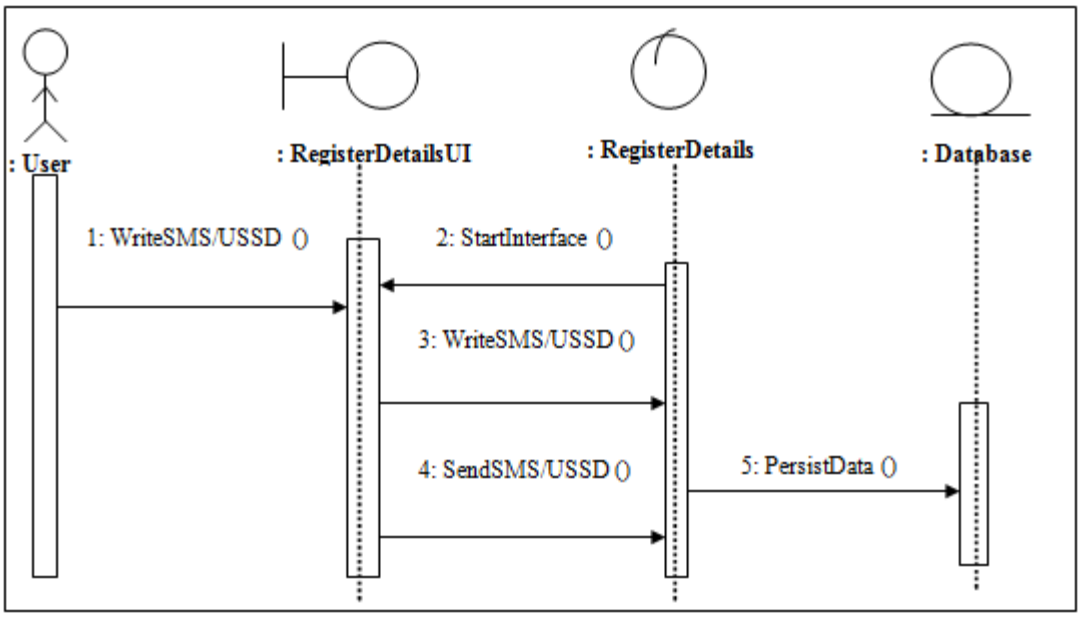


Figure 3.17: Register Details Sequence Diagrams

Print Registration Card

When registration period is over, every candidate will have their registration card with barcodes containing registration numbers. The cards will be produced by the Administrator. The print registration card interface will be made available to the user through the print registration card control object. The user will then get the registration card details and print.

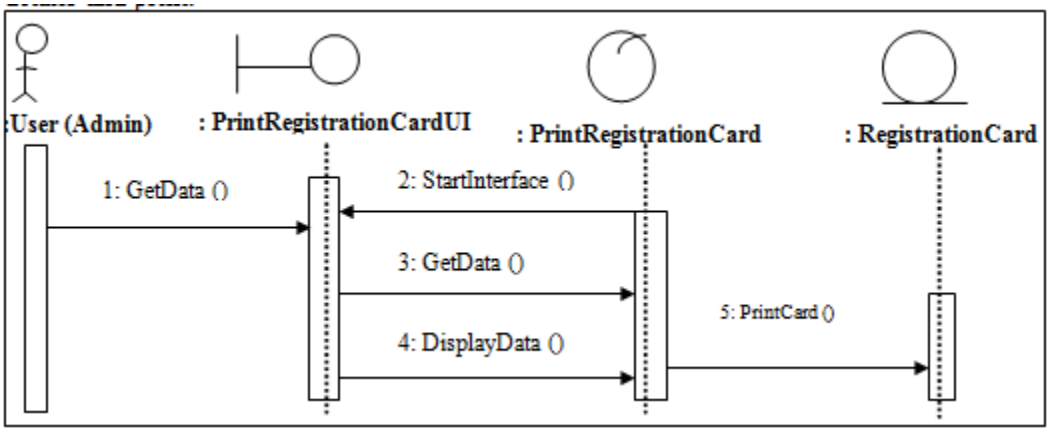


Figure 3.18: Print Registration Card Sequence Diagram

Amend Details

When candidates register their details, the system at some point will broadcast the registration details to candidates' mobile phones in form of SMSs for the candidates to verify their details before the closure of registration period. In an event of anomalies, the affected candidate goes to his/her examinations center to have their details amended by the teacher responsible for registration of candidates. The amendment will be done using mobile phone as well. The amend details user interface will be started and then the control object will be instantiated. The teacher retrieves the candidate's details, have them amended and saved.

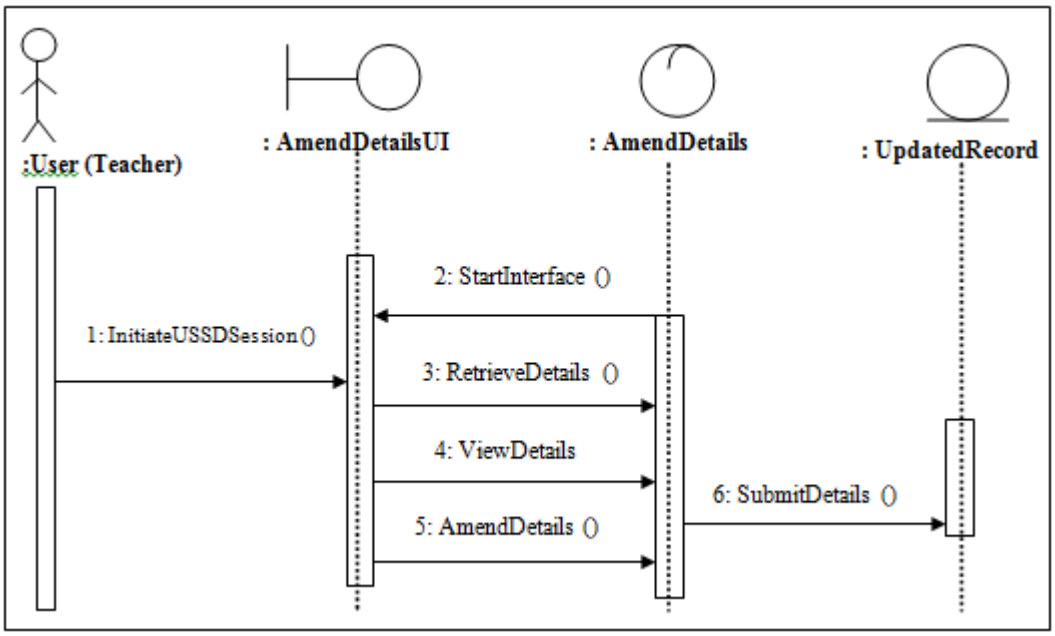


Figure 3.19: Amend Detail Sequence Diagram

Send and Receive Data

Candidates will have to receive their registration details for verification through their mobile phones. Examinations results will also have to be broadcast to candidates' mobile phones. The data comes from the system generated by the system administrator. When the control object is instantiated, the send data interface is started so that the administrator sends the data. The user entity receives the data at the other end.

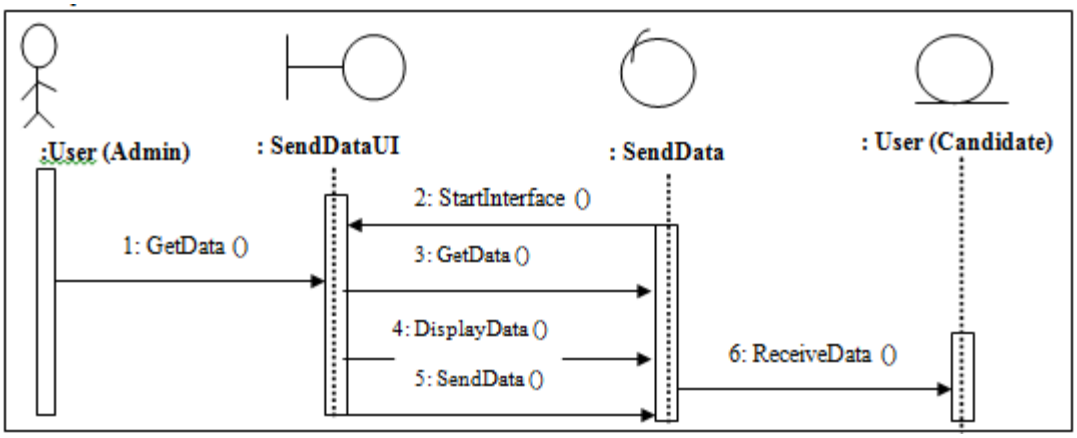


Figure 3.20: Send and Receive Data Sequence Diagram

Print Report

Different categories of reports will be generated from the system by different users at different levels. The user will have to select the report type to be generated. The control object will be instantiated and the generate report user interface will be started. The control object will then ask the boundary object to display the created report. The control object will finally execute the generate report action.

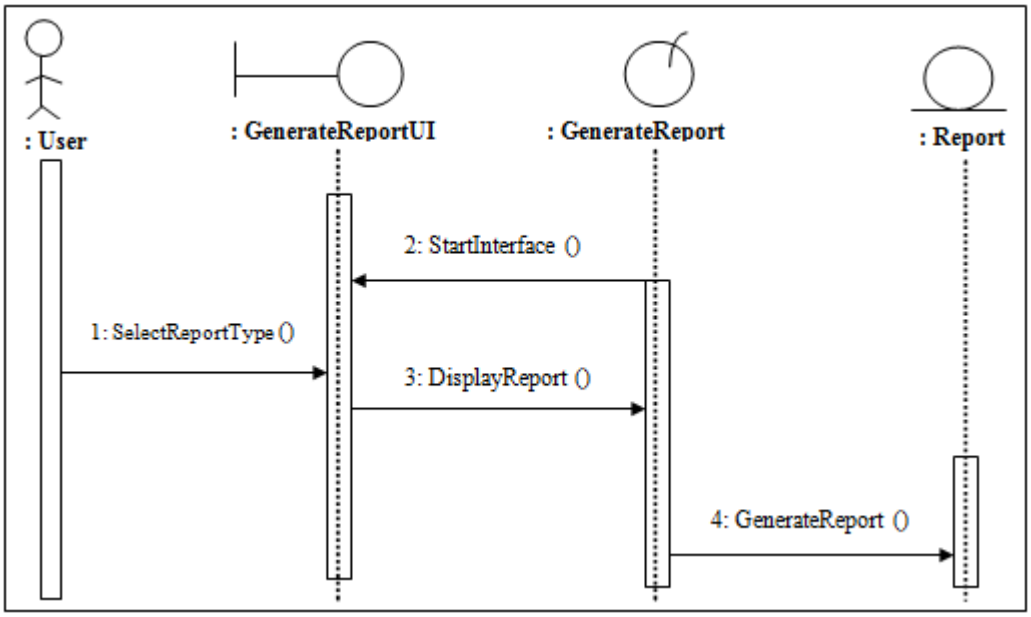


Figure 3.21: Print Report Sequence Diagram

3.3.5.3 Class Diagram

The class diagram shows a collection of classes, interfaces, associations, collaborations and constraints. Class diagram is also known as a structural diagram because it describes what must be present in the system being modeled. A class diagram is at the heart of UML as it represents the core purposes of UML by separating the design elements from the coding of the system. Class diagram is basically a graphical representation of the static view of the system and represents different aspects of the application hence a collection of class diagrams represents the whole system.

The purpose of class diagram is to model the static view of an application. It is used for analysis and design of the static view of the application, describing responsibilities of the system, used as a base for component and deployment diagrams and also for forward and reverse engineering.

A class is a general concept; an object class can be a general definition of one kind of system object. An association is a link between classes that shows that there is a relationship between these classes. Objects represent something in a real world i.e. individual, building, transaction etc. The figure below shows the objects identified in the proposed system.

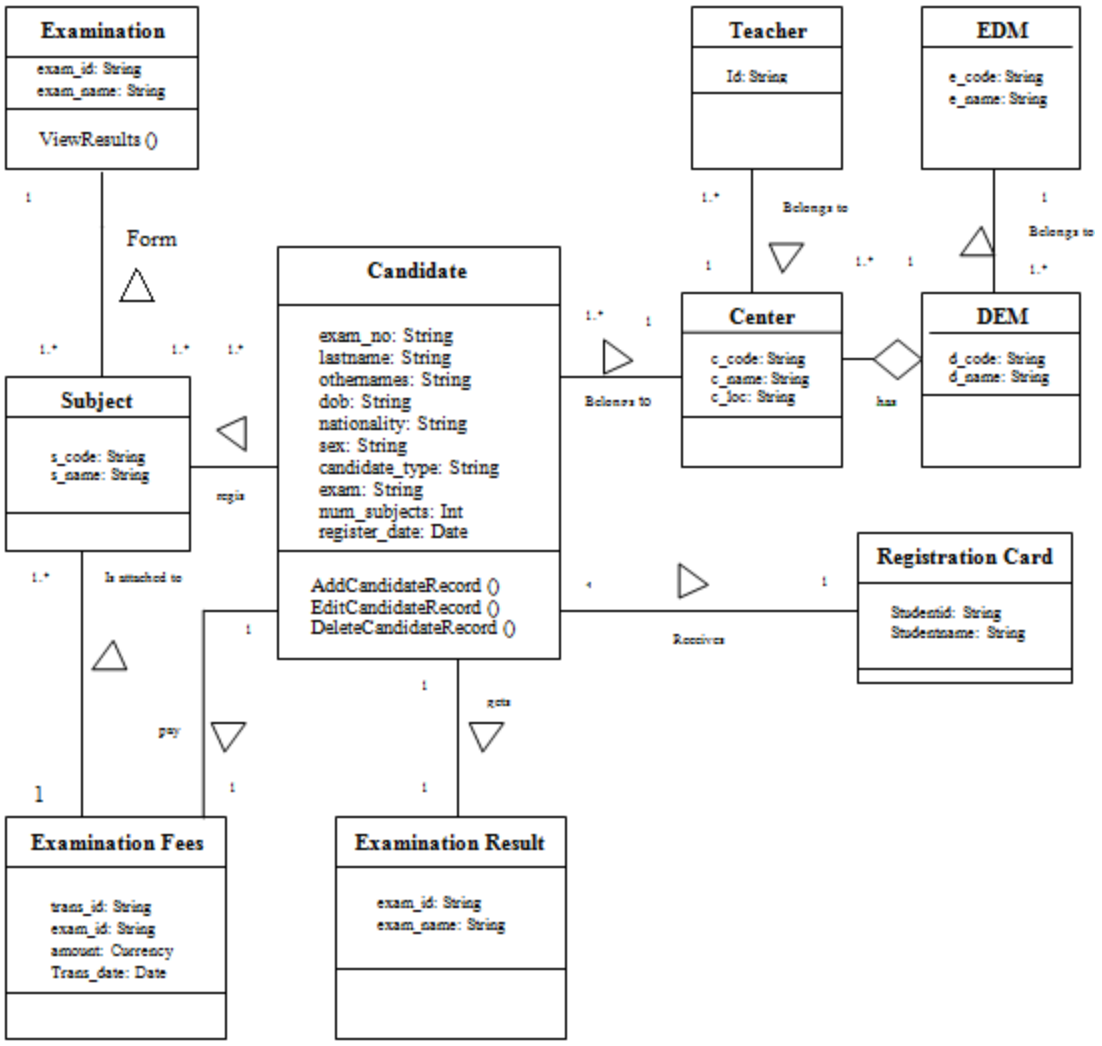


Figure 3.22: Class Diagram for the Proposed System

3.3.5.4 Data Models

Modeling of data strives to provide a representation of user reality by ignoring some of the complexity of the real world. An Entity Relationship Diagram (ERD) is a visual representation of different data using conventions that describe how these data are related to each other. In other words, it is a type of flowchart that illustrates how entities such as people, objects or concepts relate to each other within a system. ER diagrams are most often used to design or debug relational databases in the fields of software engineering, business information systems,

education and research [147]. ER models mirror grammatical structure, with entities as nouns and relationships as verbs.

ER diagrams are composed of entities, relationships and attributes. They also depict cardinality which defines relationships in terms of numbers. An entity is a definable thing such as a person, object, concept or event that can have data stored about it. An entity key refers to an attribute that uniquely defines an entity in an entity set. Relationships define how entities act upon each other or are associated with each other. They are typically shown as diamonds or labels directly on the connecting lines. An attribute is a property or a characteristic of an entity. Cardinality in ERD defines the numerical attributes of the relationship between two entities or entity set. It can be one-to-one, one-to-many, or many-to-many. Figure 44 below shows the ERD for the proposed system.

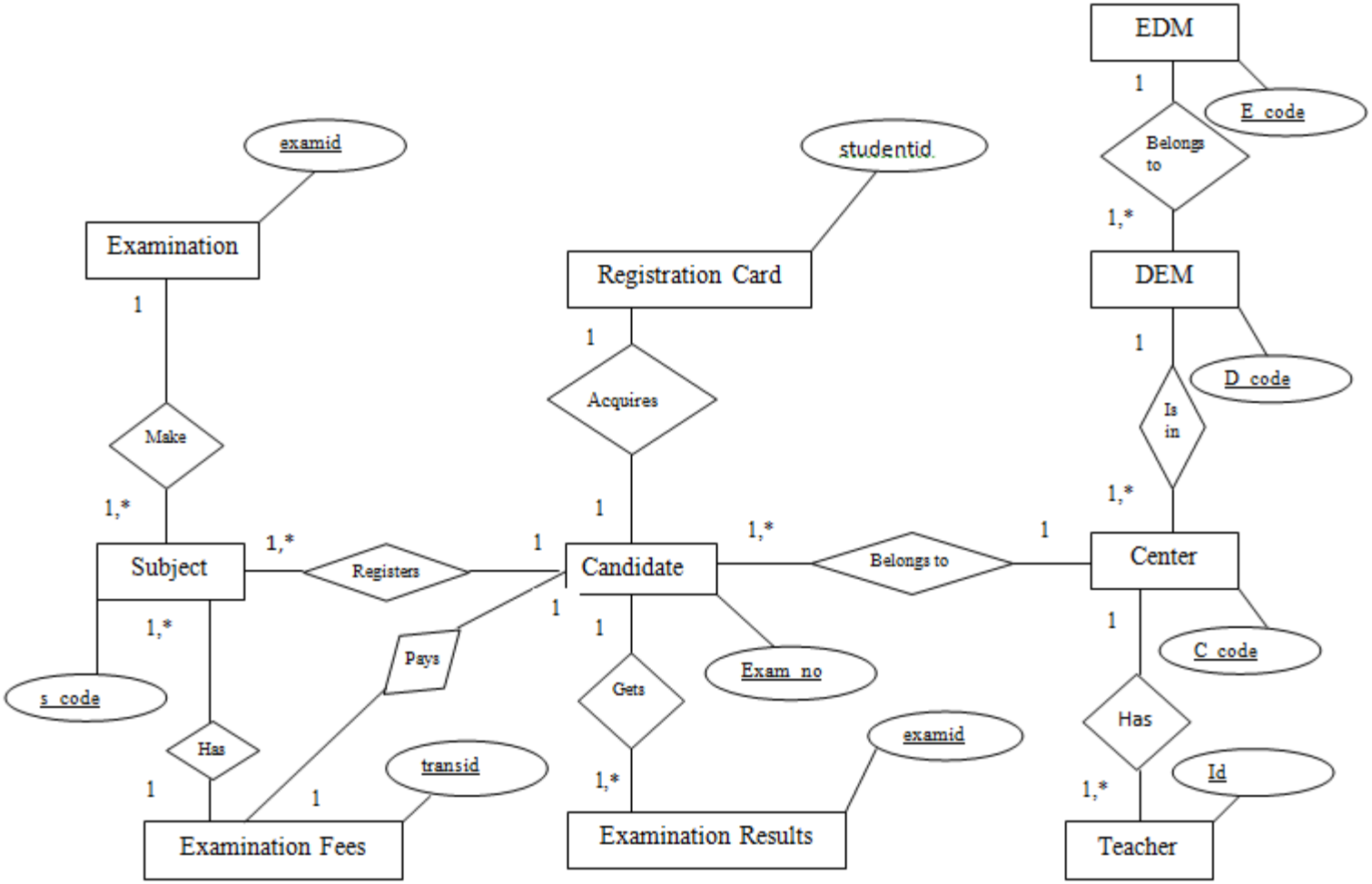


Figure 3.23: Entity Relational Diagram for the Proposed System

As part of data modeling, the relational database schema for the proposed system is presented. A relation is a table with columns and rows. Columns possess names of attributes while rows contain the records of the relation. A relational database schema is an outline of how the database is logically built. The following table shows the relations that form the relational database for the proposed system.

CANDIDATE		
Attribute	**Description**	**Datatype**
exam_no	Examination number of a candidate	Variable-Length Character
nrc_no	National registration card number	Variable-Length Character
lastname	Candidate surname	Variable-Length Character
othernames	Candidate names	Variable-Length Character
dob	Candidate date of birth	Date
nationality	Nationality of a candidate	Variable-Length Character
sex	Gender of a candidate	Variable-Length Character
candidate_type	Either internal or external candidate	Variable-Length Character
exam	Type of examination a candidate registers for i.e. PSLCE, JCE, MSCE	Variable-Length Character
num_subjects	Number of subjects a candidate registers for	Integer
subjects	Names of subjects registered	Variable-Length Character
reg_date	Date of registration	Date
sn_status	Special needs status	Variable-Length Character
CENTER		
Attribute	**Description**	**Datatype**
c_num	Center number	Variable-Length Character
c_name	Name of center	Variable-Length Character

c_loc	Location of center	Variable-Length Character
DEM		
Attribute	**Description**	**Datatype**
d_code	District code	Variable-Length Character
d_name	District name	Variable-Length Character
EDM		
Attribute	**Description**	**Datatype**
e_code	Education division code	Variable-Length Character
e_name	Education division name	Variable-Length Character
TEACHER		
Attribute	**Description**	**Datatype**
t_id	Teacher ID	Variable-Length Character
t_name	Teacher name	Variable-Length Character
SUBJECT		
Attribute	**Description**	**Datatype**
s_code	Subject code	Variable-Length Character
s_name	Subject name	Variable-Length Character
s_state	Nature of subject. Whether compulsory or not	Variable-Length Character
EXAMINATION		
Attribute	**Description**	**Datatype**
exam_id	Examination unique code	Variable-Length Character
exam_name	Name of examination	Variable-Length Character
EXAMINATION FEES		
Attribute	**Description**	**Datatype**
trans_id	Transaction ID	Variable-Length Character
Exam_no	Examination number of candidate paying the fees	
exam_id	Examination unique code	Variable-Length Character
amount	Fees amount paid	Currency

trans_date	Date of transaction	Date
EXAMINATION RESULT		
Attribute	**Description**	**Datatype**
exam_id	Examination unique code	Variable-Length Character
exam_name	Name of examination	Variable-Length Character
Exam_no	Examination number of a candidate	Variable-Length Character
grades	Candidate scores in the examination	Variable-Length Character
SPECIAL NEEDS		
Attribute	**Description**	**Datatype**
sn_id	Unique ID of status	Variable-Length Character
sn_name	Name of special need status	Variable-Length Character

Table 3.18: Database schema for the proposed system

3.3.6 System Implementation

The system prototype user application for administration of national examinations was developed using Hypertext Preprocessor (PHP) scripting language. PHP is a script language and interpreter that is freely available. Like Microsoft's ASP (Active Server Pages), the PHP script is embedded within a web page along with its Hypertext Markup Language (HTML). Before the page is sent to a user that has requested it, the web server calls PHP to interpret and perform the operations called for in the PHP script. HTML is used in the development of the prototype because though the proposed system is SMS and USSD based, it has web based interface for some of the users i.e. system administrator, EDM and DEM.

JavaScript was also used in the development to add some functions (behavior) to the system. JavaScript is a lightweight, interpreted, object-oriented language with first class functions, and is best known as scripting language for web pages. JavaScript runs on the client side of the web, which can be used to design/ program how the web pages behave on the occurrence of an event. In the prototype, JavaScript was used for functions like acknowledgement of a successful

transaction, confirmation of some transactions like deletion of a record etc. A Cascading Style Sheet (CSS) is a web page derived from multiple sources with a defined order of precedence where the definitions of any style element conflict. CSS gives more control over the appearance of a web page to the page creator than to the browser designer or the viewer. When a browser reads a style sheet, it will format the HTML document according to the information in the style sheet.

The prototype was developed using Mysql for data storage. Mysql is a database system used on the web and it runs on a server. It can be used for both small and large applications. It is a relational database and it uses a standard Structured Query Language (SQL) to manipulate its data. It is an open source database engine which is developed, distributed, and supported by Oracle Corporation. Mysql runs on virtually all platforms including Linux, Unix, and Windows. Although it can be used in a wide range of applications, Mysql is most often associated with web-based applications and online publishing.

Web based applications need a Web server to run. A Web server is a program that uses HTTP (Hypertext Transfer Protocol) to serve the files that form web pages to users, in response to their requests, which are forwarded by their computers' HTTP clients. Web servers often come as part of a larger package of internet- and intranet related programs for serving email, downloading requests for File Transfer Protocol (FTP) files, and building and publishing Web pages. The prototype uses Apache Web server which is a freely available Web server that is distributed under an open source license. According to a survey, 60% of all web sites on the Internet are using Apache, making Apache more likely used than all other web servers combined.

Candidates will be registering for examinations as well as receiving examinations results through SMS or USSD hence a gateway will be required for transmission. A gateway allows a computer to send or receive SMS or USSD transmissions to or from a telecommunications network. Most messages are eventually routed into the mobile phone network. A gateway is a website that allows users to send messages from a web browser to people within a cell served by that gateway. Gateways solve a common telecommunications problem that of different wireless telephony providers using different or proprietary communication protocols. The gateway acts as a relay, translating one protocol into another. Along with many commercial software products, open source SMS gateway software can be downloaded online.

3.4 Summary

This chapter has outlined the materials and methods that were utilized in the baseline study as well as the development of a prototype. A Mixed Methods Methodology was used in the research study. Purposive sampling was used for the selection of the sample during the baseline study. Use Case driven Object-Oriented System Development was used in the design and development of the prototype. The current business process that MANEB uses to register candidates for national examinations and dissemination of examinations results has been presented. The current processes were critically analyzed in order to model the proposed system.

CHAPTER FOUR

RESULTS

4.1 Introduction

The results that were got from the baseline study and the development of prototype are presented in this chapter. The baseline study was mainly to establish the challenges faced by MANEB when registering candidates for national examinations and dissemination of results. The proposed system strives to solve the challenges currently faced by MANEB.

4.2 Baseline Study

Results of the baseline study got after analyzing the key variables are shown in this section.

4.2.1 Demographic Data

Quantitative data was collected from 10 districts of Lilongwe, Mchinji, Dowa, Dedza and Salima in the central region and Blantyre, Chikwawa, Neno, Mwanza and Chiradzulu in the Southern region. Secondary schools were sampled within these districts for teachers and students questionnaires. Parents were also purposively selected from within the districts to respond to the parents' questionnaire. 2 schools were selected from each district (one from urban and the other from rural) giving a total of 20 schools. 2 students and 1 teacher from each school participated in the study while 2 parents (one from urban and the other from rural) also responded to the questionnaire. In total 40 students, 20 teachers and 20 parents participated in the baseline study. The schools were both public and private.

4.2.1.1 Gender of Parents

The data collected from the 20 parents showed that 8 (40%) were male while 12 (60%) were female meaning that more female parents participated in the survey than male parents.

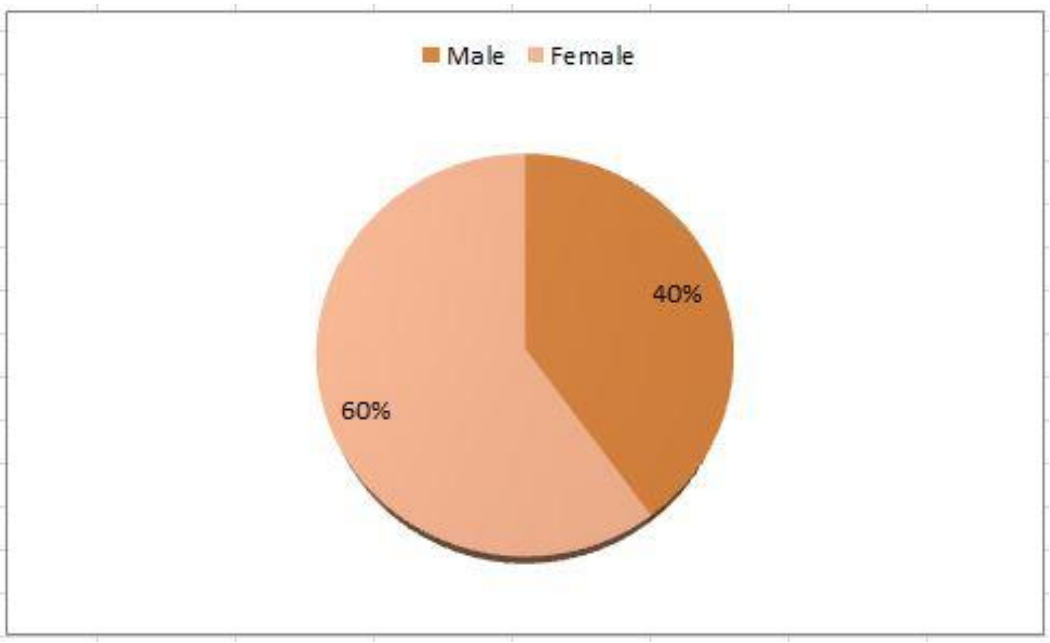


Figure 4.1: Gender of parent respondents

4.2.1.2 Locality of parents

9 out of the 20 parents that participated in the study live in the urban areas representing 45% whereas 11 of them live in the rural areas representing 55% as shown in the figure below.

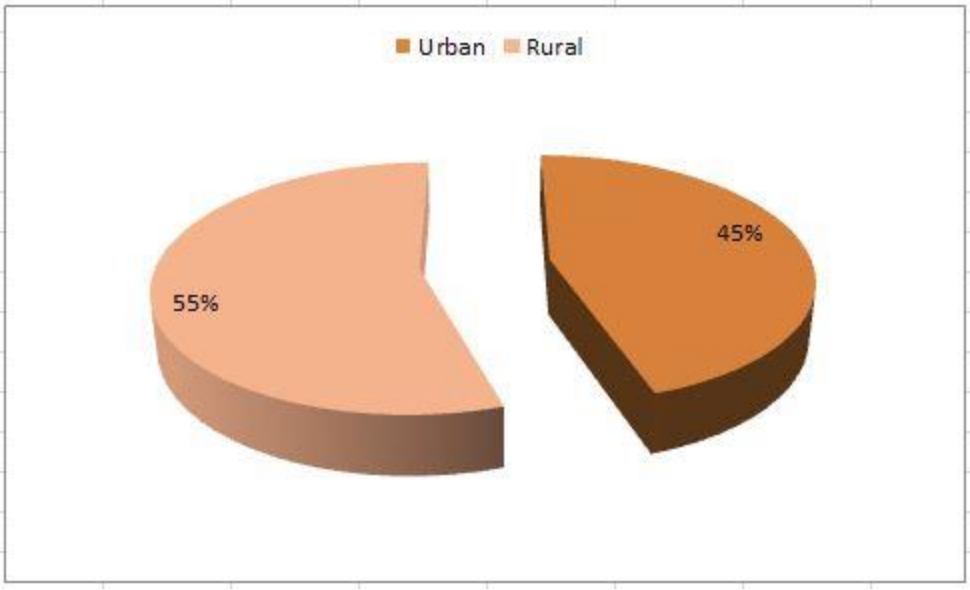


Figure 4.2: Location of parent respondents

4.2.1.3 Age of Parents

The parents were also of different age groups. As shown in the figure below, 3 parents (15%) were of the age range 26 – 35 years, 14 parents (70%) were of the age range 36 – 45 years and 3 parents (15%) were above 45 years.

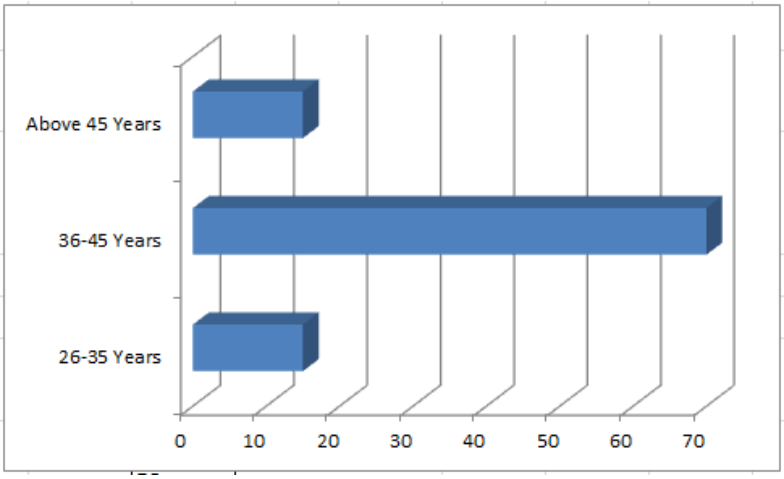


Figure 4.3: Age Group of Parents

4.2.1.4 School Type

The schools were sampled to be both public and private. Out of the 40 schools that were sampled, 28 which represents 70% were public (government owned) while 12 which represents 30% were private (owned by individuals). The following figure shows the school types.

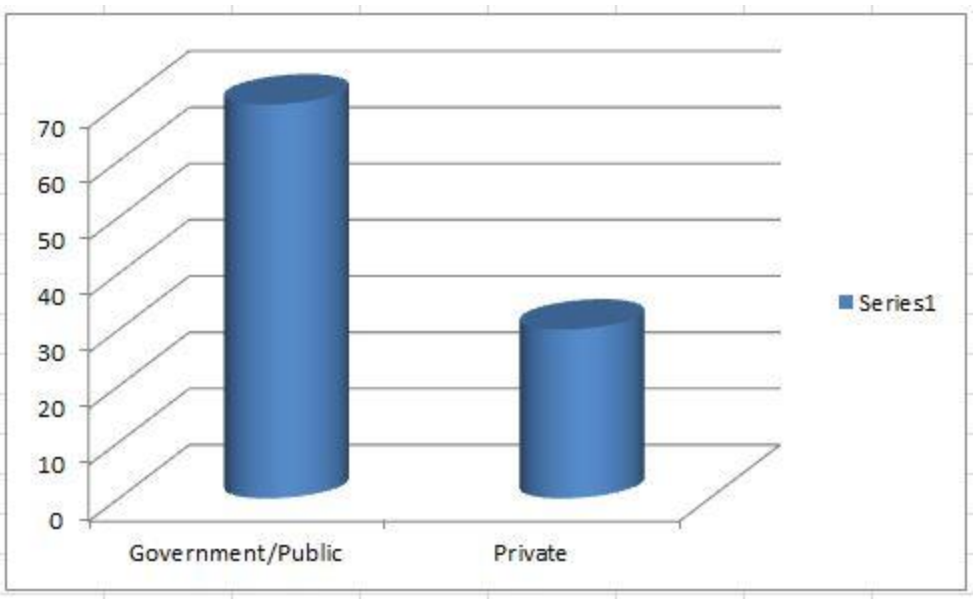


Figure 4.4: School Type

4.2.1.5 School Location

Just like the parents, the schools were also selected from both urban and rural areas. It was found out that 10 of the schools i.e. 50% were from the urban areas while the other 10 schools were sampled from the rural areas. The pie chart below shows the location of the schools that were involved in the study.

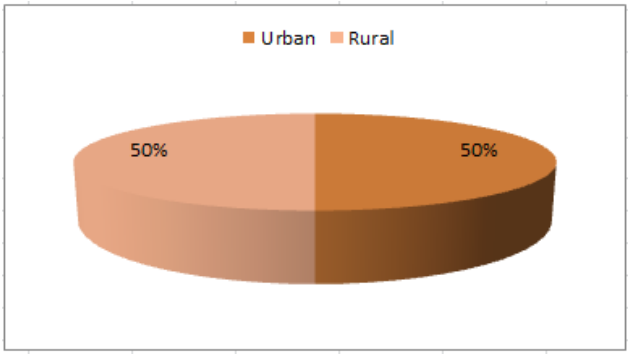


Figure 4.5: Location of Schools

4.2.1.6 Parents Qualification

The highest level of qualification for the parents was also sought from parent respondents. This was important in order to know if parents will be able to understand how to use the

proposed system. The bar chart below indicates that 4 of the 20 parents representing 20% had Junior Certificate of Education, 9 representing 45% had Malawi School Certificate of Education, 3 representing 15 % had College certificate and finally 4 which represents 20% had Diploma.

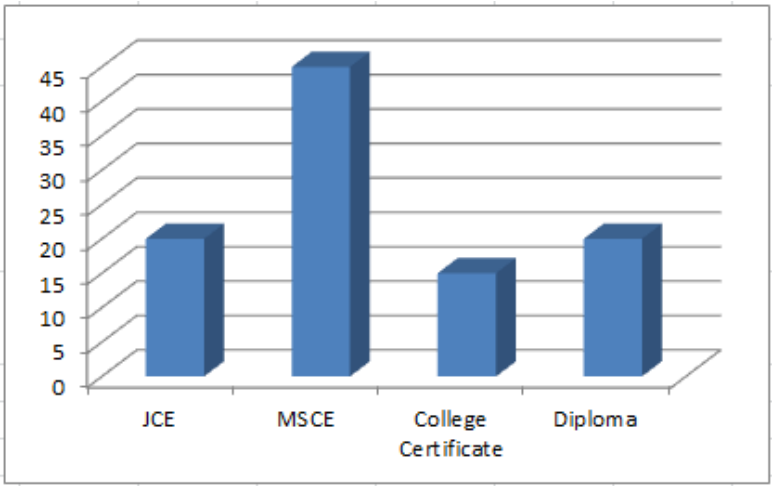


Figure 4.6: Level of Education of the Parents

4.2.1.7 Positions of Teachers in Schools

In schools, some teachers are assigned the duty of helping in the administration of national examinations that involves registration of candidates, handling and reporting of errors observed by candidates to the head teacher and also taking care of examinations results sheets and / or books. The chart below displays the various positions these teachers have in the selected schools.

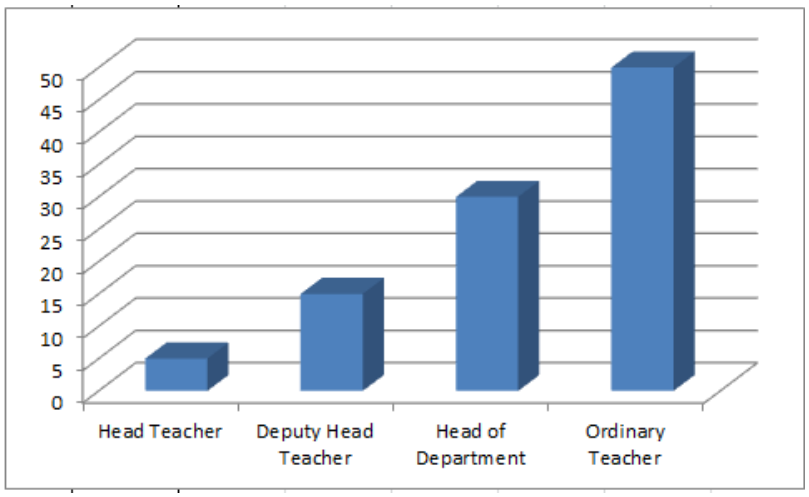


Figure 4.7: Positions of Teachers in Schools

4.2.1.8 Number of Students in National Examinations Classes

The number of students in classes that sit for national examinations i.e. forms two and four was again recorded. This was to help have an idea of how much work the teachers have in the various schools in as far as the administration of national examinations is concerned.

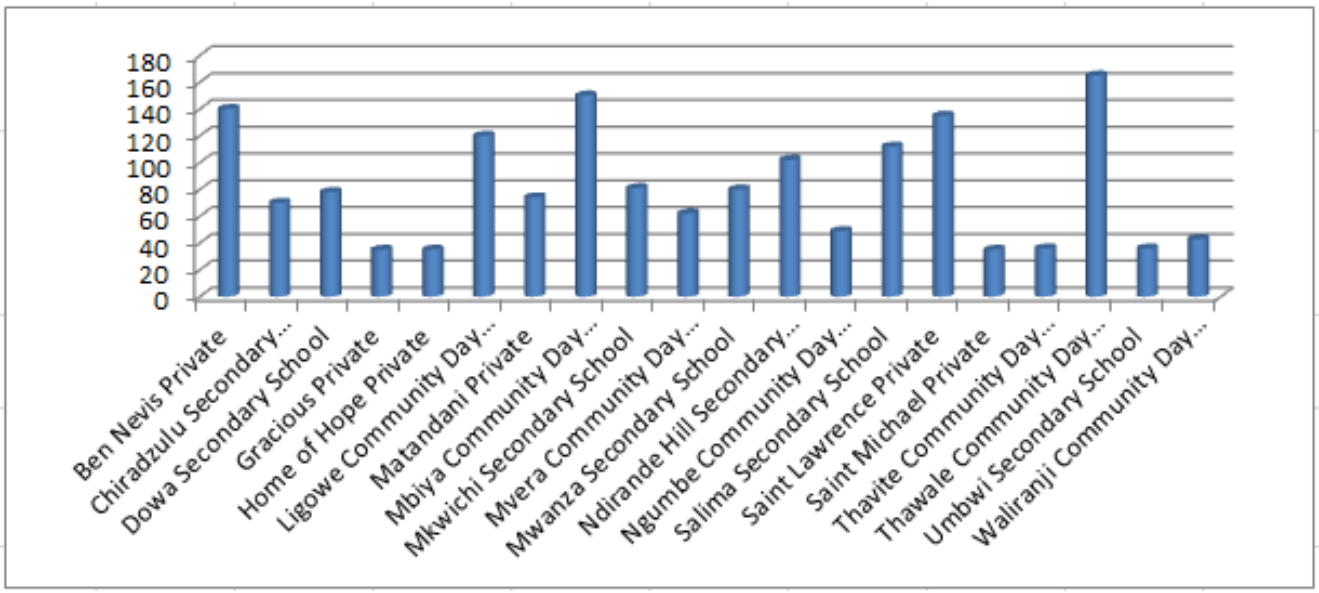


Figure 4.8: Number of Form Two Students in the Schools

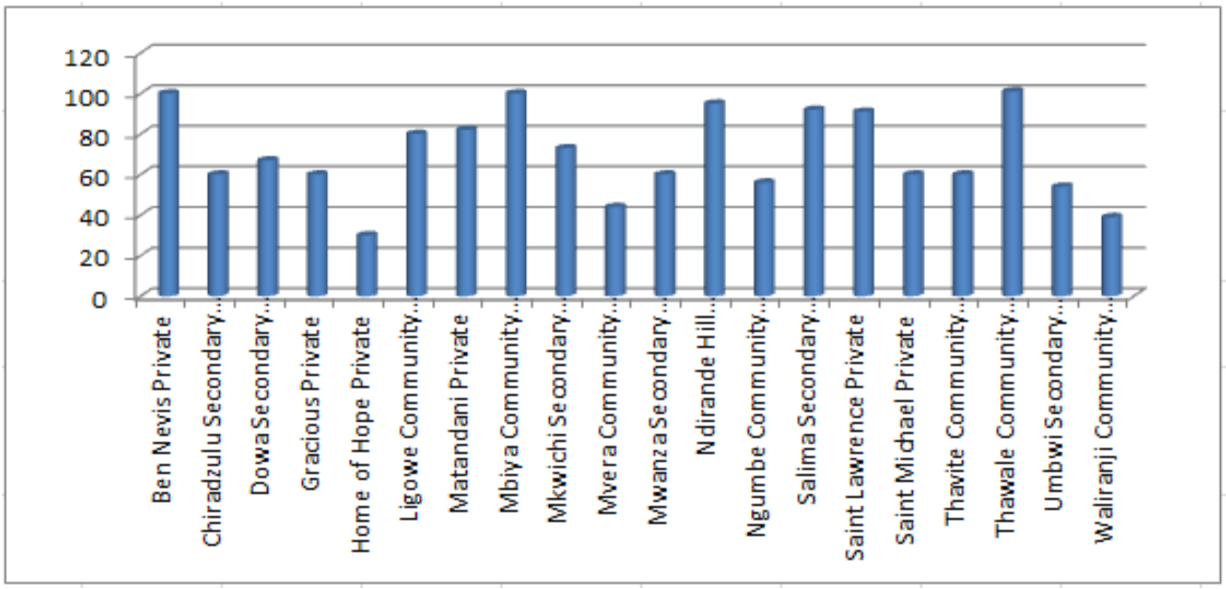


Figure 4.9: Number of Form Four Students in the Schools

4.2.2 Examinations Administration Procedures

This section of the chapter looks at the second objective of the study which was to comprehend the procedures that are followed when registering candidates for national examinations, verification of registration details and how the observed errors are dealt with as well as the dissemination of examinations results to candidates when marking and grading are finalized. It was noted that a number of transactions are done manually except that Microsoft Office packages like Word, Excel and Access are used to capture and manipulate data.

4.2.2.1 Parents' Rating of Registration Process

Parents were asked to rate the process of registering their children for national examinations as being very good, good, poor or bad. 20 % of the parents (n = 4) said that the process is very good. 25% (n = 5) indicated that it is good. 50% (n = 10) said the process is poor while 1 parent representing 5% labeled the system as bad. The figure below shows how the parents rated the current process of registration.

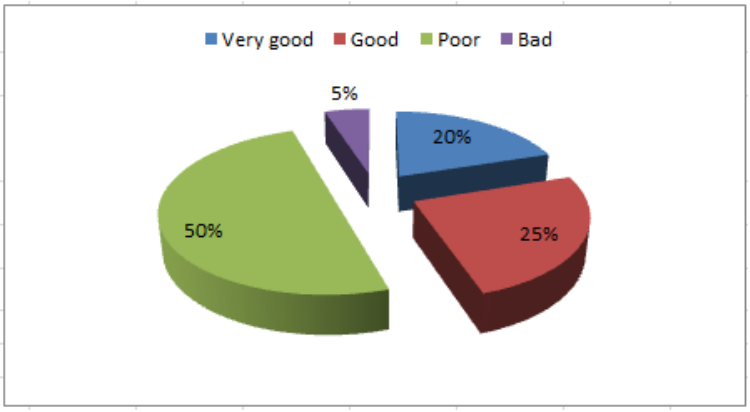


Figure 4.10: Parents Rating of the Current Registration Process

4.2.2.2 Learners' Rating of Registration Process

Learners in the sampled schools were also asked to rate the current registration process. Their responses were as shown in the figure below. 5% (n = 2) indicated that the current process is very good, 32.5% (n = 13) said it is good, 55% (n = 22) said it is poor while 7.5% (n = 3) labeled the current registration procedure as bad.

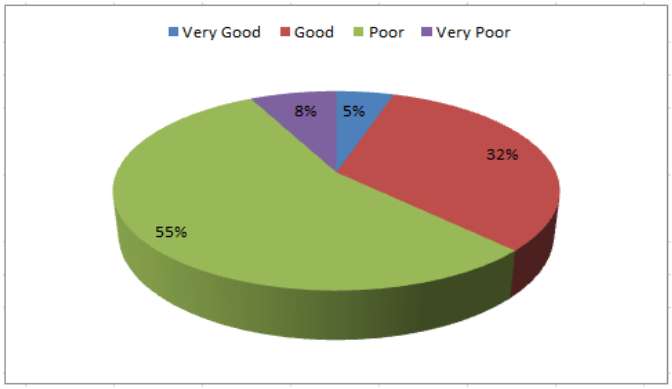


Figure 4.11: Students Rating of the Current Registration Process

4.2.2.3 Teachers views towards the reliability and effectiveness of the Registration, Verification and Results dissemination Processes

Teachers that are involved in the administration of national examinations in the schools were asked to rate the registration, verification and results dissemination procedures in terms of their reliability. For registration, 35% of the respondents said it is not reliable while another 35% said it is somewhat reliable. The remaining 30% percent indicated that it is reliable. For verification,

55% of the respondents said it is not reliable while 30% indicated that it is somewhat reliable. The remaining 15% said it is reliable. For results dissemination process, 60% indicated that it is not effective where as 40% said it is effective. The figures below display the results.

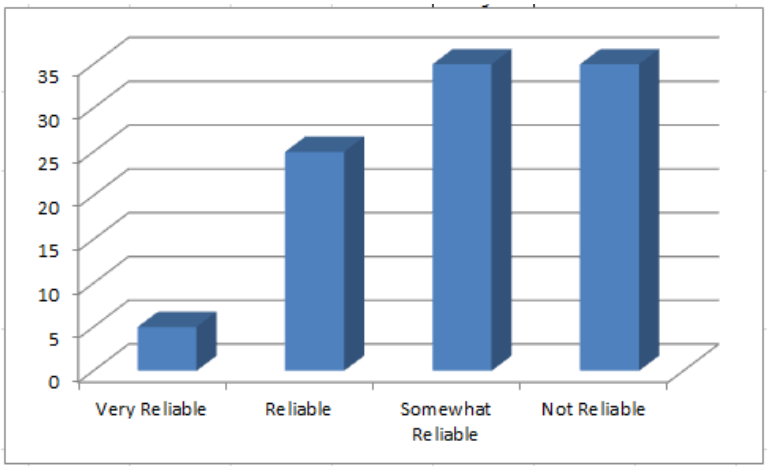


Figure 4.12: Reliability of Registration process

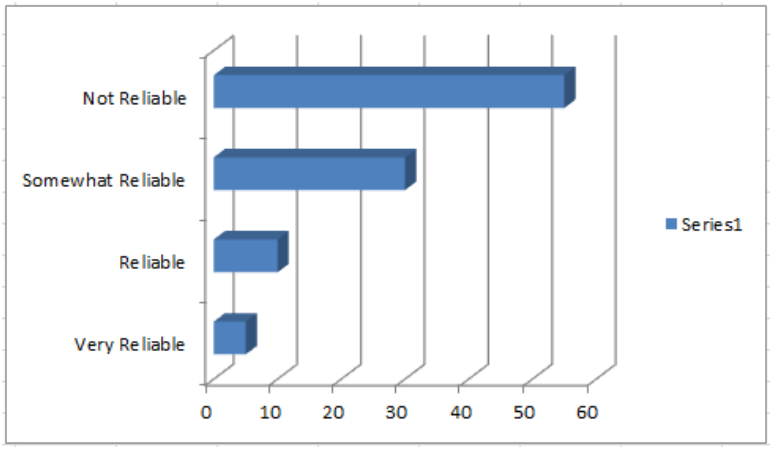


Figure 4.13: Reliability of Verification Process

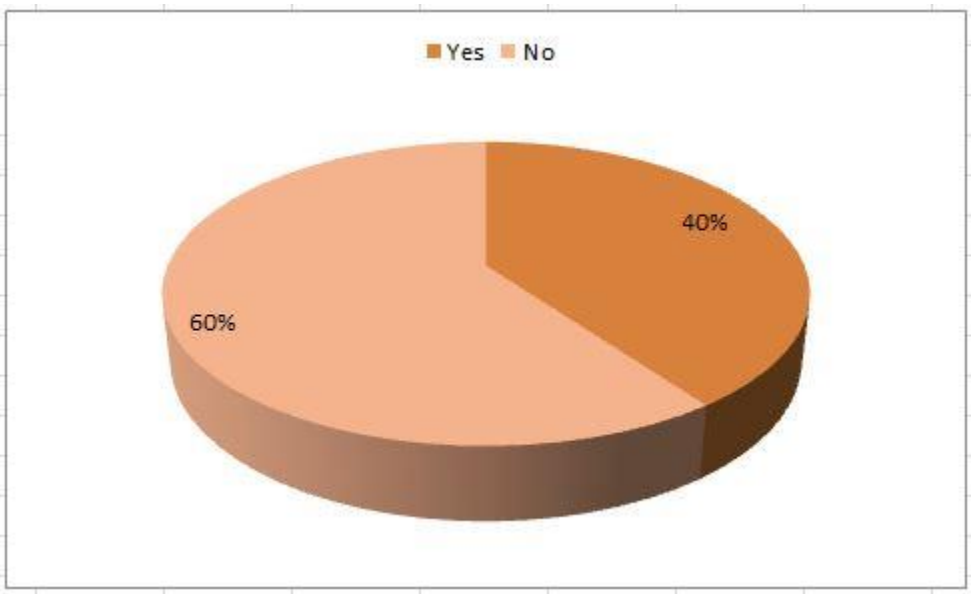


Figure 4.14: Effectiveness of Results Dissemination

4.2.2.4 Time to Access Examinations Results

Parents were requested to tell as to how long it takes them to know examinations results of their children from the time they are released. When results are released, MANEB sends examinations results sheets or books to all the centers through the office of the DEM. Learners or their parents have to walk to the centers to access the results. Mostly, the centers do not receive their copies in time as a result the learners throng to the DEMs office or the Ministry of Education headquarters to check their results. The figure below shows that 25% of the respondents indicated that they accessed the results within a day, 55% said they got the results after some days, 10% got their results after some weeks and another 10% of the respondents said results were known after some months.

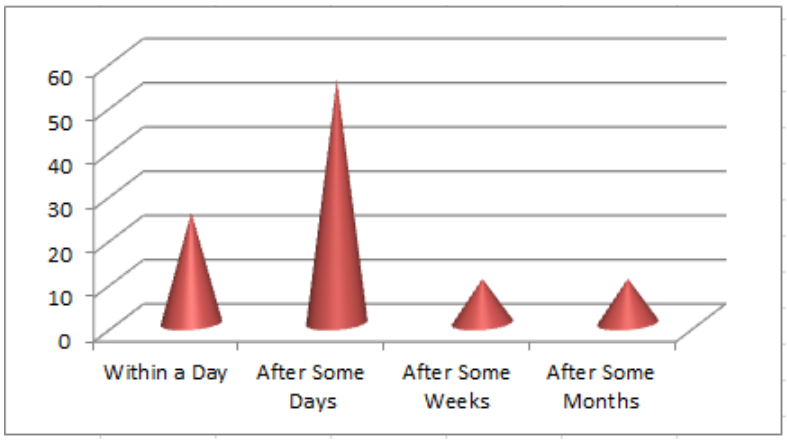


Figure 4.15: Duration of Accessing Results

4.2.2.5 Registration Challenges

During the baseline study, the teachers that are involved in handling affairs to do with national examinations were required to highlight some of the challenges that are faced when registering students for the national examinations. According to the responses, there are a number of challenges that make the administration of national examination a difficult task.

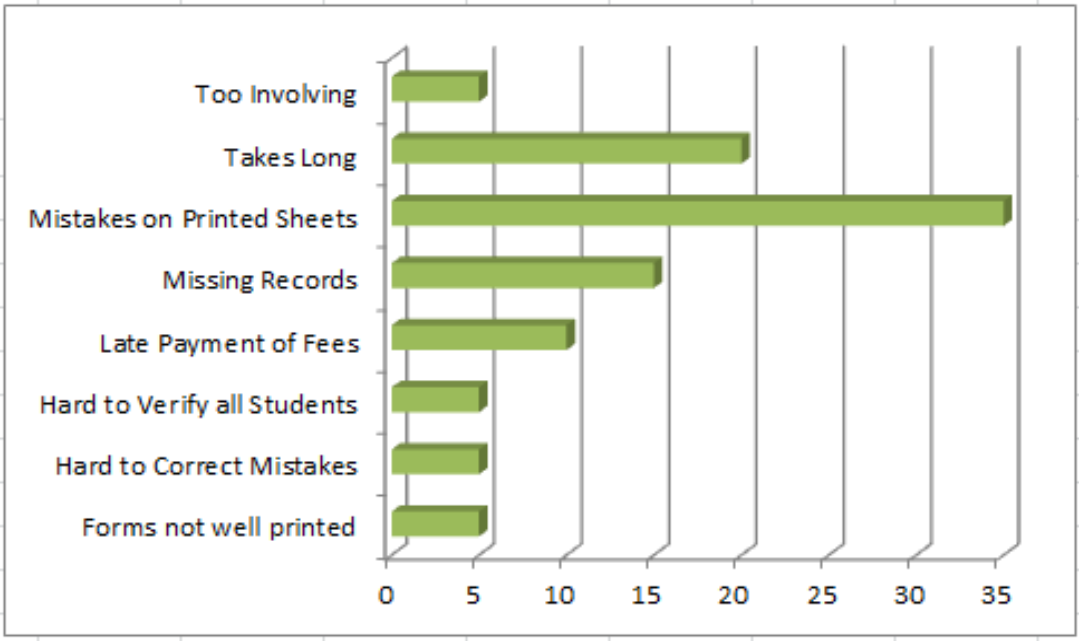


Figure 4.16: some of the challenges encountered

4.2.2.6 Candidates failure to write examinations due to registration challenges

Teachers who took part in the baseline study were asked to indicate if some students in the past failed to sit for national examinations because of irregularities in the process of registration, a thing that makes students repeat in such grades or at times drop out from school. Results showed that 12 out of the 20 respondents representing 60% indicated that some students had failed to sit for their examinations in the past due to registration anomalies, 4 respondents representing 20% said they had not experienced such phenomenon whereas 4 respondents representing another 20% said they were not sure. The figure below shows the results.

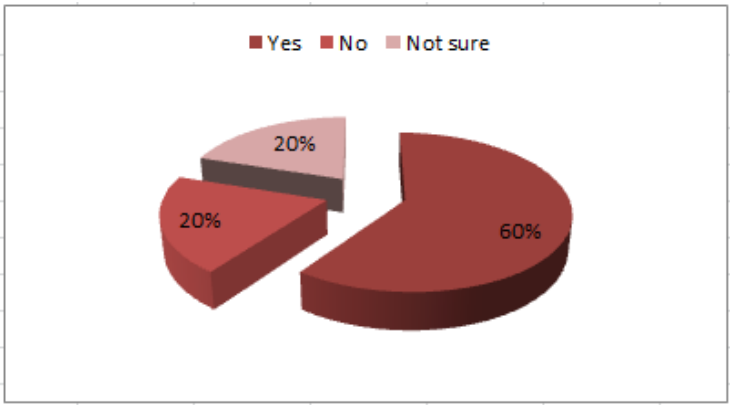


Figure 4.17: Candidates' failure to write examinations

4.2.3 Mobile Services

After the current processes of examinations administration were understood and associated challenges established, using mobile services i.e. SMS and USSD was thought to be the recommended solution that can solve the challenges. During the study, respondents were asked to provide some information about their possession and usage of mobile services. This helped to gauge the feasibility of introducing a mobile application as a solution to the challenges currently being faced.

4.2.3.1 Possession of Mobile Phone

Parents and students were asked whether they have mobile phones. All the 20 parents and 40 students who responded to the questionnaires indicated that they had cell phones. This was regardless of the locality (urban or rural) of the respondents. It was also observed that at least one member in each family had a cell phone. This shows that the penetration of mobile phones is

almost 100% meaning that every family with a candidate will be able to register them and receive information regarding registration details and examinations results using cell phones.

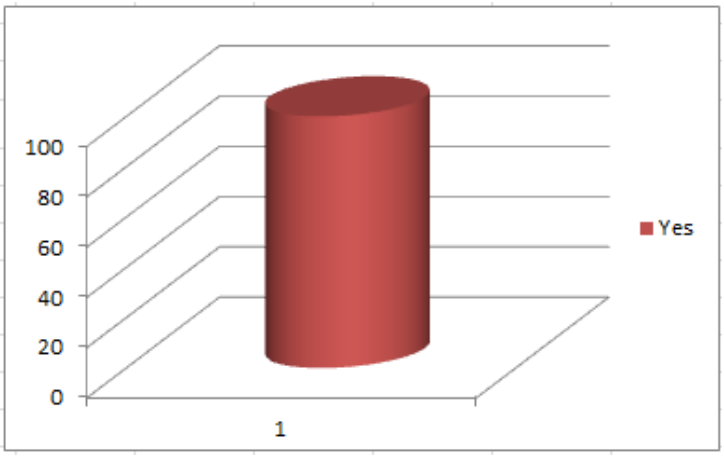


Figure 4.18: Possession of Mobile Phone

4.2.3.2 Ability to create and Read SMS

Apart from just having a mobile phone, the parents and students were also asked if they know how to write and read messages using a phone. Again all the respondents i.e. 100% indicated that they know how to write messages on the phone and read messages from the phone. This means that if the proposed system is implemented, parents/students will not be having problems registering their details for national examinations and also they will be able to open and read every message that they receive from MANEB. The chart below shows that all the respondents know how to create and read messages.

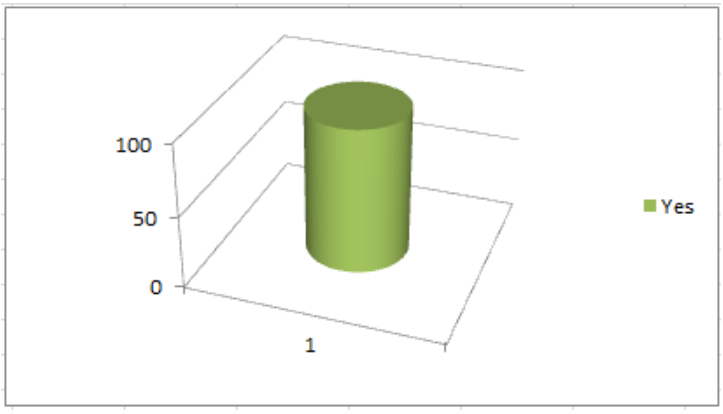


Figure 4.19: Ability to write and read messages

4.2.3.3 Availability of Mobile Service Network

To ensure people will be able to use mobile services in any location, respondents were asked to mention the mobile service provider that they use. It was found out that there is at least one telecommunications provider in each and every location regardless of whether it is urban or rural. The following figure indicates that 50% of the respondents indicated the availability of Airtel network while the other 50% said they use TNM (Telecom Networks Malawi). It is worth mentioning that other mobile network providers are also present in these areas but at lower magnitudes.

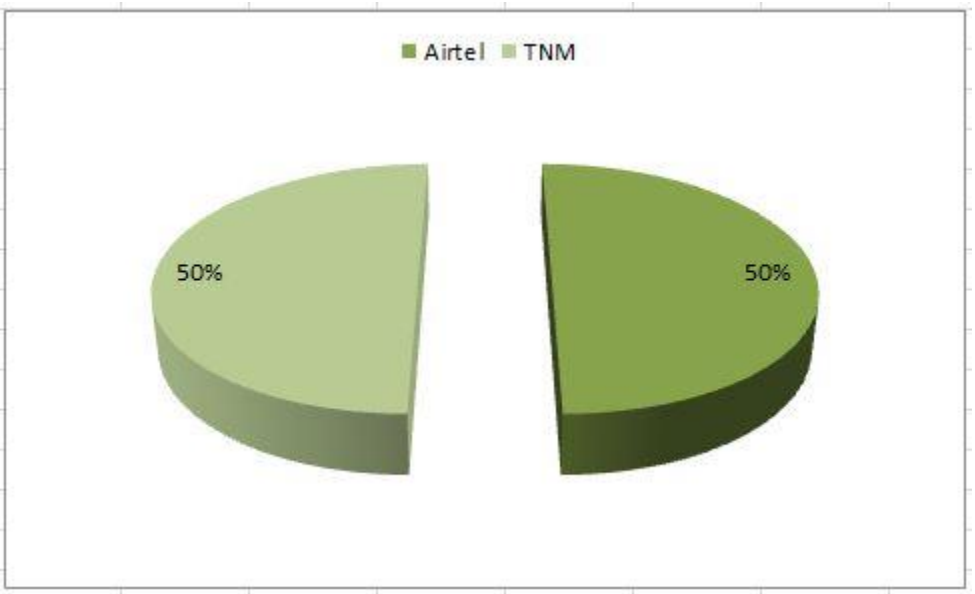


Figure 4.20: Availability of Mobile Service Provider

4.2.3.4 Members of the Family with Mobile Phones

During the study, parents were asked to indicate the number of family members who possessed mobile phones. This was done as a way of trying to ascertain that each family will be able to register their children using a cell phone so that the proposed system does not turn out to be a burden to some families that cannot afford to have a mobile phone. After analysis, it was found out that all the interviewed parents indicated that at least 2 members of their families had mobile phones as depicted in the following pie chart.

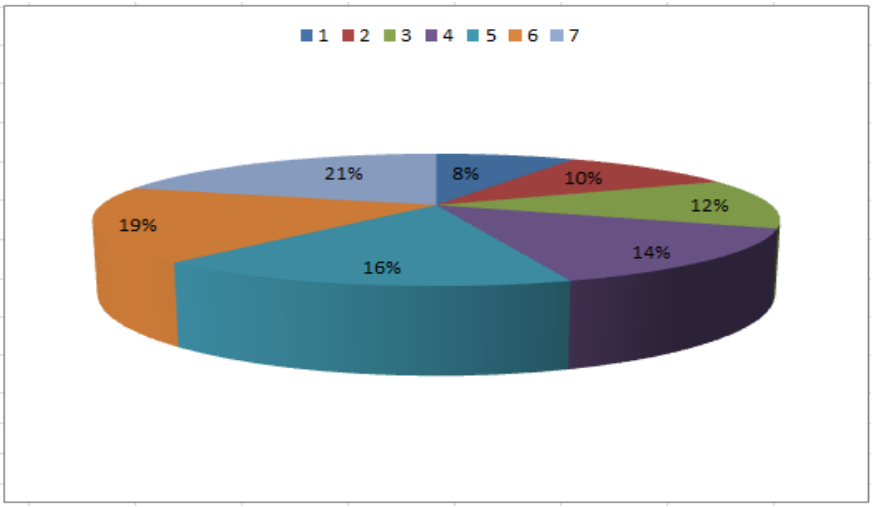


Figure 4.21: Family Members with Mobile Phones

4.2.3.5 Use of Mobile Money Services

Since payment of examinations fees forms part of the registration for national examinations, the proposed system aims at replacing the current practice of paying examinations fees through the school cashier or bursar with paying using mobile money services. Respondents (both students and parents) were asked if they had used mobile money services before and also to indicate the mobile money service providers that they have dealt with. 100% of the respondents said they had used mobile money services before. The bar chart below shows the mobile money providers that the respondents have dealt with.

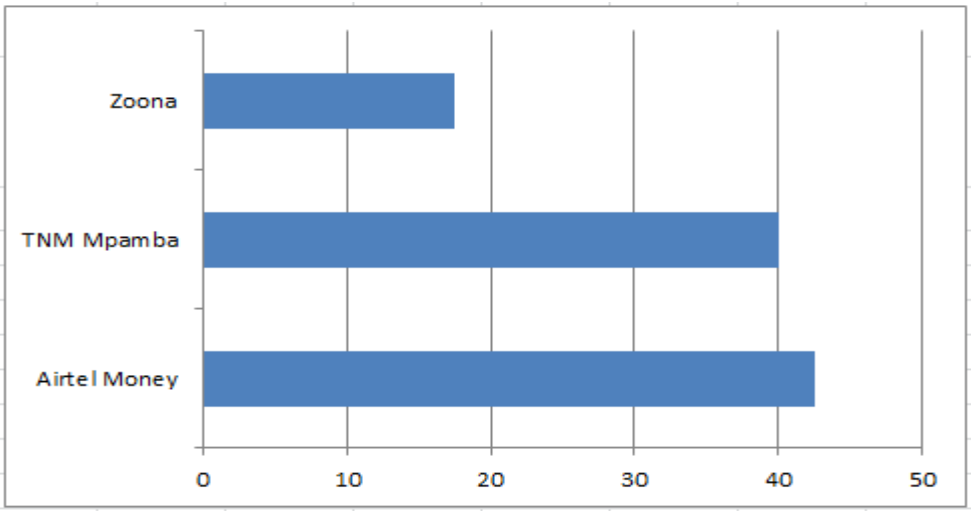


Figure 4.22: Mobile Money Service Providers

4.2.4 The Proposed System

This section of the chapter looks at the views of the different respondents on whether the introduction of the proposed system would be an ideal solution to the challenges currently experienced when registering candidates for national examinations, verifying candidates' registration details before actual writing of examinations as well as disseminating the examinations results after marking and grading.

The following figure shows the results of the students' views on the proposed system. 30 out of the 40 students representing 75% had the view that introduction of the SMS based system would really be a solution to the challenges, 2 out of the 40 representing 5% had the view that introducing the system would not solve the current challenges while 8 out of 40 representing 20% said they were not sure if the proposed system would at all solve the challenges being experienced.

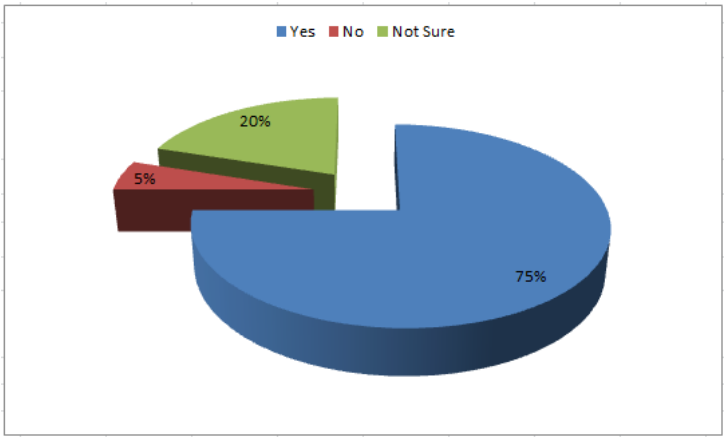


Figure 4.23: Students' perception of the proposed system

Parents also were asked to give their views on the introduction of the proposed system. Out of the 20 parents who were given the questionnaires to respond to, 17 (85%) said they felt introducing the system would be a solution to the current situation, 1 (5%) said the proposed system would not solve the situation and 2 (10%) said they were not sure. These results are shown in the figure below.

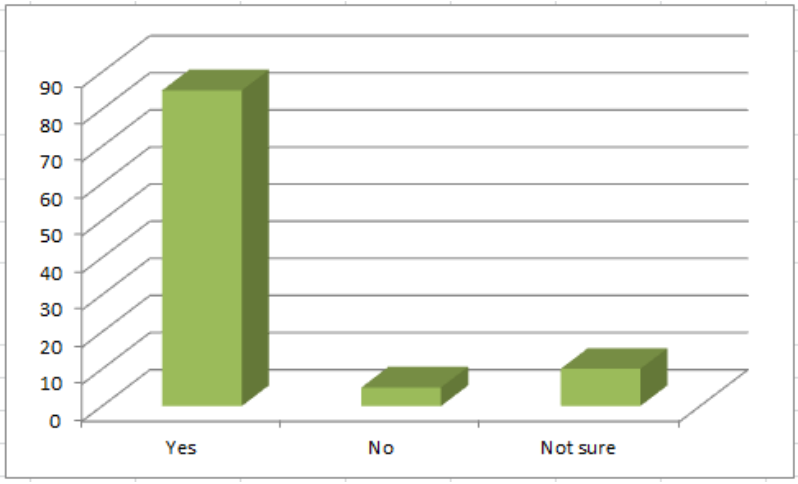


Figure 4.24: Parents' perception of the proposed system

Finally teachers were also requested to give their recommendations on the introduction of the mobile registration and dissemination of results as well as mobile payment of examinations fees. 18 out of the 20 respondents which represent 90% said yes while 2 of the 20 which is 10% indicated to be not sure.

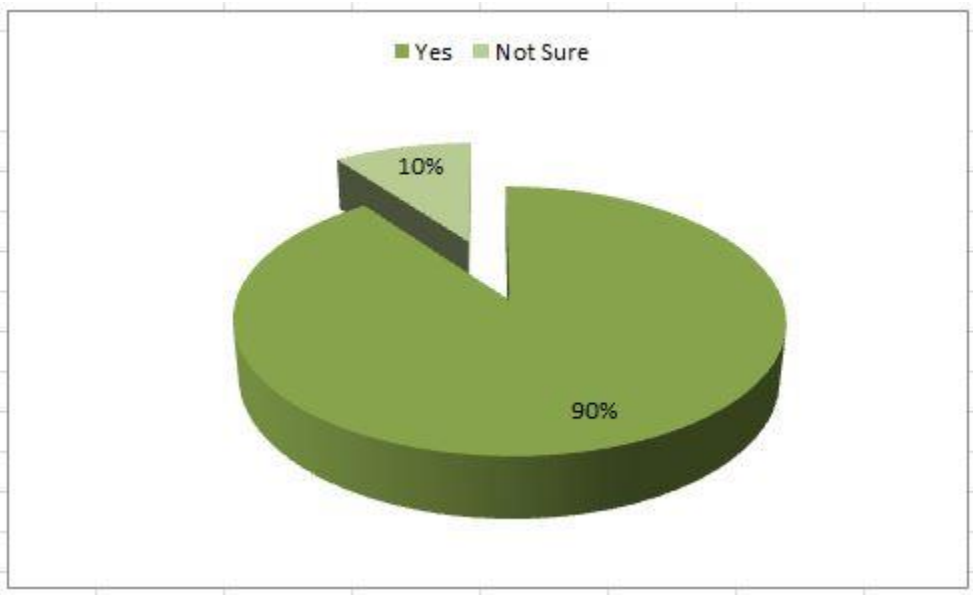


Figure 4.25: Teachers views on the proposed system

On whether introduction of mobile money services would be ideal to replace the current payment system that is through the school's cashier or bursar, teachers responses were as in the figure

below i.e. 17 out of the 20 respondents (85%) said yes while 3 out of the 20 (15%) indicated that they were not sure.

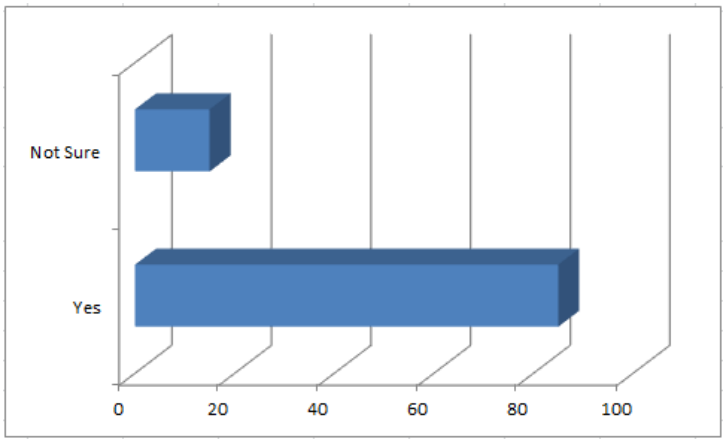


Figure 4.26: Teachers views on the mobile payment

4.3 System Implementation

The manual procedures of registering candidates and sending out of examinations results can be replaced with the automated system in order to eliminate the challenges that the current system brings about. A prototype was developed in a quest to show how an automated student registration and results dissemination system will operate. The system prototype is called Students Data Management System (SDMS) and it has two components; SMS/USSD and Web components. A SMS or USSD application requires a gateway which allows a computer to send or receive transactions to and from a telecommunications network. Usually, an individual or organization has to subscribe with a mobile service provider in order to be able to use their gateway, a thing that proved to be expensive to the researcher. As a result, a USSD simulator was developed that sends requests to the database in order to add candidates' registration records and retrieve both registration details and examinations results. The USSD simulator was developed using JAVA programming language. PHP functions were written to sit between the simulator and the database. These functions actually do accomplish the USSD functionality of the simulator to insert and retrieve data by reading the users' choices from the simulator and provide them with the functionality they require according to their choice.

The functionalities that were implemented in the prototype include sending registration records to the database using the USSD simulator, retrieving both registration records as well as

examinations results from the database using the USSD simulator, logging in to the web component of the system, managing (adding, updating and archiving) users, viewing registration and examinations data, uploading of examinations results, searching candidates, generation of registration cards with barcodes as well as logging out from the system.

4.3.1 USSD Simulator

With the simulator, a candidate firstly dials a mobile number that is assigned to initiate the USSD session as shown in the figure below.

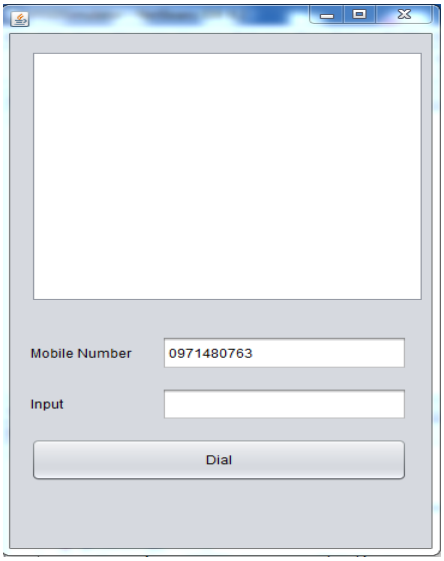


Figure 4.27: Initiating USSD session

After dialing, a candidate is presented with a screen displaying the various tasks they want to do. A candidate is expected to input a number against the task to be performed.

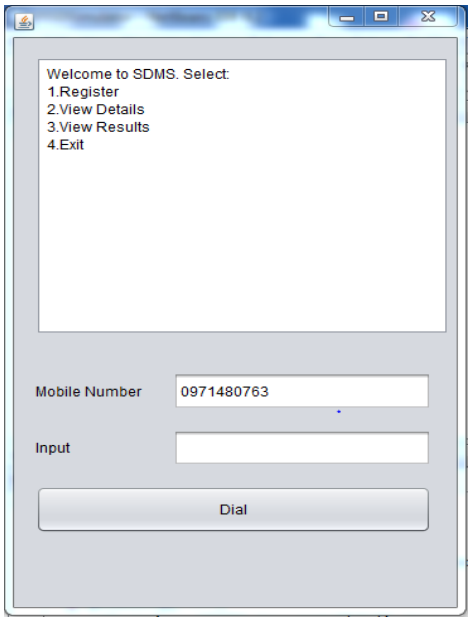


Figure 4.28: Screen showing tasks

When a candidate selects register from the above window i.e. inputs 1, he/she is asked to provide the registration details in sequence. Firstly, the candidate chooses the examination type i.e. PSLCE, JCE and MSCE then proceed providing other details like examination number, names, age, sex, center, subjects etc.

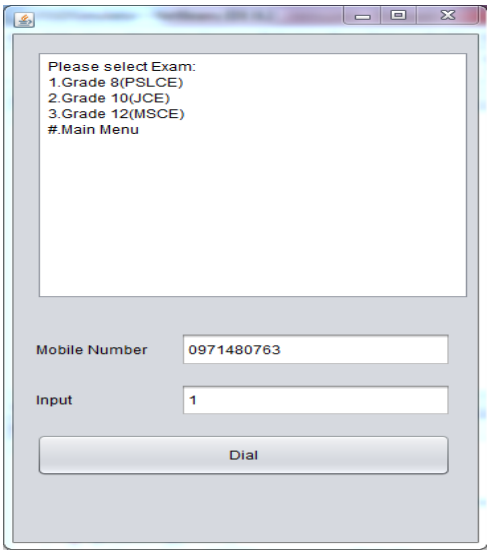


Figure 4.29: Screen for examination types

Examinations number is suplied first followed by all the other required details.

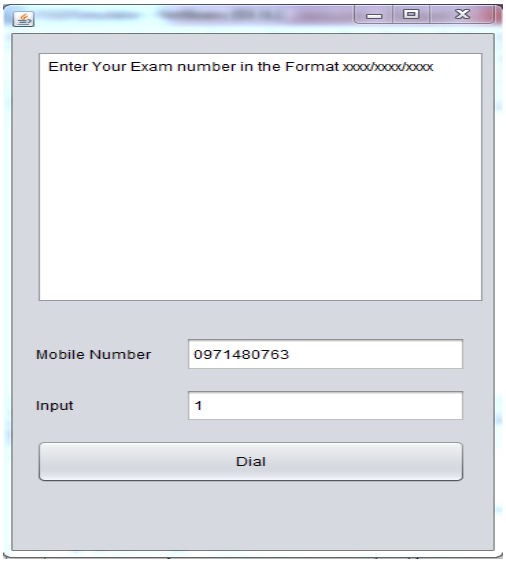


Figure 4.30: Screen to enter examination number

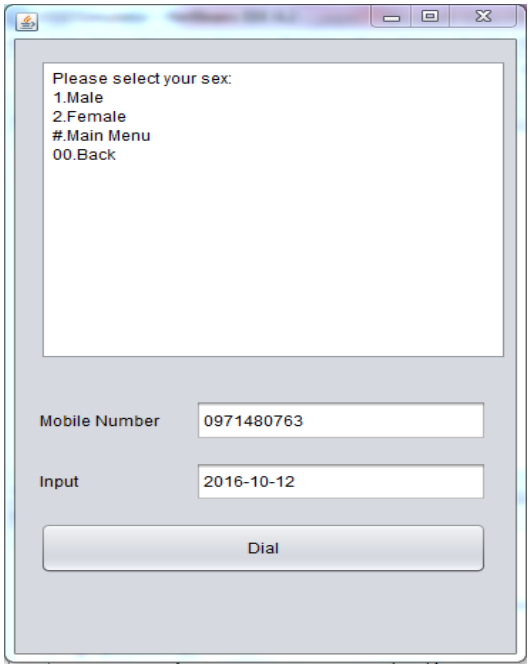


Figure 4.31: Candidate selects sex

When a candidate supplies all the required details for registration, the system will print a registration successful message.

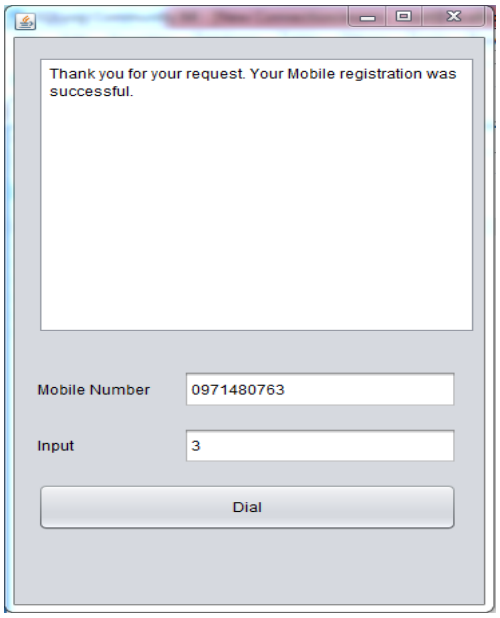


Figure 4.32: Successful registration message

To view registration details, a candidate inputs 2 from the initial screen. The candidate will then be asked to provide examination number and the details will be retrieved.

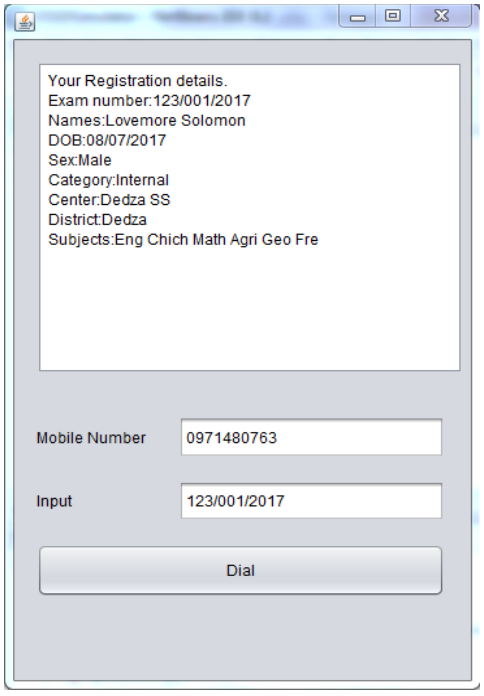


Figure 4.33: Screen showing registration details

Similarly, to check examinations results, a candidate inputs 3 from the initial screen and provide examination number to retrieve the results.

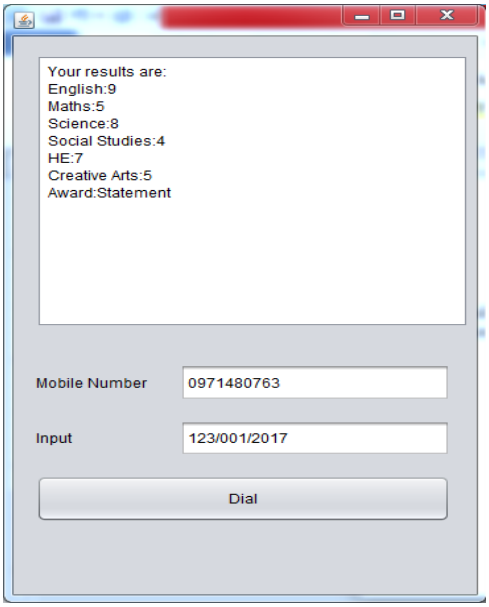


Figure 4.34: Screen showing examinations results

4.3.2 Web Application Login

The Web component of the system prototype is accessed through the internet by logging in the system using the log in credentials given to a user. The users are categorized into administrators and ordinary users.

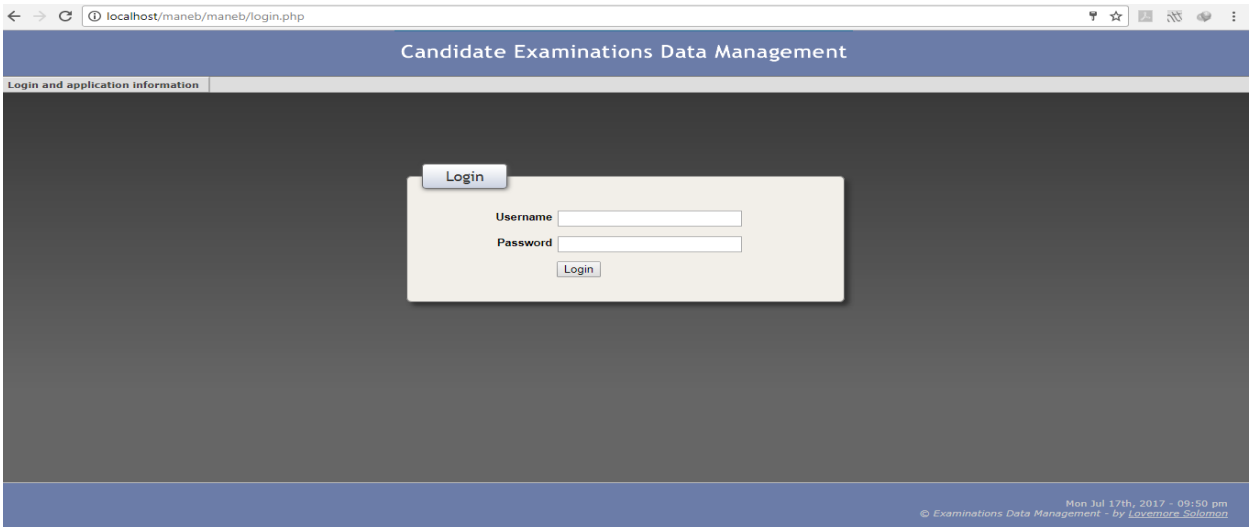


Figure 4.35: Web Application Login Form

The administrator will be able to perform all the administrative tasks within the system by gaining access to the admin page whereas the ordinary user will be denied access to the admin page. This is illustrated in the figure below.

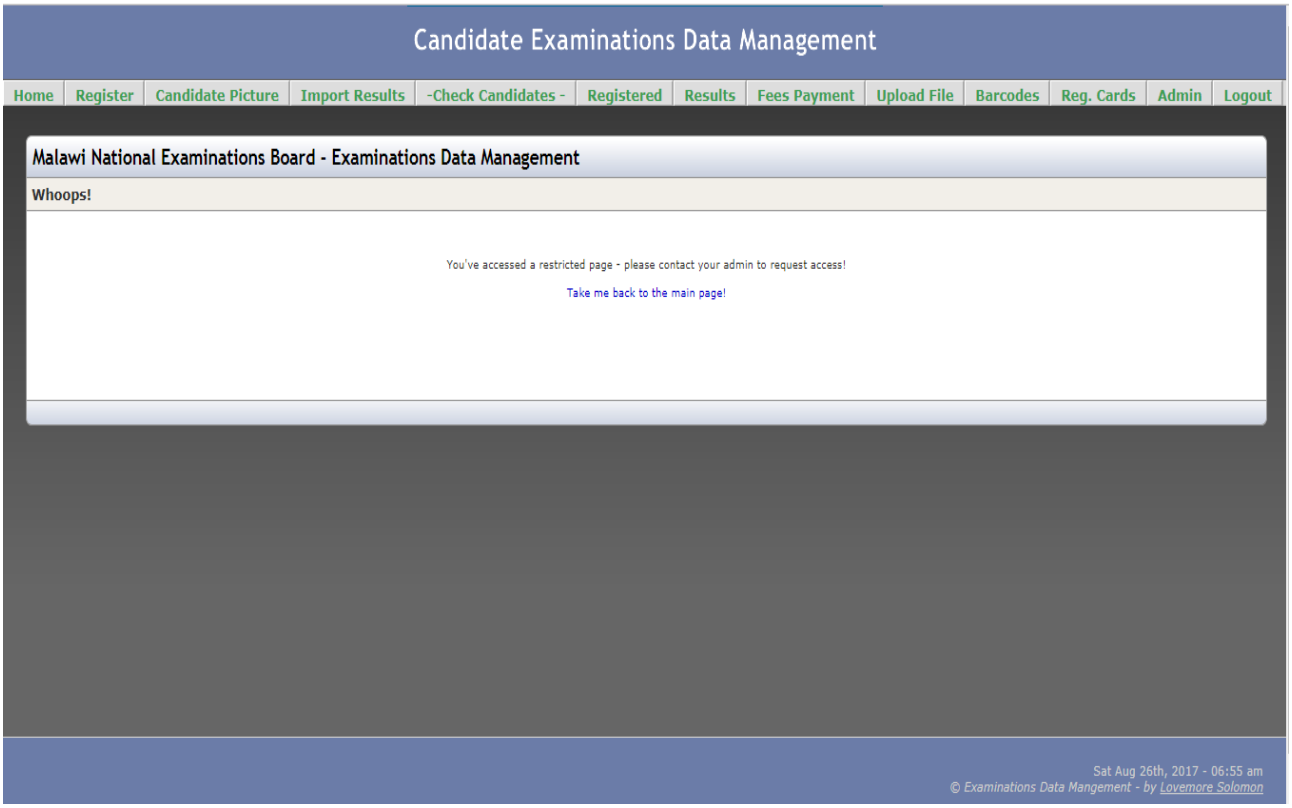


Figure 4.36: Denying Access to Unauthorized User

4.3.3 Administrative Tasks

The user with administrative role will be responsible for performing a number of administrative tasks within the system including, adding and updating users, Subjects, DEM, EDM, Center, Teacher, Candidate Type, Examinations, Special Needs status etc. The following figures indicate some of the roles of the administrator.

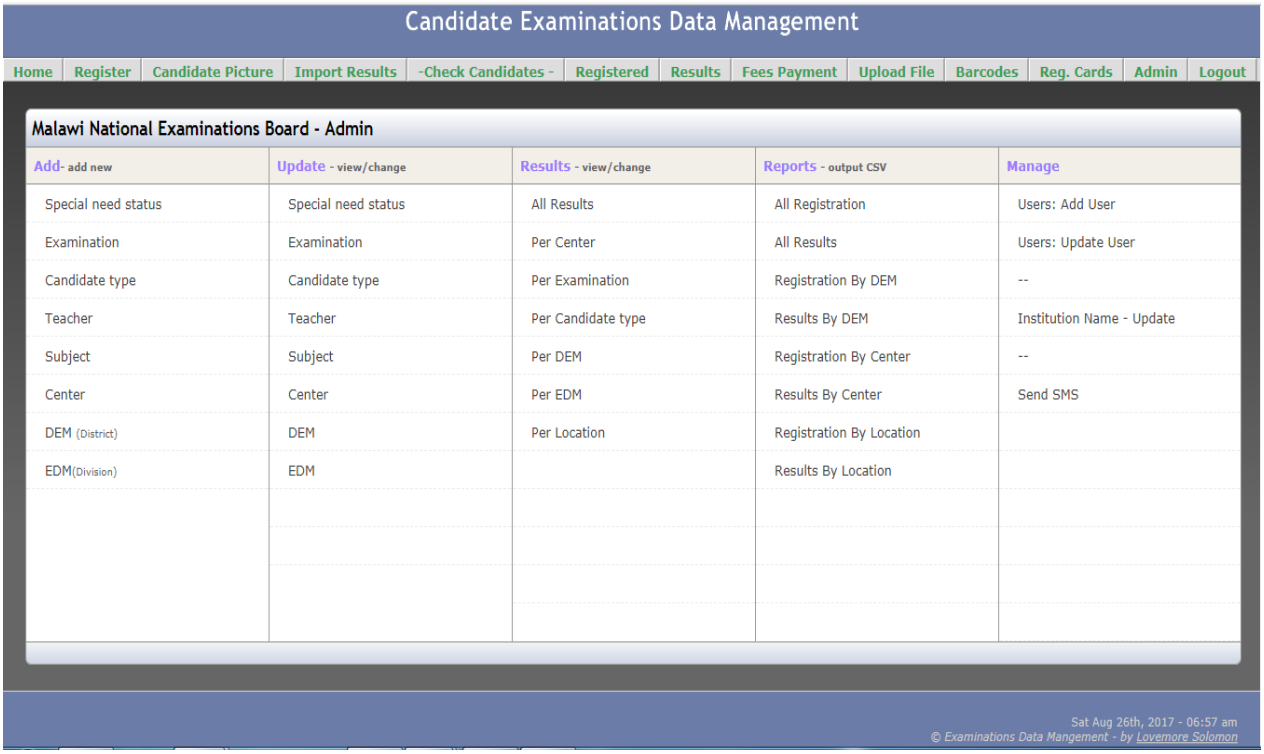


Figure 4.37: The administrator page

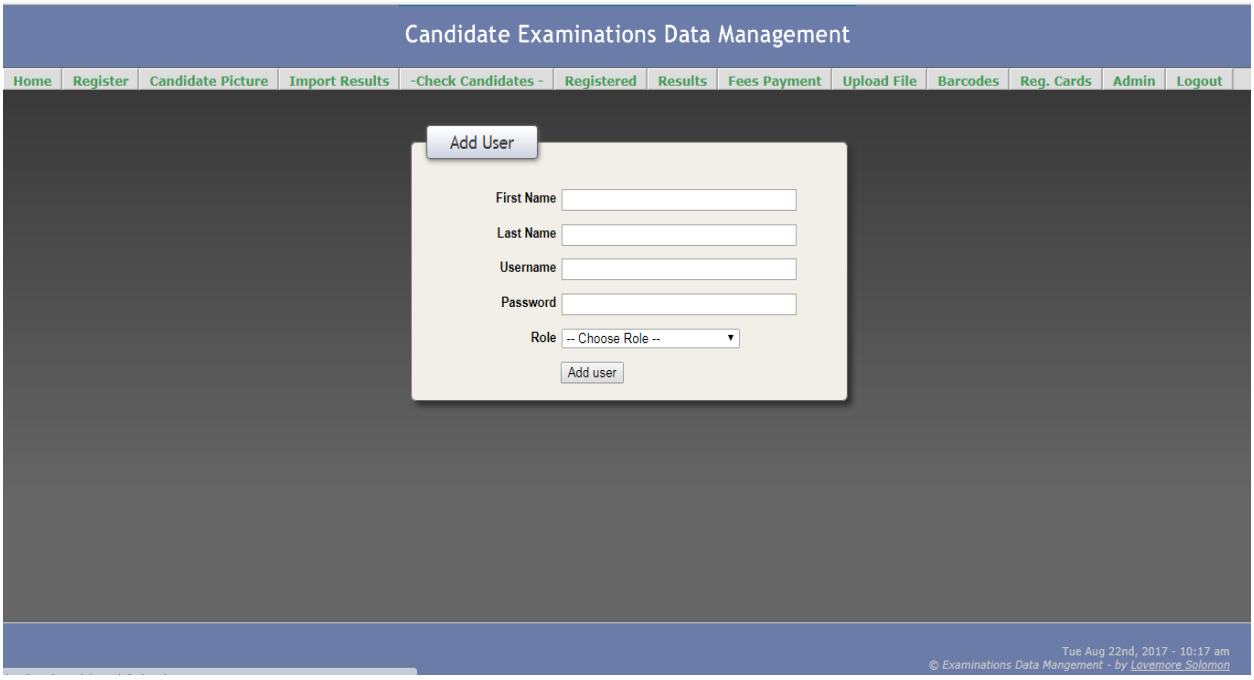


Figure 4.38: Adding a User

The administrator will also be responsible for updating of the user profile. First, the available users will be listed and then choose the user to be updated as indicated below.

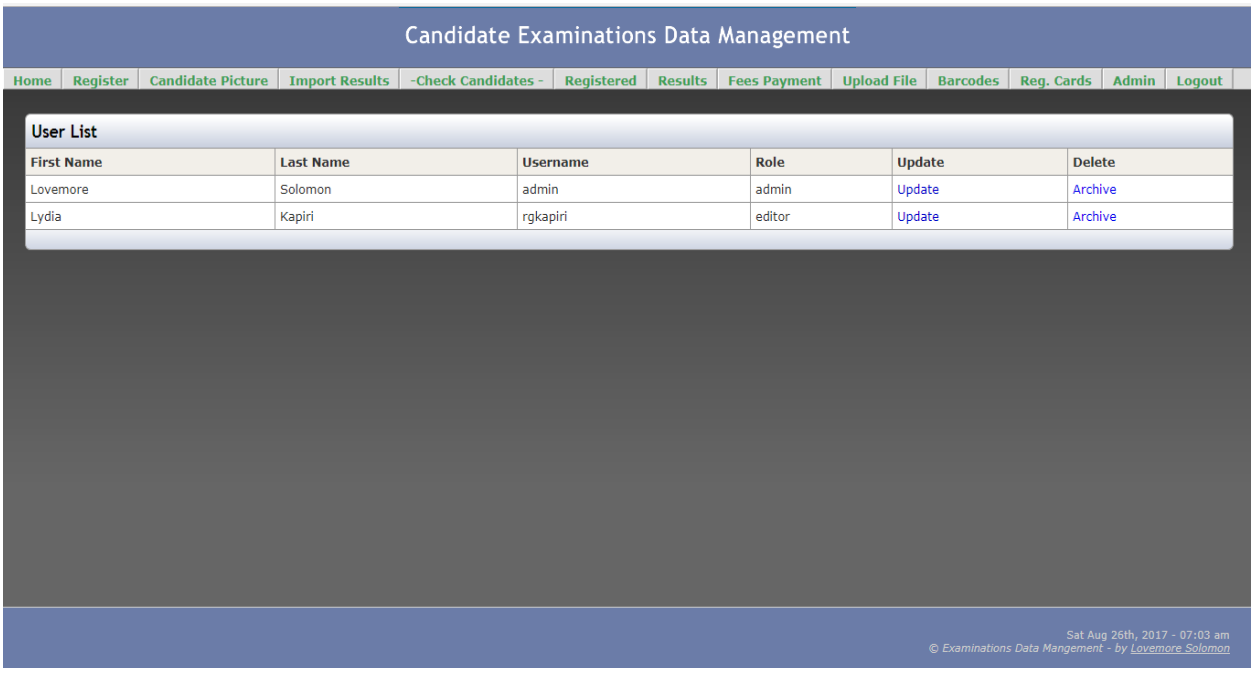


Figure 4.39: Listing available users

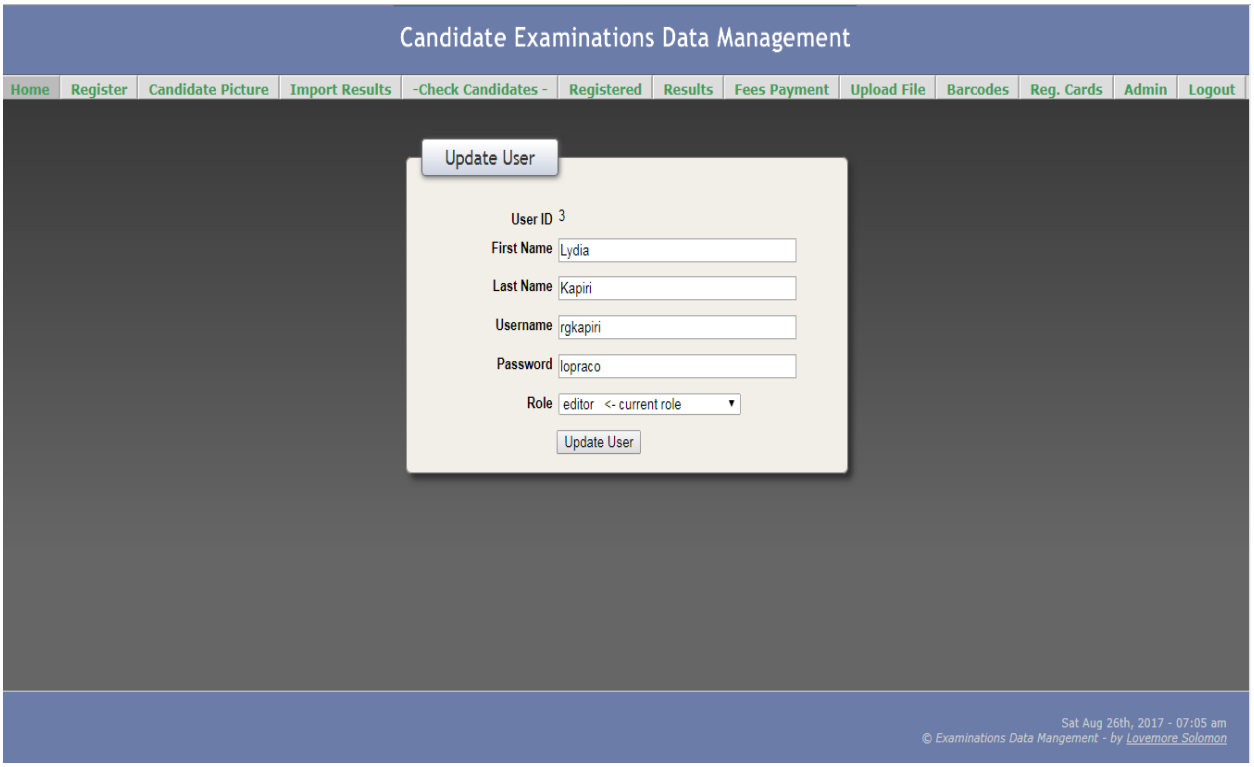


Figure 4.40: Updating User

When the name of an institution (in this case MANEB) changes, the administrator will be able to change the name in the system so that it reflects the new name.

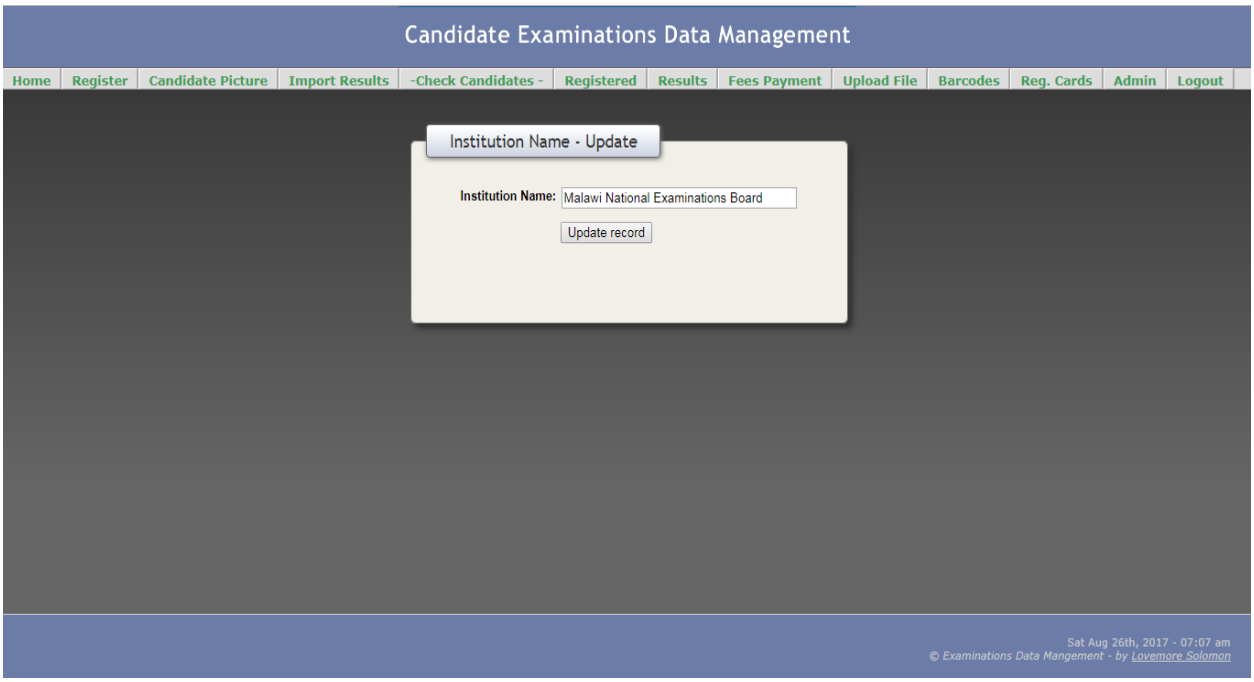


Figure 4.41: Updating name of institution

In an event that a new educational district is created, the administrator will be able to add the DEM name as shown in the below figure.

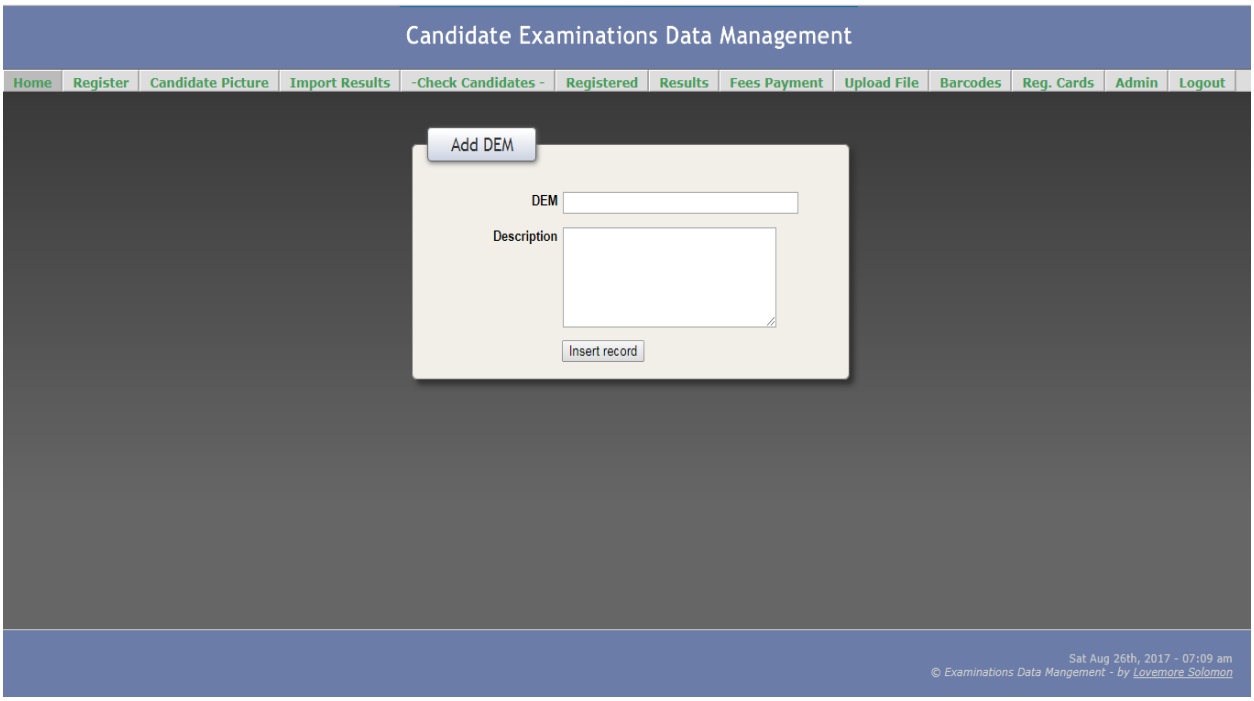


Figure 4.42:Adding a new education district

Fig 4.36 Adding a new education district

Sometimes examinations are renamed or abolished. When such a thing happens, the administrator is capable of renaming it if it has been renamed or remove it from the system when it has been abolished.

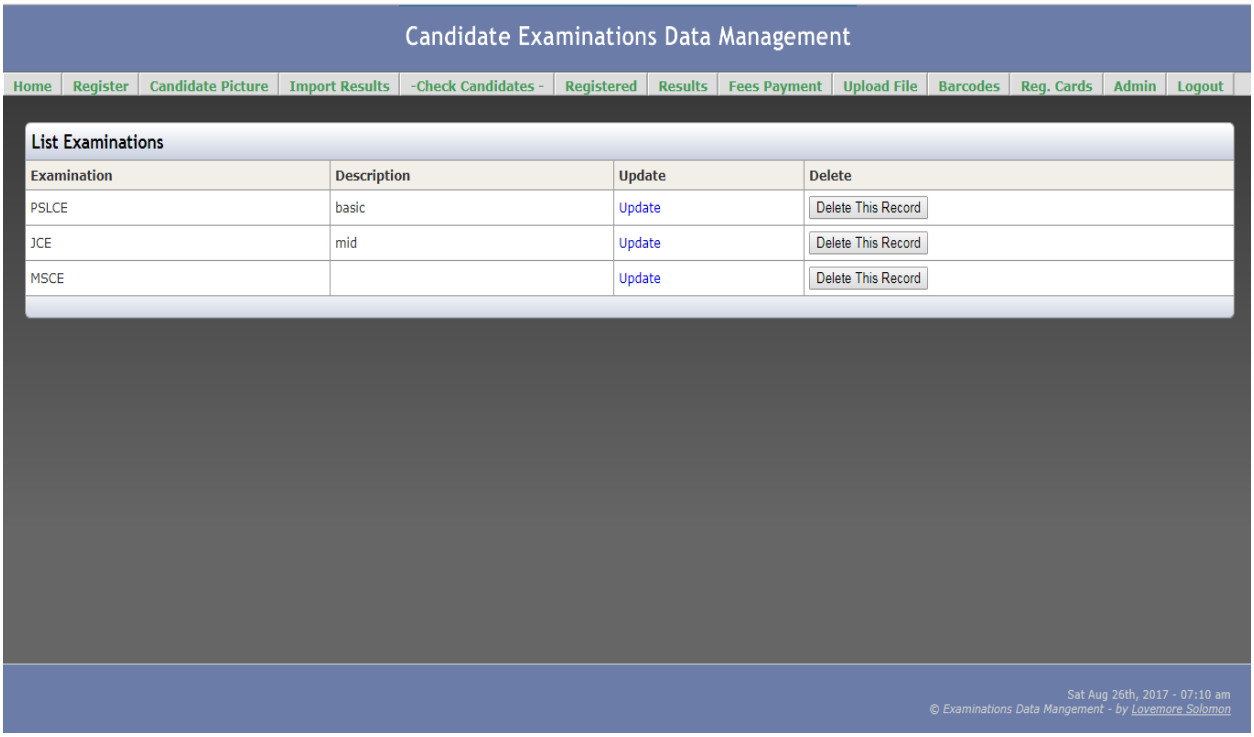


Figure 4.43: Updating/Deleting an exam

4.3.4 Candidate Registration

In an event that the SMS/USSD based component for candidate registration is not operational, candidates will be registered using the web based application as depicted below.

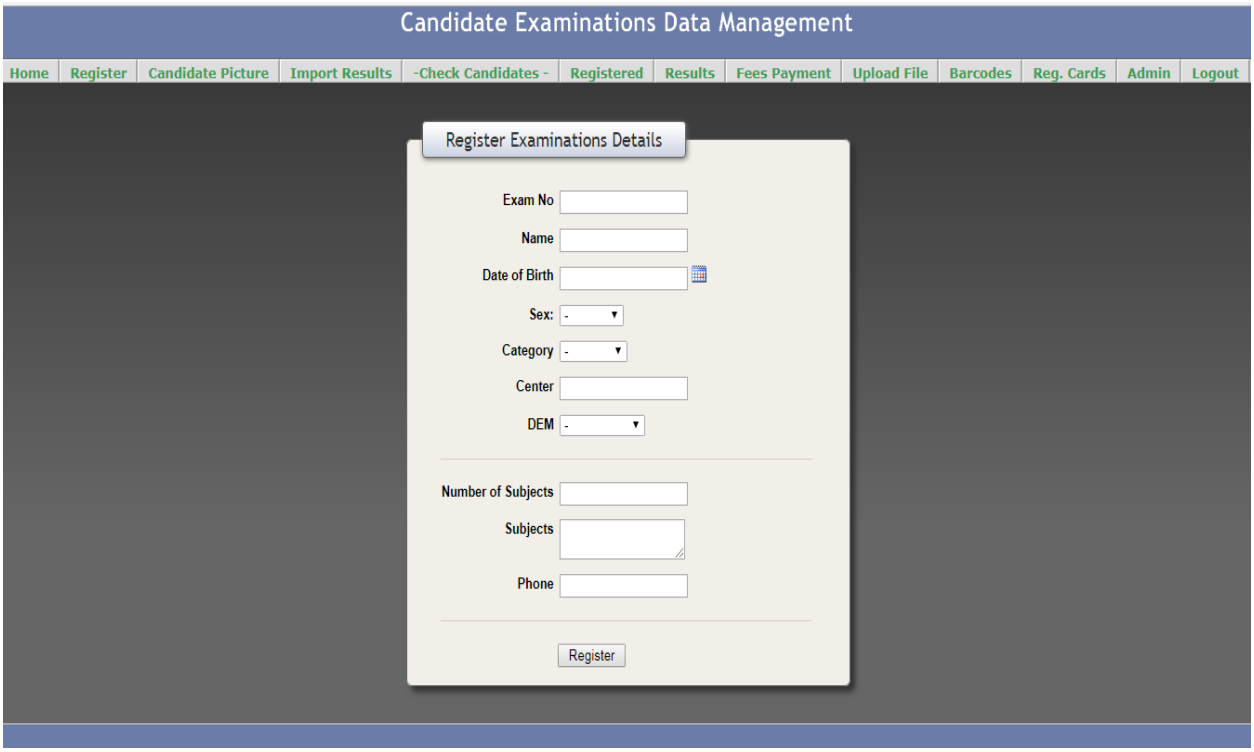


Figure 4.44: Candidate Registration

4.3.5 Viewing Registration Details

Users will be able to view registration details of candidates by listing them. The system administrator, over and above the viewing will be in a position to update and delete individual registration records.

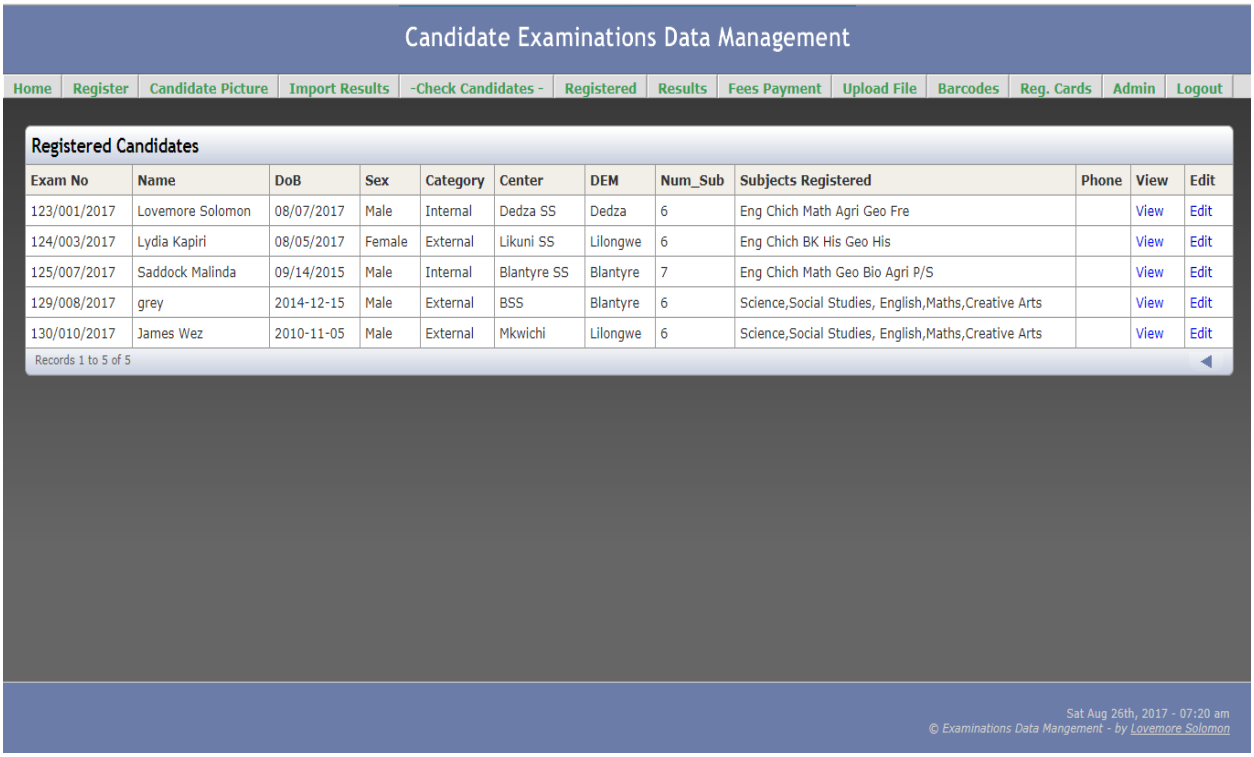


Figure 4.45: Viewing registration details

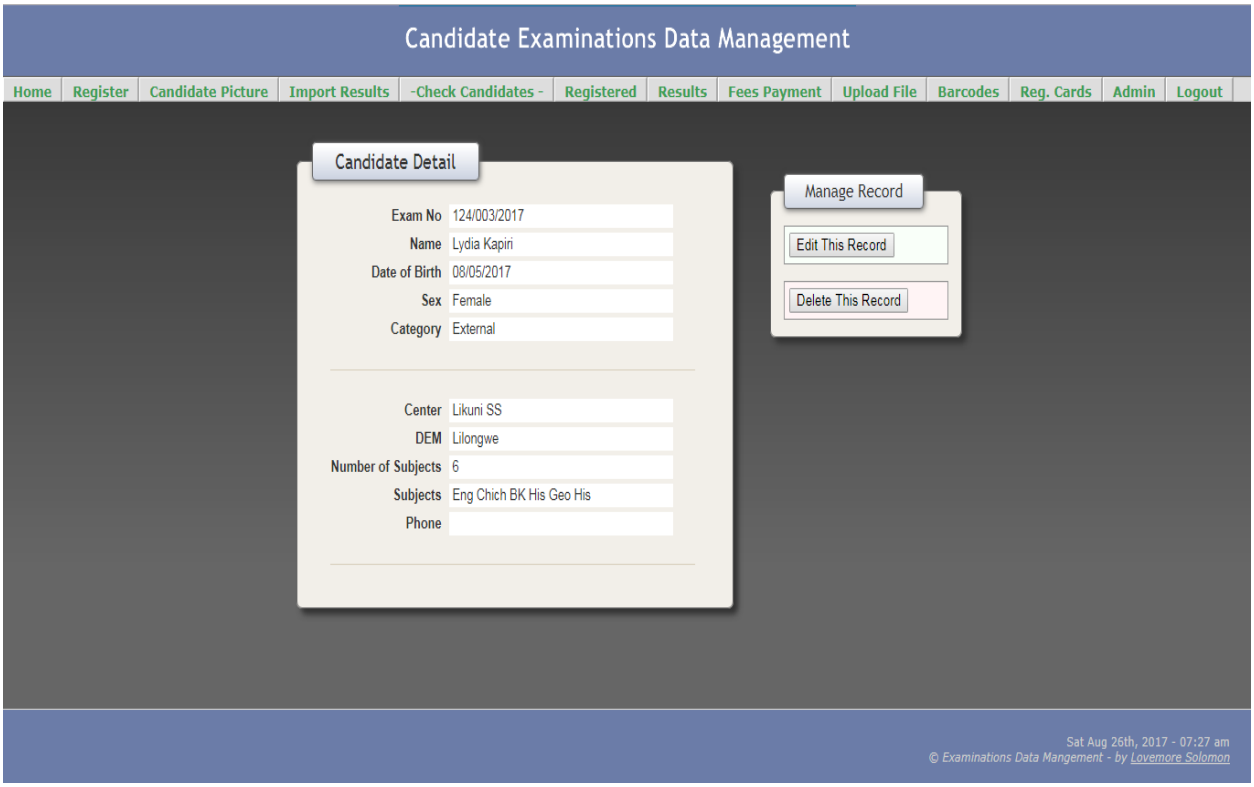


Figure 4.46: Editing registration record

4.3.6 Validating and Filtering Candidates

On the day of writing examinations, candidates will have to be validated by scanning their registration cards. The administrator will also be capable of filtering registered candidates according to sex, center as well as district. The validation and filtering tasks are done using the interface shown below.

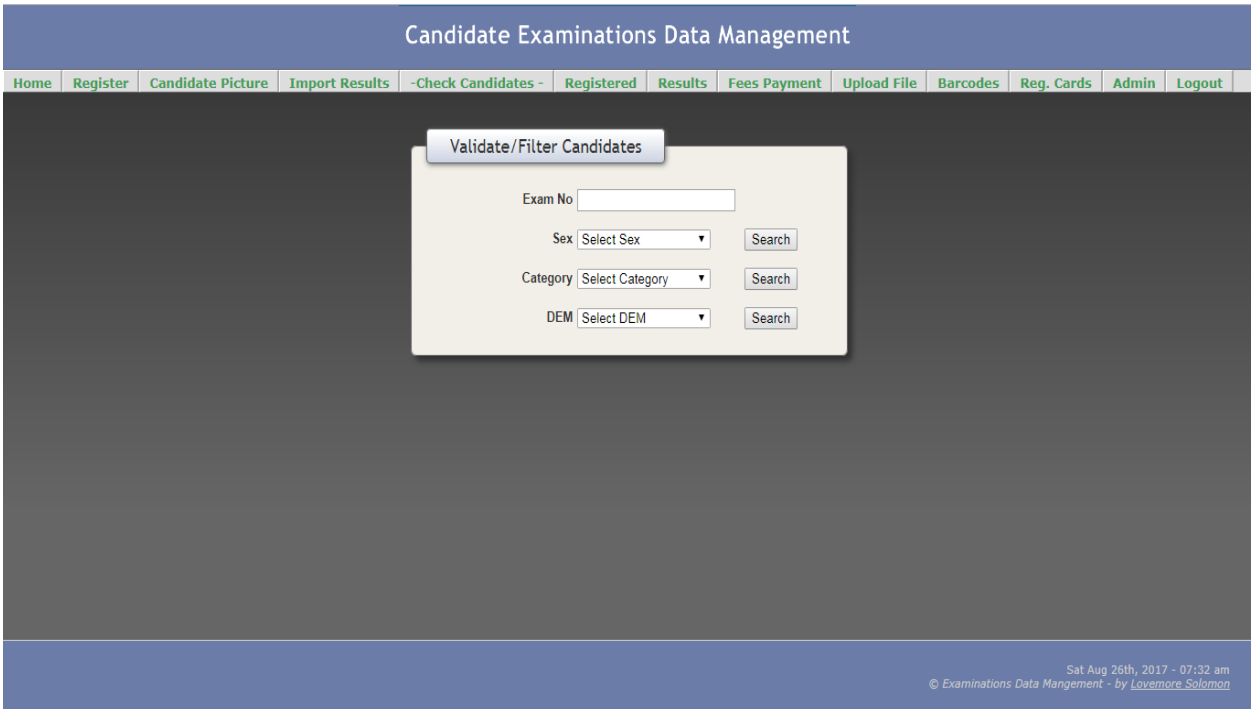


Figure 4.47: Searching and filtering candidates

4.3.7 Importing Examinations Results

Normally, when marking and grading of examination scripts is done, scores and grades are captured in excel spreadsheets. These results are supposed to be imported into the system so that they can be sent to candidates via the mobile component. To be uploaded successfully, the spreadsheets are firstly converted into Comma Separated Value (CSV) files. Figure 4.41 below highlights the process of importing results.

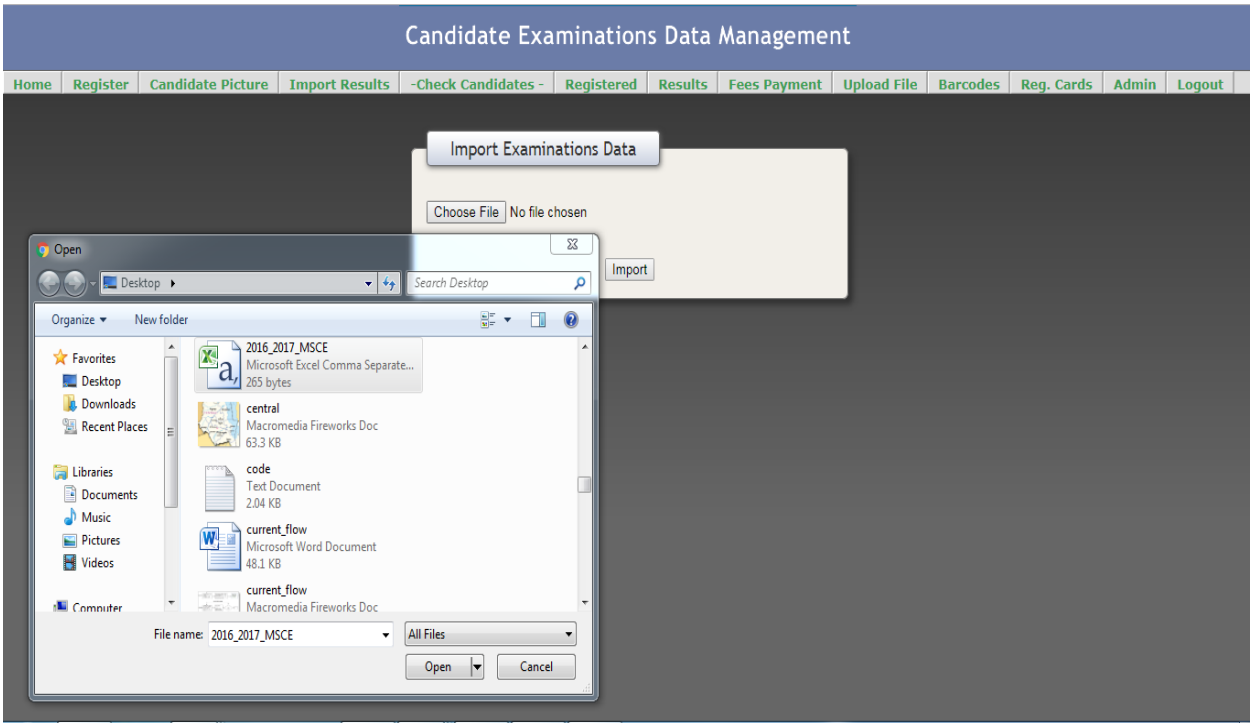


Figure 4.48: Importing Examinations Results

4.3.8 Viewing Examinations Results

Examinations results can be viewed in a similar way as registration details. An administrator can also edit delete individual records.

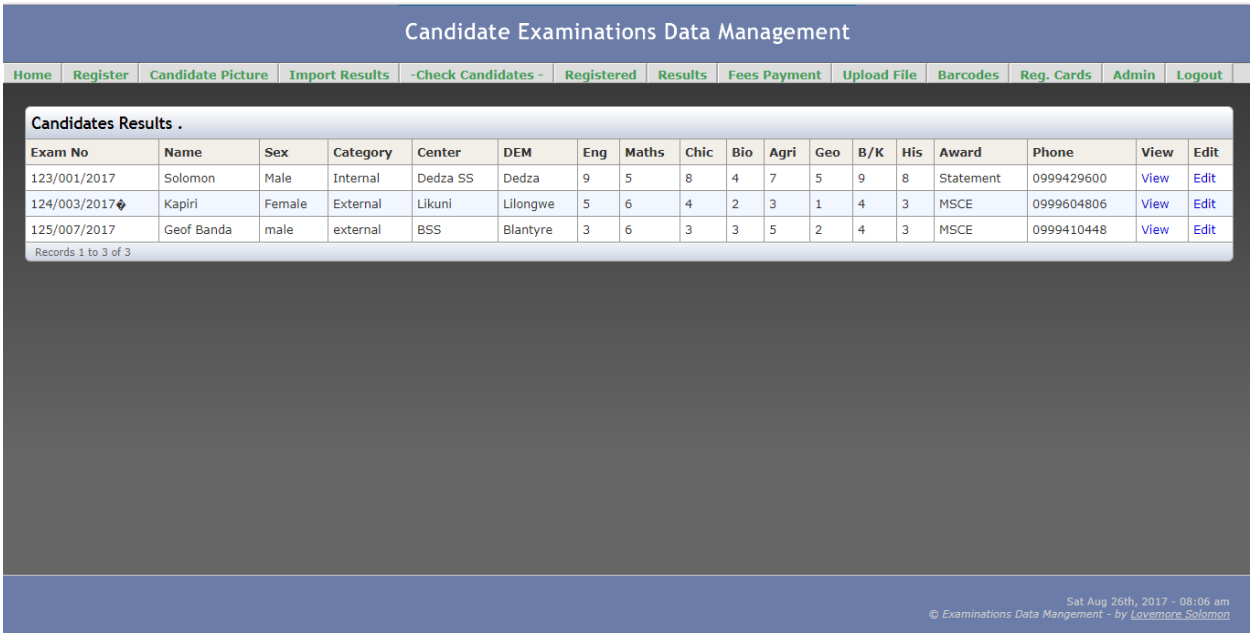


Figure 4.49: Viewing examinations results

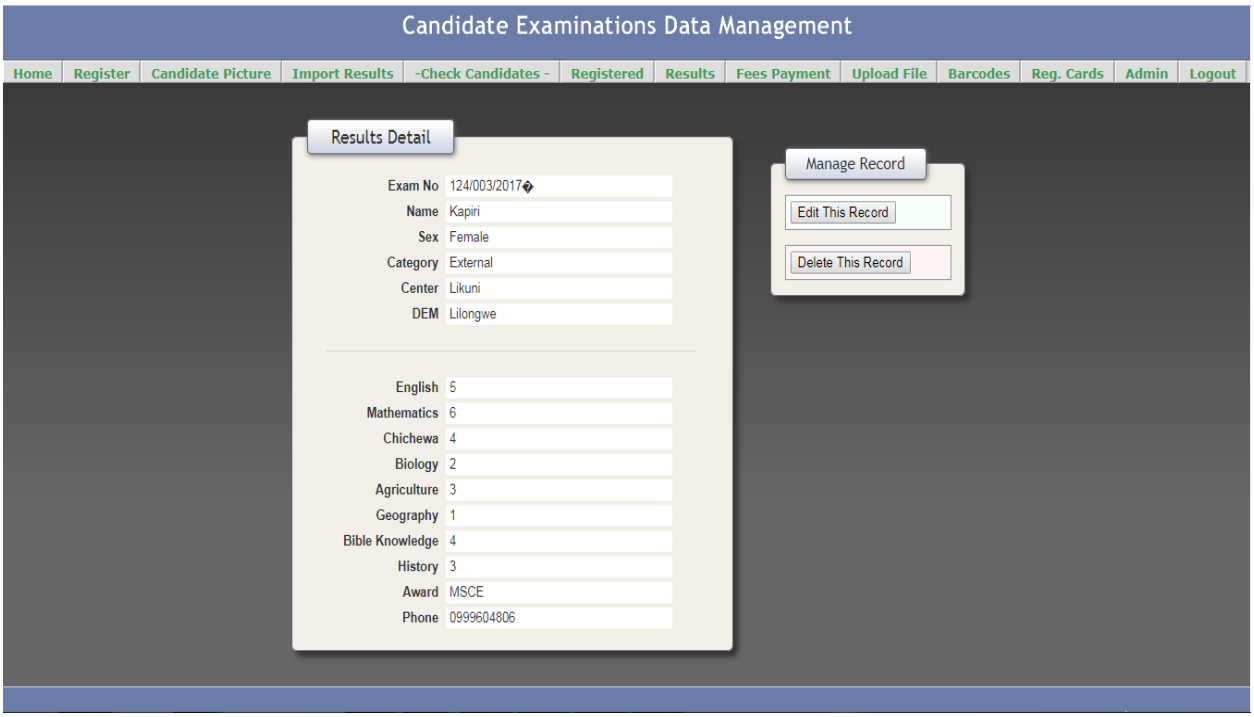


Figure 4.50: Editing examinations results record

4.3.9 Generation of Registration Cards

Since candidates will be registering using mobile phones, the system will be required to produce registration cards for every candidate. The cards will have barcodes with examination numbers imbedded. The cards will be used to validate candidates on the day of writing examinations by scanning the barcodes.

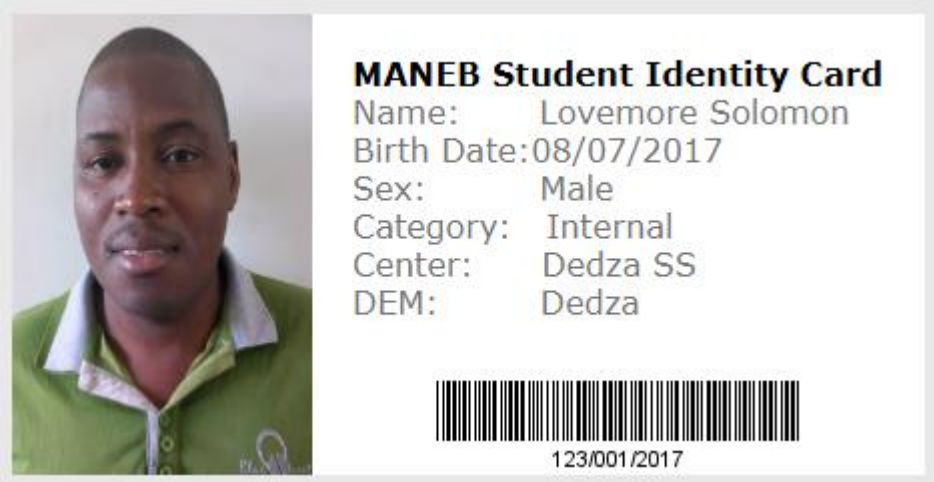


Figure 4.51: Candidate registration card

4.3.10 Logging out

Every user, when they are done using the system, will have to log out.

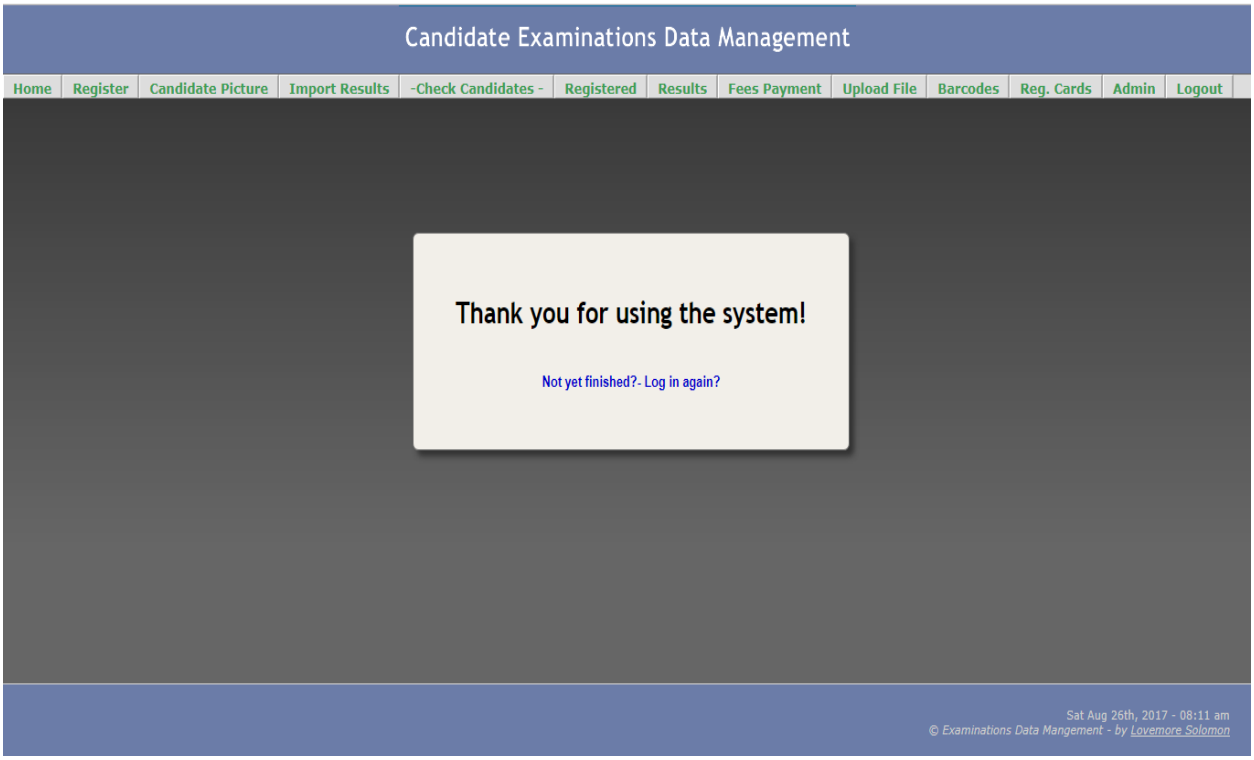


Figure 4.52: Log out screen

Fig 4.43 Logging out

4.3 Summary

In this chapter, the data that was collected from the baseline study was successfully analyzed. The results have been presented in the form of tables and charts. The study established that MANEB currently experiences omission of candidates, incorrect registration details, difficulties verifying candidates' registration details as well as delayed examinations results. Hence the participants of the study recommended the introduction of SMS/USSD based registration and results dissemination system. A prototype of the proposed system has been developed using a USSD simulator. The web component included the authentication of users logging into the system, administration tasks, viewing both registration and examinations results, registration of candidates (in an event that the SMS/USSD system is down), validation and filtering of candidates, importing examinations results, generating candidates' registration cards with barcodes as well as logging out from the system.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Introduction

The analyses in this study were conducted to gain insight into some of the challenges associated with the processes of registering candidates for national examinations as well as dissemination of examinations results that were deemed to influence the rate of repetition and dropout in classes that sit for national examinations. In this chapter, the discussion of the results given in chapter four is presented. The chapter looks at the baseline study results, the business process mapping models and the prototype implementation. The conclusion to the research, recommendations and suggested future works to the research are also provided in this chapter.

5.2 Baseline Study

Since 1994 Primary education in Malawi has been free but not compulsory. Primary education takes 8 years (standards 1 to 8) and falls in the category of basic education which is meant to equip children with basic knowledge and skills to allow them function as competent and productive citizens in a free society when they grow up. Pupils who are able to reach standard 8 sit the Primary School Leaving Certificate Education (PSLCE) which determines their eligibility for entry into secondary school. The PSLCE are jointly set, conducted and marked by the Ministry of Education and the Malawi National Examinations Board (MANEB). Secondary education begins in Form 1 and ends in Form 4. Technically, a student could end secondary school at the age of 18 if he or she never has to retake a school year, which is rare. Under the current education system, children in Malawi at the end of Form 2 sit the Junior Certificate of Education (JCE). At the end of Form 4 the students sit the Malawi School Certificate of Education (MSCE), an exam that determines a student's tertiary education.

The introduction of free primary education and the overall increase in population has seen a large increase in the number of students in classes that sit national examinations i.e. standard 8, Form 2 and Form 4. This increase in the number of candidates has brought a number of challenges in

the way MANEB conducts and administers the national examinations. The baseline study was therefore carried out to identify the challenges brought by the current processes (which are largely manual) that MANEB utilizes to register candidates for national examinations and also how MANEB disseminates examinations results to candidates or parents. The challenges were identified through a survey and analyses of the survey results were done. The insights gained from interviews with MANEB and Ministry of Education officials were also discussed.

Apart from the challenges, the baseline study sought to establish the use and availability of mobile services in the districts (urban and rural) as a way of deducing whether the proposed system would be feasible or not. The baseline study went further to seek users' views on whether the proposed system would be recommended or not which the majority of the respondents were in favor of.

The findings of the baseline study are discussed in the following sections with references to figures and tables in chapter 4.

5.2.1 Demographic Data

The research tools which were used in the study i.e. questionnaires had sections that were meant to capture the demographic data of the respondents. Respondents were required to provide information about their age, sex, education qualification, location etc.

According to the data collected from parent respondents, 40% of the parents were males while 60% were females. This gives an indication that female parents are very much involved in matters to do with education of children in many families (see chapter 4 section 4.2.1 figure 45). The demographic data also shows that the study was done in both locations i.e. urban and rural. This was so important because the study was nationwide in nature hence the sampled respondents had to come from both locations as is evidenced in figure 46 of chapter 4 section 4.2.1.

The age range of respondents particularly parents which is from 26 years to above 45 years (see figure 47 of chapter 4) shows that the research targeted the right age range so that the knowledge and competence of these parents on how to use mobile services could be measured as it is widely

understood that most aged people are not conversant with emerging technologies. This also applies to the qualification of the parent respondents (figure 50 chapter 4). It is seen that a greater percentage of them (45%) had just the Malawi School Certificate of Education (MSCE) but are still able to use modern mobile services and facilities.

Schools' enrolment (in classes that sit national examinations) was another important variable that was sought. The study relieved most schools have enrolment of more than 70 candidates in such classes (Tables 10 and 11 of chapter 4). This clearly shows how much work the teachers have when registering the candidates for national examinations using the current procedures.

5.2.2 Examinations administration procedures

During the baseline study, the researcher also aimed at comprehending the current procedures that are followed in order to register candidates for national examinations and also to disseminate examinations results to candidates. The researcher needed to understand how the various respondents rate the current processes, how much time it takes to accomplish the various tasks, some common challenges experienced in the current processes and also if the challenges have in some places led to failure of candidates to write examinations.

The findings of the research show that almost all the categories of respondents rate the current system as not good and very unreliable. Parents, teachers and learners described the current system as having a number of problems (figures 52, 53, 54, 55 and 56 of chapter 4). The rating of the current system was based on the effectiveness of the registration procedures, verification of registration details and dissemination of results. All the three processes take too long to complete. For instance, when respondents (parents and students) were asked to indicate as to how long it takes for them to access examinations results after being released, a greater percentage of them i.e. 55% indicated that they got their results after some days (figure 57 of chapter 4) and others got their results after weeks. This obviously supports the idea of introducing the proposed system that will enable them to access their results instantly after being released.

The bar chart in figure 58 indicates some of the challenges that are faced when registering and verifying the registration details. The challenges include registration and verification forms not well printed, hard to correct mistakes, hard to verify all students, late payment of fees, missing records, mistakes on printed sheets, takes too long and too involving. The figure also indicates that the most common challenge with the current system is the occurrence of mistakes on printed sheets. This entails that there are a lot of queries when it comes to verification and these queries usually take long to be sorted out.

Teachers were also asked to provide information if they had experienced a phenomenon where some candidates failed to write their examinations as a result of challenges with the current system. Figure 59 of the previous chapter shows that a greater percentage (60%) of the teachers has had such scenarios in their schools, a situation that compels the affected students to repeat the class or completely drop out of school.

5.2.3 Mobile Services

Having proposed the introduction of a mobile SMS/USSD based system as an ideal solution to the challenges currently faced by MANEB in executing its duties of administering national examinations, the researcher thought of finding information from the respondents about their possession and utilization of mobile services and facilities so as to ascertain that if implemented the system will be used anywhere across the country regardless of where the user is located. The respondents were asked if they possess mobile phones, if they have the knowhow of creating, sending, opening and reading Short Message Service messages, if they have any mobile network coverage in their area, the number of members in their families with mobile phone and if they have used any mobile money services before.

All the parents as well as students indicated that they have mobile phones (figure 60 of chapter 4). Since the proposed system will be SMS based, the type of phone that the respondents have does not necessarily matter. It was evident that those respondents in rural areas have ordinary or feature phones as compared with those in the urban areas where the majority have smart phones. In order to have an idea of the rate of penetration of mobile phones across the country, the respondents were required to indicate the number of family members in their families who had

mobile phones. Figure 63 clearly stipulates that all the respondents had at least two members of their families with mobile phones. This implies that every candidate can manage to have a mobile phone number to be supplied during registration for national examinations. This number will be necessary for receiving any information regarding examinations, for example verification of registration details and examinations results.

Again, all the respondents (parents and students) indicated that they are capable of writing and reading SMS on the phone (figure 61 of chapter 4). This means that if the proposed system is implemented, the end users who are the candidates and their parents will be able to send and read messages to and from MANEB.

Another variable that would assist to find out the degree to which mobile phones are used in the country was to know the availability of mobile network coverage more especially in rural areas. Availability of mobile network ensures the utilization of mobile services within an area. From the results, all the respondents indicated that they have at least one mobile network provider in their area. There are just a few mobile network providers in Malawi. But according to figure 62 of previous chapter, most people use one or both of the two major mobile network providers which are Airtel Malawi and Telecom Networks Malawi (TNM). The mobile networks according to the study are available in all the sampled places regardless of the location.

On the use of mobile money services i.e. use of mobile money agents to send and receive money, all the respondents said that they had used such facilities before. This also supports the feasibility of the proposed system as candidates will no longer be paying their examinations fees through the school cashier or bursar but instead they will be using mobile money agents to send the money directly into MANEB's account. Figure 64 illustrates the mobile money operators currently available in Malawi.

5.2.4 The proposed system

As the researcher's ultimate goal and objective was to design and implement an SMS and USSD based system using cloud infrastructure in order to counter the challenges alluded to earlier in this chapter, all the three categories of respondents i.e. parents, students and teachers were asked

to give their views on whether the introduction of the aforementioned system can in true sense help to mitigate the challenges.

When asked, 75% of the students said that they really believed that the proposed system would be a solution to the challenges while 20% of them said they were not sure if the proposed system would really solve the challenges. The remaining 5% said they did not think that the proposed system can be an ideal solution to the problems. 85% of the parent respondents strongly believed that the system is a good solution, 10% were not sure while the remaining 5% said no (figures 65 and 66).

On the recommendation to introduce the system, 90% of the teachers recommended that the system be introduced to lessen their tasks when it comes to registration of candidates where as 10% were unsure.

From the responses, it can be deduced that it is not optional to replace the current system with the proposed system as most respondents thought that the proposed system will enhance the effectiveness of registration, verification and dissemination of examinations results. The respondents' recommendation is in tandem with the reviewed literature that says mobile applications do provide solutions to quite a number of scenarios.

5.3 Business Process Mapping

The current business processes which MANEB uses for registration of candidates for national examinations, verification of registration details and dissemination of examinations results are mostly manual and paper based as has been shown in chapter 3. The business processes as described by MANEB were translated into diagrams in chapter 3. It is from the current business processes that the proposed automated business processes for the administration of national examinations were mapped. The mapped automated processes were also presented in chapter 3. Automating business processes greatly improves operation efficiency, saves on time being spent on carrying out activities and also reduces on inaccuracies and errors. All these do characterize the manual based systems that MANEB is currently employing when administering national examinations.

Chapter 3 also highlights the overall architecture of the proposed system that utilizes cloud infrastructure. The wide spread use of mobile phones particularly SMS and USSD make the proposed system a viable solution of automating the current MANEB processes. At the backend of the proposed system, the administrators and other specialized users will have web interfaces for the manipulation of the data.

The whole system architecture will make use of cloud environment where the registration data and other information will be stored in the cloud servers. Cloud computing lowers operating costs as resources can be rapidly allocated and released on demand and also the institution does not worry of huge ICT infrastructure expenses as these costs become the responsibility of the cloud service provider.

5.4 System Implementation

The system implementation was presented in chapter 4 and this section provides a discussion of the implementation. As the results of the baseline study have depicted, the manual and paper based administration of national examinations brings about a number of problems which include mistakes on printed sheets, not well printed registration and verification forms, hard to verify students, missing records, time consuming, theft of examinations fees by private schools owners etc. It is evidently clear that automating the current processes of administering examinations can significantly reduce the challenges that MANEB faces in as far as handling of data is concerned. The challenges mostly result from transferring of data in CDs/DVDs, printing of nominal rolls for verification of details by candidates and also preparation of examinations results sheets and books that are circulated in schools.

While all the business processes and models necessary for automation were mapped, the scope of the prototype development was scaled down to transmitting USSD messages between the users and the system, viewing and manipulating the data through web interface and generation of registration cards. Some administrative tasks i.e. management of users and data are also implemented. The implementation of a fully-fledged system would require more time since other components of the system are complex and need time for researching. These basic functionalities were implemented based on the Use Cases and the data models presented in chapter 3.

The systems development approaches discussed in chapter 3 i.e. Object Oriented Systems Development Methodology (OOSDM) were followed from the analysis up to the implementation. The baseline study and the interviews helped to gather the necessary information which was then analyzed to formulate useful system requirements. The system requirements were got from the documents that were sourced from MANEB that are used to transfer and manage examinations data. These system requirements provide a way to comprehend the business needs of an entity i.e. MANEB.

From the requirements formulated, the system was designed as shown in chapter 3. The design formed the basis for development of the prototype and a fully-fledged automated system when it will be required in future. Models were developed using information got from the literature review. The models provide blueprints of the system and are essential because they give a representation or simplification of reality.

The development of the prototype used a number of tools such as JAVA, PHP and its associated HTML, JavaScript, CSS, Apache Web Server and mysql database engine. All the tools used in the prototype development were freely downloaded from the Internet without any cost attached to them. The system prototype was tested using dummy data. During the testing, fifty records were registered. The system was deployed on a server and accessed remotely to simulate the cloud environment. It was shown that using mobile SMS or USSD tremendously reduces the time it takes to register candidates. The system prototype's performance was measured in terms of its throughput, response time and error rate which were compared with those of the current system.

5.5 Conclusion

In an effort to enhance the administration of national examinations more especially management of candidates' registration and examinations results data, MANEB should strive to use modern technologies such as mobile applications and cloud computing. In the study, a baseline survey was conducted to establish the challenges faced by MANEB regarding registration, verification of registration details as well as dissemination of examinations results. The reviewed literature that was gathered unleashed similar challenges that examinations bodies in other countries

particularly Africa face when administering examinations. The literature also gave insights of the nature of national examinations that are offered in other countries around the Globe, mobile SMS and USSD technologies, importance of Information and Communication Technology (ICT) in education, cloud computing, Digital Financial Services (DFS) etc. The technologies were thoroughly reviewed and comprehended as the proposed system makes use of such technologies. The candidate data management system models were designed based on the findings from the baseline study and the interviews with MANEB and Ministry of Education officers. The models were in turn used as a blueprint to inform the system prototype development.

Throughout the research study, the researcher was trying to answer or meet the research objectives that were laid out at the very beginning when the research problem was being developed. Objective number one was met by carrying out the baseline study from which it was revealed that there are a number of challenges with the current process. The registration and results dissemination processes face challenges in the effective management and handling of data. Manual and desktop based registration and paper based dissemination of results are carried and face problems like being prone to human errors, time consuming, theft of examinations fees, tedious, missing or incorrect candidates' records, difficulties in verifying details of candidates, delayed examinations results etc.

The extensive literature reviewed during the study helped to answer objective number two of the study. The literature demonstrated how various mobile SMS applications are designed and implemented. A thorough understanding of cloud computing was also achieved. The understanding of these technologies from the literature assisted the author to design a model based on cloud architecture and SMS mobile application to address the challenges faced by MANEB.

On the third objective, the current business processes of MANEB were successfully mapped to the automated business processes for the administration and management of candidates' data. The automated business processes employed cloud architecture and SMS/USSD technologies. Mobile network providers also formed part of the model for transmission of SMSs and USSDs.

The final objective of the study was to develop a mobile (SMS and USSD based) application prototype to enable candidates register for national examinations and also receive examinations results. The prototype was developed and tested with dummy data. From the results, it is clear that a mobile based automated system provides a more convenient, fast and accurate way of transmitting candidates' data between MANEB and the candidates themselves.

The initial cost of adopting and implementing a system that makes use of cloud architecture is always high but the benefits in the long run are worth the initial cost. MANEB will be urged to adopt the system to mitigate the challenges it is currently facing.

5.6 Recommendations

Since the study has shown that the proposed mobile system is an ideal solution to the challenges and be implemented, the following recommendations are put forward:

a) MANEB, through the Ministry of Education, Science and Technology should lobby for more funding from Government to implement the system.
b) The Government through the Malawi Communications Regulatory Authority (MACRA) should urge telecommunication companies in the country to extend their network coverage to the remotest areas so that wherever there are settlements, people should have mobile network in order to be able to use the system.
c) The Government of Malawi should expedite the e-government project which will be implemented using cloud infrastructure so that the system should be deployed using the same environment.

5.7 Future Works

The prototype developed is but a simple system showing proof of the concept of the candidates' examinations data management. Further development of the system prototype to a fully-fledged candidate examinations data management system will have to be done.

Since the proposed system only looks at the registration, verification and dissemination of results, future works should also focus on having a single and complete examinations

management system that will also automate the processes like online taking of examinations by candidates as well as marking, grading and scoring of examinations scripts.

As part of security, future works should consider incorporation GPS/GIS to be able to track and record the position a candidate is registering from as well as the use of biometrics to capture the physical part of registering candidates.

5.8 Summary

This chapter was aimed at giving further narration on the results that were got in chapter four. The results of the baseline study whose aim was to establish the challenges hindering the current processes as well as measuring the feasibility of the proposed system were presented in section 5.2 of the chapter. The mapping of current and proposed automated processes was also discussed in section 5.3. The subsequent sections of the chapter discussed the implementation of the proposed system, the conclusion of the study, recommendations to stakeholders of the research study and suggested future works.

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APPENDICES

Appendix A: Student Questionnaire

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE

Student questionnaire

Dear Respondent,

I am a student pursuing a Master of Science Degree in Computer Science. I am currently doing a research on: **Enhancement of National Examinations Administration Using Mobile Technologies: A case of Malawi National Examinations Board**. You form part of the group selected to participate in the study by answering some few questions. The study is purely academic and any information you provide will be treated with maximum privacy.

Instructions

1. Answer all questions
2. Tick or circle the correct answers where provided
3. Write answers for the other questions in the spaces provided

Section A: Personal Data

1. What is the name of your school _____
2. In which district and region is your school _____
3. Type of your school
    a. Government/Public
    b. Private
4. What is the location of your school
    a. Urban
    b. Rural
5. In which class/grade are you?
    a. Form One
    b. Form Two
    c. Form Three
    d. Form Four
6. Have you ever registered and sat for national examinations (MANEB) before?
    a. Yes
    b. No
7. If yes, which examinations
    a. PSLCE
    b. JCE
    c. MSCE

Section B: Examinations Procedures

8. How can you describe the registration process for MANEB examinations?
    a. Very good
    b. Good
    c. Poor
    d. Very poor
9. Did you verify your registration details when registration period was closed?
    a. Yes
    b. No

10. How did you access your examinations results after being released?
    a. Through the school
    b. Through District Education Manager's office
    c. Through MANEB
    d. Through the Internet
11. How long did it take to know your examinations results?
    a. Instantly
    b. Within a day
    c. After a few days
    d. After some weeks
12. How can you describe process of administration of national examinations (registration, verification and dissemination of results)?
    a. Very good
    b. Good
    c. Poor
    d. Very poor

Section C: Use of Mobile Services

13. Do you or your parents/any relative have a mobile phone?
    a. Yes
    b. No
14. Are you able to send and read Short Message Service (SMS) using a cell phone?
    a. Yes
    b. No
15. Have you ever used any mobile payment service?
    a. Yes
    b. No
16. If yes, which of the following mobile payment service have you used?
    a. Airtel Money
    b. TNM Mpamba
    c. Zoona

17. In your opinion, can the use of mobile phones help to improve the administration of national examinations (Registration, Verification, Fees payment and Results dissemination)?
    a. Yes
    b. No
    c. Not sure

THANK YOU SO MUCH FOR RESPONDING TO THE QUESTIONS

Appendix B: Teacher Questionnaire

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE

Teachers questionnaire

Dear Respondent,

I am a student pursuing a Master of Science Degree in Computer Science. I am currently doing a research on: **Enhancement of National Examinations Administration Using Mobile Technologies: A case of Malawi National Examinations Board**. You form part of the group selected to participate in the study by answering some few questions. The study is purely academic and any information you provide will be treated with maximum privacy.

Instructions

4. Answer all questions
5. Tick or circle the correct answers where provided
6. Write answers for the other questions in the spaces provided

Section A: Personal Data

1. Name of your school_____
2. District and Region _____
3. School category
   a. Secondary
   b. Primary
4. School type
   a. Government/Public
   b. Private
5. School locality
   a. Urban
   b. Rural
6. What is your position at the school?
   a. Head teacher
   b. Deputy Head teacher
   c. Head of Department
   d. Ordinary teacher
7. Are you involved in the process of students' registration for national examinations (MANEB)?
   a. Yes
   b. No

Section B: Examinations procedures

8. Would you briefly describe how registration of students for national examinations is done?

_____

_____

_____

_____

_____

9. What are the challenges that are associated with the current registration process?

_____

_____

_____

_____

10. Is verification of registration details done at your school?
    a. Yes
    b. No
11. If yes, how are observed errors rectified?

_____

_____

_____

12. Have some students over the past years failed to sit for national examinations due to irregularities in the current registration and verification processes?
    a. Yes
    b. No
    c. Not sure
13. How do students pay the examinations fees to MANEB?
    a. Through the bank
    b. Through school cashier/bursar
14. How do students access their examinations results?
    a. Checking with District Education Office (DEM)
    b. Checking with the school
    c. Checking with MANEB
    d. Through the internet
15. How can you rate the reliability of the whole examinations administration (Registration, Verification, Results dissemination and Fees payment)?
    a. Very reliable
    b. Reliable
    c. Somehow reliable

d. Not reliable

Section C: Mobile technology

16. In your opinion, do you think using mobile technology i.e. Short Message Service (SMS) can help to mitigate the anomalies in the current system?
    a. Yes
    b. No
    c. Not sure
17. If yes, would you commend the introduction of SMS based system of registering students as well as dissemination of examinations results?
    a. Yes
    b. No
    c. Not sure
18. Would you recommend the use of mobile payment method i.e. airtel money, TNM mpamba, Zoona etc for payment of examinations fees by students?
    a. Yes
    b. No
    c. Not sure

THANK YOU SO MUCH FOR RESPONDING TO THE QUESTIONS

Appendix C: Parent Questionnaire

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF COMPUTER SCIENCE

Parents questionnaire

Dear Respondent,

I am a student pursuing a Master of Science Degree in Computer Science. I am currently doing a research on: **Enhancement of National Examinations Administration Using Mobile Technologies: A case of Malawi National Examinations Board**. You form part of the group selected to participate in the study by answering some few questions. The study is purely academic and any information you provide will be treated with maximum privacy.

Instructions

7. Answer all questions
8. Tick or circle the correct answers where provided
9. Write answers for the other questions in the spaces provided

Section A: Personal Data

1. What is your gender?
    a. Male
    b. Female
2. Where are you currently staying (District and Region) _____
3. What is the locality of your area of stay?
    a. Urban
    b. Semi Urban
    c. Rural
4. Have any of your children sat for national examinations (MANEB)?
    a. Yes
    b. No
5. If yes, how can you describe the process of registration for national examinations?
    a. Very good
    b. Good
    c. Poor
    d. Bad
6. How long did it take you to access examination results of your child after being released?
    a. Instantly
    b. Within a day
    c. After a few days
    d. After some weeks
7. Do you have a mobile (cellular) phone?
    a. Yes
    b. No
8. If yes, which service provider do you use?
    a. Airtel
    b. TNM
    c. Access _____
    d. MTL
9. For how long have you been using a mobile phone

Section B: Mobile Phone Usage

10. Do you know to send and read a Short Message Service (SMS) using a phone?
    a. Yes
    b. No
11. Have you ever used any mobile payment facility?
    a. Yes
    b. No
    c. Can't remember
12. If yes, which of the following facilities have you used?
    a. Airtel Money
    b. TNM Mpamba
    c. Zoona
13. Do you think using mobile phones can improve registration and access to examination results of students?
    a. Yes
    b. No
    c. Not sure

THANK YOU SO MUCH FOR RESPONDING TO THE QUESTIONS

Appendix D: Interview guide

Research Interview Guide

1) Explain in detail how the following activities are done as far administration of national examinations is concerned:
    a. Registration
    b. Verification
    c. Dissemination of results
2) What is required of students to register for national examinations?
3) How long does the verification of registration details take?
4) What can you say about the degree/magnitude of errors that are observed during verification exercise?
5) Does MANEB afford to rectify all the anomalies before students sit for examinations?
6) Are examinations results accessed by students or their parents in good time?
7) What do you think are the major challenges that the processes you have explained in question 1 have?
8) Do you think that introducing a mobile SMS application for registration, verification and dissemination of results would help solve the problems experienced?
9) In your own thinking, what do you think should be done to eradicate the current challenges?

THANK YOU SO MUCH FOR RESPONDING TO THE QUESTIONS

Appendix E: Code Listing

USSD Code

```
ini_set('display_errors', -1);

define('FLOG_FILE_NAME', 'logs/sdms_' . date('Y-m-d') . '.log');

include_once('flog.php');

include_once 'db.php';

$req_xml = file_get_contents("php://input");

//Create XMLRPC Server

$xmlrpc_server = xmlrpc_server_create();

//register the entry method to the XMLRPC server

@xmlrpc_server_register_method($xmlrpc_server,"USSD_MESSAGE",
"application_entry");

//start the server listener

header('Content-Type: text/xml');

$response = xmlrpc_server_call_method($xmlrpc_server, $req_xml, array());

echo $response;

function application_entry($method_name, $params, $user_data) {

    ////flog("Received request is\n" . print_r($params, true));

    $payload = $params[0];

    $req_seq = $payload['SEQUENCE'];

    //$req_end_of_ses = $payload['END_OF_SESSION'];

    $req_lang = $payload['LANGUAGE'];

    $req_ses_id = $payload['SESSION_ID'];

    $req_imsi = $payload['IMSI'];
```

```
$req_service_key = $payload['SERVICE_KEY'];

$msisdn = $payload['MOBILE_NUMBER'];

$req_body = isset($payload['USSD_BODY']) ? $payload['USSD_BODY'] : "1";

$session_id = $msisdn . $req_ses_id;

session_id($session_id); //Create unique session ID

session_start(); // Start the session

//Lets load the menu from the json file

$menusConfig = "sdms_menu.json";

$menu = json_decode(file_get_contents($menusConfig), true);

if (!is_array($menu) || count($menu) <= 0) {

    //Failed to load the menu file. We end the session and exit......

    unset($_SESSION);

    exit;

}

if (!isset($_SESSION['menu_option'])) {

    //Its the main menu in play here

    $gw_response = get_response_array($msisdn, $req_ses_id, $req_seq,

    $menu['main'], 'FALSE');

    $_SESSION['menu_option'] = "1";    //Initialize main menu to 1

    // //flog("Menu option is " . $_SESSION['menu_option']);

} else {

    //Process the main menu selection

    switch ($_SESSION['menu_option']) {

        case "1":
```

```
        $response = process_main_menu_response($msisdn, $req_body,
        $menu);
        break;
    case "1.1":
        $response = process_exam_room_choice($msisdn, $req_body,
        break;
    case "1.2":
        $response = process_exam_no($msisdn, $req_body, $menu);
        break;
    case "1.3":
        $response = process_names($msisdn, $req_body, $menu);
        break;
    case "1.4":
        $response = process_dob($msisdn, $req_body, $menu);
        break;
    case "1.5":
        $response = process_sex_choice($msisdn, $req_body, $menu);
        break;
    case "1.6":
        $response = process_category_choice($msisdn, $req_body,
        $menu);
        break;
    case "1.7":
        $response = process_exam_center($msisdn, $req_body, $menu);
```

```
                break;
            case "1.8":
                $response = process_district_choice($msisdn, $req_body,
               $menu);
                break;
            case "2.1":
                $response = process_view_details($msisdn, $req_body, $menu);
                break;
            case "3.1":
                $response = process_view_results($msisdn, $req_body, $menu);
                break;
            default:
                $gw_response = get_response_array($msisdn, $req_ses_id,
                $req_seq, $menu['main'], 'FALSE');
                $_SESSION['menu_option'] = "1";    //Initialize main menu
                break;
        }
    }
  if (!isset($gw_response)) {
        //Only if it has not yet been set -:)
        $gw_response = get_response_array($msisdn, $req_ses_id, $req_seq,
        $response[1], $response[0]);
    }
    return $gw_response;
```

```
}

function  process_exam_room_choice($msisdn,  $subscriber_input,  $menus_config)
{

    if ($subscriber_input == "1") {

        $_SESSION['exam_room'] = "Grade 7";

        $_SESSION['menu_option'] = "1.2";

        $fn_response = array('FALSE', $menus_config['1.2']);

    } elseif ($subscriber_input == "#") {

        $_SESSION['menu_option'] = "1";

        $fn_response = array('FALSE', $menus_config['main']);

    } else {

        $_SESSION['menu_option'] = "1.1";

        $fn_response = array('FALSE', $menus_config['1.1']);

    }

 return $fn_response;

}

function process_exam_no($msisdn, $subscriber_input, $menus_config) {

    if (strlen($subscriber_input) >= 10 && strlen($subscriber_input) <= 15) {

        $_SESSION['exam_no'] = $subscriber_input;

        $_SESSION['menu_option'] = "1.3";

        $fn_response = array('FALSE', $menus_config['1.3']);

    } else {

        $_SESSION['menu_option'] = "1.2";

        $fn_response = array('FALSE', $menus_config['wrong_exam_no_format']);
```

```
    }
return $fn_response;
}
function process_view_details($msisdn, $subscriber_input, $menus_config) {
    if (strlen($subscriber_input) >= 10 || $subscriber_input <= 15) {
        $msg = build_final_msg($subscriber_input, $menus_config);
        $_SESSION['menu_option'] = "";
        $fn_response = array('TRUE', $msg);
    } else {
        $_SESSION['menu_option'] = "2.1";
        $fn_response = array('FALSE', $menus_config['wrong_exam_no_format']);
    }
return $fn_response;
}
function process_view_results($msisdn, $subscriber_input, $menus_config) {
    flog("I can get in view results");
    if (strlen($subscriber_input) >= 10 || $subscriber_input <= 15) {
        $msg = build_final_msg2($subscriber_input, $menus_config);
        $_SESSION['menu_option'] = "";
        $fn_response = array('TRUE', $msg);
    } else {
        $_SESSION['menu_option'] = "3.1";
        $fn_response = array('FALSE', $menus_config['wrong_exam_no_format']);
    }
```

```
return $fn_response;

}

function save_record() {

    //initialize db access class

    try {

        $db = new db();

    } catch (Exception $ex) {

        //Error occured during db class initialization

        $response = FALSE;

    }

    $exam_no = $_SESSION['exam_no'];

    $exam_room = $_SESSION['exam_room'];

    $names = $_SESSION['names'];

    $dob = $_SESSION['DOB'];

    $sex = $_SESSION['sex'];

    $cat = $_SESSION['cat'];

    $center = $_SESSION['center'];

    $district = $_SESSION['district'];

    $subj = 6;

    $subjects = "Science,Social Studies, English,Maths,Creative Arts";


$sql="INSERTINTOcandidate(exam_no,name,dob,sex,cat,center,dem_name,sub_num,su
b,exam_room)"VALUES('$exam_no','$names','$dob','$sex','$cat','$center','$dist
rict',$subj,'$subjects','$exam_room')";

    ////flog("Query is:$sql");
```

```
    $query = $db->query($sql);
    ////flog("Insert response is:$query");
    if ($query == TRUE) {
        $response = TRUE;
    } else {
        $response = FALSE;
    }
 return $response;
}
function build_final_msg($input, $menus_config) {
    //initialize db access class
    try {
        $db = new db();
    } catch (Exception $ex) {
        //Error occured during db class initialization
        $msg = $menus_config['system_error'];
    }
    $sql = "SELECT * FROM candidate WHERE exam_no=$input";
    $result = $db->select($sql);
    if (count($result) > 0 && !empty($result)) {
        //Customer is registered
        foreach ($result as $value) {
            $msg=str_replace("{examnumber}",$value['exam_no'],
            $menus_config['view_details_msg']);
```

```
            $msg = str_replace("{Names}", $value['name'], $msg);

            $msg = str_replace("{DOB}", $value['dob'], $msg);

            $msg = str_replace("{sex}", $value['sex'], $msg);

            $msg = str_replace("{category}", $value['cat'], $msg);

            $msg = str_replace("{center}", $value['center'], $msg);

            $msg = str_replace("{district}", $value['dem_name'], $msg);

        }

    } else {

        $msg = $menus_config['no_record'];

    }

    return $msg;

}

function build_final_msg2($input, $menus_config) {

    //initialize db access class

    try {

        $db = new db();

    } catch (Exception $ex) {

        //Error occured during db class initialization

        $msg = $menus_config['system_error'];

    }

$sql = "SELECT * FROM result WHERE exam_no='$input'";

    $result = $db->select($sql);

    if (count($result) > 0 && !empty($result)) {

        //Customer is registered
```

```
        foreach ($result as $value) {

$msg=str_replace("{eng}",$value['sub_1'],$menus_config['results_msg']);
            $msg = str_replace("{maths}", $value['sub_2'], $msg);
            $msg = str_replace("{scie}", $value['sub_3'], $msg);
            $msg = str_replace("{ss}", $value['sub_4'], $msg);
            $msg = str_replace("{he}", $value['sub_5'], $msg);
            $msg = str_replace("{carts}", $value['sub_6'], $msg);
        }
    } else {
        $msg = $menus_config['no_record'];
    }
  return $msg;
}
function process_names($msisdn, $subscriber_input, $menus_config) {
    if (!preg_match('/[0-9]/', $subscriber_input)) {
        $_SESSION['names'] = $subscriber_input;
        $_SESSION['menu_option'] = "1.4";
        $fn_response = array('FALSE', $menus_config['1.4']);
    } else {
        $_SESSION['menu_option'] = "1.3";
        $fn_response = array('FALSE', $menus_config['wrong_names']);
    }
 return $fn_response;
```

```
}
function process_dob($msisdn, $subscriber_input, $menus_config) {
    if (validateDate($subscriber_input) == True) {
        $_SESSION['DOB'] = $subscriber_input;
        $_SESSION['menu_option'] = "1.5";
        $fn_response = array('FALSE', $menus_config['1.5']);
    } else {
        $_SESSION['menu_option'] = "1.4";
        $fn_response = array('FALSE', $menus_config['Wrong_dob_format']);
    }
 return $fn_response;
}
function process_sex_choice($msisdn, $subscriber_input, $menus_config) {
    if ($subscriber_input == 1 || $subscriber_input == 2) {
        if ($subscriber_input == 1) {
            $_SESSION['sex'] = "Male";
        } else {
            $_SESSION['sex'] = "Female";
        }
        $_SESSION['menu_option'] = "1.6";
        $fn_response = array('FALSE', $menus_config['1.6']);
    } elseif ($subscriber_input == "#") {
        unset($_SESSION);
        $_SESSION['menu_option'] = "1";
```

```
        $fn_response = array('FALSE', $menus_config['main']);
    } elseif ($subscriber_input == "00") {
        //One step back
        $_SESSION['menu_option'] = "1.4";
        $fn_response = array('FALSE', $menus_config['1.4']);
    } else {
        $_SESSION['menu_option'] = "1.5";
        $fn_response = array('FALSE', $menus_config['1.5']);
    }
 return $fn_response;
}
function process_category_choice($msisdn, $subscriber_input, $menus_config) {
    if ($subscriber_input == 1 || $subscriber_input == 2) {
        if ($subscriber_input == 1) {
            $_SESSION['cat'] = "Internal";
        } else {
            $_SESSION['cat'] = "External";
        }
        $_SESSION['menu_option'] = "1.7";
        $fn_response = array('FALSE', $menus_config['1.7']);
    } elseif ($subscriber_input == "#") {
        unset($_SESSION);
        $_SESSION['menu_option'] = "1";
        $fn_response = array('FALSE', $menus_config['main']);
```

```
    } elseif ($subscriber_input == "00") {

        //One step back

        $_SESSION['menu_option'] = "1.5";

        $fn_response = array('FALSE', $menus_config['1.5']);

    } else {

        $_SESSION['menu_option'] = "1.6";

        $fn_response = array('FALSE', $menus_config['1.6']);

    }

return $fn_response;

}

function process_exam_center($msisdn, $subscriber_input, $menus_config) {

    if (!empty($subscriber_input)) {

        $_SESSION['center'] = $subscriber_input;

        $_SESSION['menu_option'] = "1.8";

        $fn_response = array('FALSE', $menus_config['1.8']);

    } else {

        $_SESSION['menu_option'] = "1.7";

        $fn_response = array('FALSE', $menus_config['1.7']);

    }

    return $fn_response;

}

function process_district_choice($msisdn, $subscriber_input, $menus_config) {

    if ($subscriber_input == 1 || $subscriber_input == 2 || $subscriber_input
== 3 || $subscriber_input == 4) {
```

```
    if ($subscriber_input == 1) {

        $_SESSION['district'] = "Lusaka";

    } elseif ($subscriber_input == 2) {

        $_SESSION['district'] = "Kafue";

    } elseif ($subscriber_input == 3) {

        $_SESSION['district'] = "Chibombo";

    } else {

        $_SESSION['district'] = "Chongwe";

    }

    $result = save_record();

    ////flog("Save record response is:$result");

    if ($result == TRUE) {

        $_SESSION['menu_option'] = "cofirm_msg";

        $fn_response = array('TRUE', $menus_config['cofirm_msg']);

    } else {

        $_SESSION['menu_option'] = "";

        $fn_response = array('TRUE', $menus_config['system_error']);

    }

} elseif ($subscriber_input == "#") {

    unset($_SESSION);

    $_SESSION['menu_option'] = "1";

    $fn_response = array('FALSE', $menus_config['main']);

} elseif ($subscriber_input == "00") {

    //One step back
```

```
        $_SESSION['menu_option'] = "1.7";
        $fn_response = array('FALSE', $menus_config['1.7']);
    } else {
        $_SESSION['menu_option'] = "1.8";
        $fn_response = array('FALSE', $menus_config['1.8']);
    }
    return $fn_response;
}
/**
 * Function for preparing the response payload - reponse to the USSD Gateway.
 *
* @param ses_id
 * @param seq
 * @param body
 * @param is_end_of_ses
 *
 */
function get_response_array($msisdn, $ses_id, $seq, $body, $is_end_of_ses) {
    $response = array();
    $response['RESPONSE_CODE'] = '0';
    $response['SESSION_ID'] = $ses_id;
    $response['SEQUENCE'] = $seq;
    $response['USSD_BODY'] = $body;
    $response['END_OF_SESSION'] = $is_end_of_ses;
```

```
    $response['REQUEST_TYPE'] = 'RESPONSE';


    if ($is_end_of_ses == 'TRUE' && isset($_SESSION['menu_option'])) {
        //We clean up the session values
        session_destroy();  //Clean up the session.
        unset($_SESSION); //Finalize the cleaning up.
    }
 return $response;
}
/**
 * Function for processing the selected option on the main menu
 * @param $msisdn
 * @param $subscriber_input
 * @param $menus_config
 */
Function  process_main_menu_response($msisdn,$subscriber_input,  $menus_config)
{
    switch ($subscriber_input) {
        case "1":
            $_SESSION['menu_option'] = "1.1";
            $fn_response = array('FALSE', $menus_config['1.1']);
            break;
        case "2":
            $_SESSION['menu_option'] = "2.1";
```

```
            $fn_response = array('FALSE', $menus_config['2.1']);
            break;
        case "3":
            $_SESSION['menu_option'] = "3.1";
            $fn_response = array('FALSE', $menus_config['3.1']);
            break;
        case "4":
            $_SESSION['menu_option'] = "";
            $fn_response = array('TRUE', $menus_config['exit']);
            break;
        default:
            $_SESSION['menu_option'] = "1";
            $fn_response = array('FALSE', $menus_config['main']);
            break;
    }
 return $fn_response;
}
function validateDate($date) {
    $d = DateTime::createFromFormat('Y-m-d', $date);
    return $d && $d->format('Y-m-d') === $date;
}
?>
```

LIST OF PUBLICATIONS

L. Solomon and J. Phiri, "Enhancing the Administration of National Examinations using Mobile Cloud Technologies: A case of Malawi National Examinations Board", International Journal of Advanced Computer Science and Applications (IJACSA), Vol. 8, no. 9, pp. 294-305, September 2017, DOI:10.14569/IJACSA.2017.080942.