UNIVERSITY OF ZAMBIA

Automation of The Candidate Registration For School Examinations In Zambia Using The Cloud Model

by

Banji Milumbe

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

The University of Zambia
School of Natural Sciences

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2017

Declaration

I, the undersigned declare that the work in this dissertation is original except where indicated by special reference in the text and no part of the research has been submitted for any other degree, diploma or academic qualification. I further declare that the research has not been presented to any other College/University for examination either in Zambia or outside Zambia

Name: .....

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Certificate of Approval

This document by BANJI MILUMBE is approved as partial fulfilment of the requirements for the award of the degree of Master of Science in Computer Science of the University of Zambia.

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Abstract

Registration of candidates is one of the activities examination bodies undertake in order to fulfil their mandate of conducting examinations and awarding certificates to deserving candidates. In today's world, utilisation of information and communication technology (ICT) has become an integral component in organisations to improve efficiency and effectiveness. This study's focus is on the candidate registration process at the Examinations Council of Zambia (ECZ), a body mandated to conduct public examinations in Zambia.

A baseline study was conducted in order to understand the challenges faced by ECZ in the registration of candidates for school examinations. The results of the baseline study show that 80 percent of the challenges were attributed to the current desktop application's failure to capture all candidate entries leading to omission of candidates, duplication of entries and loss of data. The study also revealed that 91 percent of the respondents use internet and 92 percent submitted that using a web based system for registering candidates for national examinations would improve efficiency.

Based on the results of the baseline study, a candidate registration model based on the cloud architecture was designed and used to develop a prototype that integrates mobile application, the bulk short message service (SMS) and barcode technology. The test results of the proposed system showed improved efficiency and reduced cycle time in the candidate registration process.

Keywords:

Web based application; short message service; SMS; cloud computing; candidate registration; desktop application; school examinations; Information and Communication Technology; ICT; bulk short message service; bulk SMS.

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Dedication

I would love to dedicate this research project to my beloved husband Jeremiah and my three amazing daughters, Buyemba, Nduba and Komana. There is no doubt in my mind that without their continued support and counsel I could not have completed this process.

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Acronyms

The acronyms used in this thesis are presented below:

AWS	Amazon Web Services
CSA	Cloud Security Alliance
CSP	Cloud Service Provider
DEBS	District Education Board Secretary
DRS	Data Research Services PLC
EAD	Examinations Administration Department
ECRS	Electronic Candidate Registration System
ECZ	Examinations Council of Zambia
ESO-GI	Education Standards Officer – General Inspections
GAE	Google Apps Education
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technology
IELTS	International English Language Testing Service
ITD	Information Technology Department
JAMB	Joint Admissions and Matriculation Board
KNEC	Kenya National Examinations Council
MANEB	Malawi National Examinations Board
MOGE	Ministry of General Education
NECTA	National Examinations Council of Tanzania
OCLC	Online Computer Library Centre
OMR	Optical Mark Read(er)

OPAC	Online Public Access Catalogue
PEO	Provincial Education Officer
PHP	Hypertext Preprocessor
SESO	Senior Education Standards Officer
SLA	Service Level Agreement
SMS	Short Messaging Service
TOEFL	Test of English as a Foreign Language
WAEC	West Africa Examinations Council
WASSCE	West African Senior Secondary Certificate Examination

List of Keywords

A brief description of the main concepts dealt with in the study is presented below. Different scholars have defined them in different ways. However, in this study they will mean as defined below:

Attendance Register	A listing of names of candidates by subject who have been dully registered to sit for an examination.
Examination	An assessment or test given to a candidate to assess their competencies at the completion of the curriculum.
Examination Centre	A school that is approved to conduct examinations in their premises and has been assigned an examination centre number.
Examination Material	Any material that is used for examination purposes
Headquarter Stock	Examination Materials that are kept at the Examinations Council of Zambia and are used in case of any emergency.
Candidate	Any person who has applied to sit an examination prepared by ECZ.
Illegal Candidate	A candidate who sits an examination without having registered for such an examination.

Candidate Registration	The process by which candidate details and subjects they intend to sit an examination in are captured.
Provisional Register	A document showing a list of candidates and the subjects they intend to sit an examination for used for verification of the candidate details.
Pupil	Any school going person.
Underprotest Candidate	A candidate who is dully registered to sit an examination but writes a subject that they have not registered.
Examination Malpractice	Any conduct in an examination that is likely to advantage or disadvantage a candidate.
Candidature	Number of candidates entering for an examination.

Chapter One

1.0 Introduction

This chapter presents the background to this study on the registration of candidates for school examinations in Zambia. We begin by looking at a brief introduction to the research, the motivation, scope, statement of the problem, aim, objectives, and research questions, significance of the study and research contributions. Finally the organisation of the thesis and the summary of the chapter are also presented.

1.1 Introduction to the Research

In recent years, the use of technology has become a vehicle for improving an organisation's business processes. A business process refers to a set of logically related tasks and behaviours that organisations develop over time to produce specific business results and the unique manner in which these activities are organised and coordinated [1]. Organisations in this digital age deal with large amounts of data. More so examining bodies deal with massive data that pertain to candidates' personal details, subject entries, results and certificate data. It is important to ensure that the information obtained from public examinations is complete and of high quality in order to enhance decision making.

The Examinations Council of Zambia (ECZ) was created by an Act of Parliament Number 15 of 1983 [2] whose main purpose was to set and conduct examinations and award certificates to successful candidates [3]. The full launch and operationalization of the Examinations Council of Zambia was in 1987 as a semi-autonomous public institution [4], four years after the enactment.

Since the launch of ECZ, there has been a general exponential increase in

candidature especially in the last seven (7) years from a total of 740,361in 2009 to 971,187 in 2015 representing an increase of over 30 percent [5]. The upsurge in the number of candidates registering for examinations raised concerns over the quality, and security of candidates' data and the entire examination procedures [6]. This growth has put a heavy strain on the examination body and some measures that are being undertaken include streamlining the operations and restructuring. However the soaring costs of printing examinations materials, distribution and data capture remain daunting and need a much more aggressive approach. This is especially in the areas of information capture, data storage, candidate registration, modernising and automating most of the manual processing systems as well as harnessing the alternative data capture technologies from the current systems.

Since the Examinations Council of Zambia became operational in 1987, the methods of registering candidates have changed from the mere manual system to use of Optical Mark Read (OMR) forms and then in 2009 a desktop application was developed and implemented. Throughout this transitioning from one method to another challenges have been encountered which have compromised the quality of examination records of some candidates.

According to an internal audit carried out on the verification of examination entries [7], a number of disparities were found between the candidates entered at the school level and those that appeared on the final examination attendance register from the Examinations Council of Zambia. The internal audit findings showed that there were also omissions of some candidates, wrong subjects entered and in some instances no proper record of the candidate. Due to this revelation, it became necessary that the candidate registration process be automated further so as to intensify monitoring of the whole process and also put stringent measures that would detect double entries and wrong examination numbers.

1.2 Motivation

The need to eliminate the challenges that have been experienced in the candidate registration process in Zambia for school examinations cannot be over emphasised. Having observed the challenges mentioned in [7] [8] [9]that ECZ has faced in the candidate registration process over the years and the effects on the management of examinations as well as on the candidates, has prompted the need to further investigate the issues surrounding these errors and propose a solution.

Given the advancements in technology and new ways of capturing people's details like candidate details for school examinations, it has become increasingly important to design a new system of registering candidates which will remove third party handling of data. This system should be web based with some reference information to ensure that data are correctly entered and also with centralised reporting. In addition, a system that addresses these challenges will benefit the management of the whole examination process by ensuring improved efficient and effective service delivery.

1.3 Scope

This research involved a baseline study that was conducted in the ten (10) provinces of Zambia, sixty two (62) districts and fifty (50) schools that established the challenges faced by the Examinations Council of Zambia concerning the registration of candidates. A candidate registration model and the software prototype based on the cloud model was implemented in this study as well as the use of barcode technology in the candidate identity. The results of this research were statistical analyses of the data from the study conducted in all ten (10) provinces of Zambia in selected schools and districts. The detailed

implementation using the cloud technologies was beyond the scope of this study.

1.4 Problem Statement

The ECZ has continued to face challenges in the candidate registration process despite changing the system for registering candidates for school examinations. Errors such as omissions of candidates and subject details, misspelt names, and non- capturing of candidate details have continued to occur [10]. As a result, the information on the final examination attendance register is incomplete and a lot of time is spent correcting these errors.

With the introduction of the General Certificate of Education (GCE) mid-year examination in 2014 [11], the number of examination sessions has increased and this underscores the need for efficient and effective ways of capturing candidates' registration details. If challenges in the candidate registration process are not addressed, this will result in undersupply or oversupply of examination materials. In the case of undersupply, some candidates may not sit the examinations whereas in the case of oversupply, it gives room for examination malpractices and wastage of resources. It is against this background that this study attempted to address the questions in section 1.8.

1.5 Aim

The aim of this study was to design and develop a candidate registration system using the cloud model in order to enhance efficiency and effectiveness in the registration process.

1.6 Objectives

The following were the objectives of the research:-

1. To conduct a baseline study in order to establish the challenges faced by ECZ in the registration of candidates for school examinations.

2. To develop a cloud model based on ECZ business processes in order to address the challenges in (1).

3. To build a web based prototype that integrates bulk SMS system based on the model in (2) to address the challenges in (1).

1.7 Research Questions

The research questions emanating from the problem were:-

1. What are the challenges faced by ECZ in the registration of candidates for school examinations?

2. Is it possible to develop a cloud model based on ECZ business processes in order to address the challenges in (1)?

3. How can we come up with a web based prototype integrated with bulk SMS which is based on the model in (2) to address challenges in (1)?

1.8 Significance of the Research

An evaluation of the candidate registration process for school examinations is worth undertaking as it would help come up with interventions to address the challenges in the current registration process. If the causes of the errors were identified, it would help the ECZ to redesign the candidate registration process

based on the evidence found.

This study therefore is significant as it will help the Examinations Council of Zambia to change systems and procedures for capturing candidate registration data so as to attain the desired standard of data quality. Furthermore, it is important to note that while studies related to performance of candidates in examinations and their attendance have been conducted in Zambia, there is very little body of evidence on challenges related to candidate registration for school examinations.

1.9 Research Contributions

The challenges faced with registration of candidates for school examinations were identified which would help the ECZ come up with interventions to address the challenges in the candidate registration process.

A candidate registration system that uses the cloud model and integrates bulk SMS was developed and tested. Part of this work has been piloted by ECZ and will be implemented as a fully-fledged system.

1.10 Organization of the Thesis

The study includes the following chapters: Chapter 1 discusses the background of the study and problem statement. Chapter 2 discusses the literature review and the related works. Chapter 3 highlights the determination of the research design and methodology of both the baseline study and the system automation; Chapter 4 is the presentation of the findings of the baseline study and the system implementation and testing. Finally, Chapter 5 discusses the findings, draws the conclusions and recommendations are given.

1.11 Summary

This chapter focused on the introduction to the research, statement of the problem, aim of the study, the objective of the study, research questions, motivation, significance and scope of the work.

The next chapter evaluates the significance of this study in relation to the related literature from studies that were conducted responding to similar challenges arising from the need to improve the efficiency in the candidate registration process.

Chapter Two

2.0 Literature Review

2.1 Introduction

This Chapter focuses on the literature reviewed about the role of ICT in the Education Sector, Web-based systems and their advantages, Desktop applications, a comparison of desktop applications and web application, web-based systems integrated with bulk SMS, Cloud Computing advantages and disadvantages, security issues with cloud computing and the solutions offered, barcode technology, challenges with candidate registration and solutions implemented by other examining bodies. The chapter ends by looking at related works where cloud computing has been applied.

2.2 The Application of ICT in Business

The use of technology and proliferation of computers and internet use has brought about a lot of changes in the way organisations conduct their businesses. Not only in the business world but also in the education sector where the application of ICTs has brought about improvements in the education processes such as administration, assessment and management of various stages in the education sector. The application of ICT in business and social life as noted by [12] has opened up new possibilities for running and managing organisations, for marketing products and services and for communication between individuals and groups. The proper, planned use of ICT can be highly beneficial but the mere fact of using ICT does not of itself automatically accrue benefits. If ICT is misapplied or installed without sufficient analysis of the real management or organisational

problems then no benefits will be gained and money will be wasted [12]. As [13] rightly put it, ‘Successful firms are those that learn how to use the new technologies’. What a business would like to do in five years often depend on what its systems will be able to do [13].

The internet has made work easier in that one can access different facilities anywhere anytime. Applications are being developed that enable information to be received in real-time regardless of the user’s location. Lucey, 2005 further states that internet has opened up numerous possibilities for doing business at a local and global level. It enables business to interact with other businesses (business-to-business or B2B) and with customers (business-to-consumer or B2C) more directly. Information can be exchanged directly through the internet that has become an invaluable and integral part of business and personal life in the modern world [12]. With the rapid development of processing and storage technologies and success of the internet, computing resources have become cheaper, more powerful and more available than ever before. This technological trend has enabled the realisation of a new computing model called cloud computing, in which resources are provided as general utilities that can be leased and released by users through the internet in an on-demand fashion [14].

2.3 Review of the Literature

2.3.1 The Role of ICT in the Education Sector

Information and Communication Technologies (ICTs) are versatile and powerful technologies whose role in the system of assessment in education is vital. The examination system is one of the key contemporary issues as technology continues to play a transforming role in societies all over the world. The prospects for the utilisation of new technologies in the field of education continue to be part of the transformations that has hit the education sector with a

strong bearing on the assessment and evaluation of the education system in public examinations. In their study, [15] established that ICT can be utilised as an integral component to improve efficiency, effectiveness and excellence in learning, teaching and assessment [15].

Harding and Raikes assert that in the world of ICT-led innovation, new styles of learning have an exciting image but assessment usually fails to raise much enthusiasm even though it is a vital component of education as a whole. Computer based learning is clearly set to play an increasingly important role in education, but this is turning out to be a much more complex matter than many of the pioneers of ICT in learning envisaged [16].

In examinations, developed nations have long adopted the use of ICT to conduct their examinations. Globally recognized and reputable examinations like TOEFL, IELTS, and many others are some of the examinations conducted using ICT. The use of ICT to conduct examination by Joint Admissions and Matriculation Board (JAMB) has given the Nigerian educational system a new lease of life in terms of the paradigm shift. The benefits realised include; saving of time and manpower for the test administration, Faster and more controlled test revision process, fewer response interpretation errors (reading, decoding), Convenience of individualised administration at requested date and location, improved test security due to electronic transmission and encryption and improved translation and localisation with universal availability of content [17]

According to [6], some of the benefits the education sector and its clientele stand to derive from automated assessments and examinations include: lower long-term costs, instant feedback to students, creation of digital records of student growth and development which can easily be passed along from grade to grade, greater storage efficiency, increased productivity and low operational variability.

Internet has created a technology innovation, a new digital market place, rendering the need for centralised cloud service unavoidable. [18], [19], [20], [21] [22]. While the enterprise begins to embrace the internet of things via the ability to communicate more digitally, the promises of business improvement at a reduced shared cost is leaking quietly. The emerging cloud computing utility model of shared services has now benefited enterprise to focus on the core competencies and pay for only the services rendered. This also applies to education sector where a number of services can be shared.

While having technology innovation enables to open new digital market place and enhance operating efficiency, it does not guarantee improved competitiveness. Services like business processes reengineering, customer experience and technology adoption contributes a bigger share for enterprise wealth. Information services are the contribution from the integration of Information Technology and Information Processes. Cloud computing utility model have begun to mature in almost every enterprise, including Infrastructure as a Service (IaaS) [23].

Employing new technology in any project implies certain inherent risks, so an adequate technology management is a precondition for a successful software development project [24]. In the education sector also ‘besides these ‘traditional’ qualities, evolution of the market puts forward new quality requirements’ [25].

Examinations bodies should not fear to put their systems on the cloud but instead put measures in place to ensure safety and availability of the systems. That is why in the proposed model, the backup servers are locally hosted so that if the cloud service is unavailable, the systems would continue running and data would be synchronised once the cloud service is available.

2.3.2 Cloud Computing

Computing is being transformed to a model consisting of services that are commoditised and delivered in a manner similar to utilities such as water, electricity, gas, and telephony. In such a model, users access services based on their requirements regardless of where the services are hosted. Several computing paradigms have promised to deliver this utility computing vision [26]. Many scholars have defined cloud computing and we will consider two (2) definitions. Cloud computing has been defined by its characteristics by Buyya as follows, ‘ Cloud is a parallel and distributed system consisting of a collection of inter-connected and virtualised computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements (SLA) established through negotiation between the service provider and consumers’ [14]. According to [13], Cloud computing is a model of computing in which computer processing, storage, software, and other services are provided as a pool of virtualised resources over the network, primarily the internet. These ‘clouds’ of computing resources can be accessed on an as-needed basis from any connected device [13].

Characteristics of Cloud Computing

The US National Institute of Standards and Technology (NIST) defines cloud computing as having the following essential characteristics [27] [13].

On-demand self-service: Consumers can obtain computing capabilities such as server time or network storage as needed automatically on their own.

Ubiquitous network access: Cloud resources can be accessed using standard network and internet devices, including mobile platforms.

Location-independent resource pooling: Computing resources are pooled to serve multiple users, with different virtual resources dynamically assigned according to user demand. The user generally does not know where the computing resources are located.

Rapid elasticity: Computing resources can be rapidly provisioned, increased, or decreased to meet changing user demand.

Measured service: Charges for cloud resources are based on amount of resources actually used.

Cloud Service Models

Cloud computing consists of the following different types of services [13] [28], [29]:-

Business Process-as-a-Service (BPaaS) where the cloud is used for standard business processes and it combines all the other service models with process expertise; Software-as-a-Service (SaaS) where the business software and related data are managed by a cloud service provider and users access the services and data via their web browser. Customers use software hosted by the vendor on the vendor's cloud infrastructure and delivered over a network. Users access these applications from a Web browser, and the data and software are maintained on the provider's remote servers. The advantage of SaaS is that clients don't have to worry about any maintenance, hardware or software [30].

Platform-as-a-Service (PaaS). A cloud service provider offers a complete platform for application, interface, and database development, storage, and testing. Customers use infrastructure and programming tools supported by the cloud service provider to develop their own applications. For example, IBM offers a Smart Business Application Development and Test Service for software

development and testing on the IBM Cloud. Another example is Salesforce.com's Force.com which allows developers to build applications that are hosted on its servers as a service; Infrastructure-as-a-Service (IaaS), this cloud model allows businesses to buy those resources as a fully outsourced service rather than purchasing servers, software, data centre space or network equipment. Customers use processing, storage, networking, and other computing resources from cloud service providers to run their information systems. Users pay only for the amount of computing and storage capacity they actually use [28], [31].

Cloud computing has the potential to dramatically change business models and the way people interact with each other because it provides access to large-scale remote resources in a very efficient and quick manner. It has the potential to level the playing field because it breaks barriers to entry [32]. Cloud computing is thought to be the solution to overcome the problem of processing large amounts of data. By using cloud computing the cost of implementing software solutions and storage of data is reduced significantly [30].

Before the emergence of cloud computing, many organisations struggled to purchase IT infrastructure in order to compete favourably but now it has become easier even for small enterprises to have access to advanced technologies offered by cloud service providers. This is so because 'cloud provide a powerful I.T infrastructure at a modest price' [32]. Figure 1 below shows the cloud computing platform

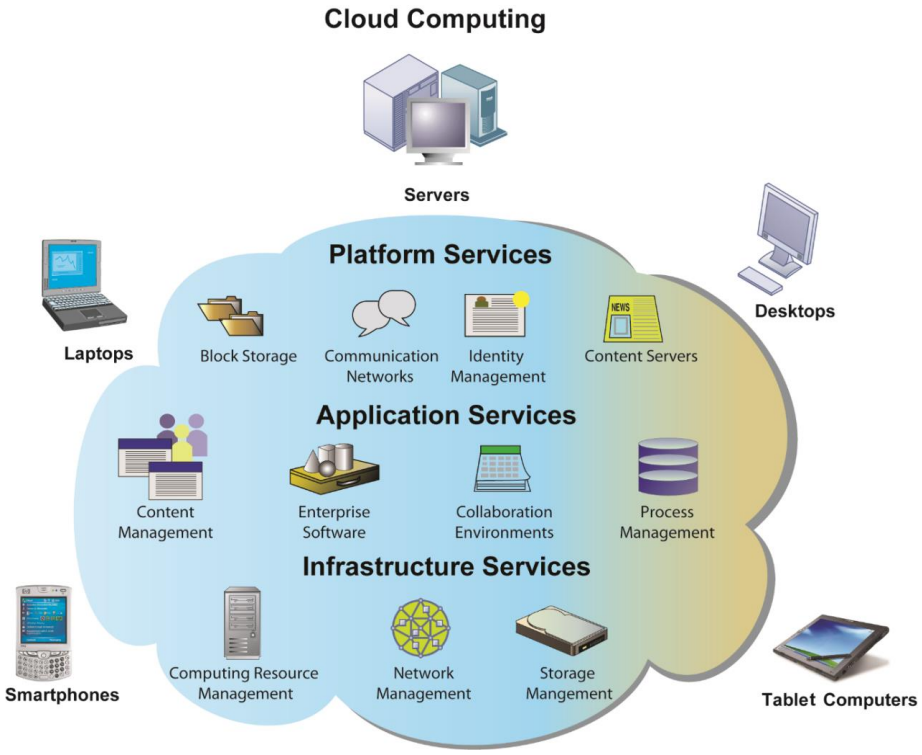

Figure 1: Cloud Computing Platform [13]

In cloud computing, hardware and software capabilities are a pool of virtualized resources provided over a network, often the Internet. Businesses and employees have access to applications and IT infrastructure anywhere, at any time, and on any device [13].

Cloud Deployment Models

Cloud computing encompasses a whole range of services that can be hosted in a variety of manners depending on the nature of the service involved and the data / security needs of the contracting organisation. A cloud can be public, private or hybrid. A public cloud is owned and maintained by a cloud service provider such as Amazon Web Services, and made available to the general public or industry group. A private cloud is operated solely for a specific organization. It may be managed by the organization or a third party and may exist on the premise or off premise. Like public clouds, private clouds are able to allocate

storage, computing power, or other resources seamlessly to provide computing resources on an as-needed basis. [33]

On the other hand, Hybrid clouds blend public and private clouds depending on the sensitivity of the data and applications in each process, and the degree of business criticality and differentiation. These clouds (private or public) remain sole entities but are associated in order to administer services. Public "sovereign" cloud is an emerging variant, under which a public cloud provider commits to keeping the cloud data and processing within a specific jurisdiction. This facilitates compliance with data protection regulations forbidding personal data from passing beyond national borders. Cloud computing may soon prove indispensable as an answer to the daunting new demands for agility, transparency, and efficiency [33], [28], [34].

Community Cloud is another development in cloud computing such that organisations with the same domain of demands share a community cloud. In other words, community cloud is a private cloud that is shared among more than one organisation. Consequently, many organisations can enjoy from the advantages of private cloud with a lower cost [35].

Advantages of Cloud Computing

Cloud computing is gaining popularity as a way to virtualize the datacentre and increase flexibility in the use of computation resources [36]. Many studies have been conducted to highlight the advantages and disadvantages of cloud computing. Having an understanding of the advantages of cloud computing motivate organisations to migrate to cloud. In the following, we discuss some of the advantages of using cloud computing in an organisation. One of the advantages cited [13] is that organisations do not have to make large investments in their own IT infrastructure like hardware and software but

instead purchase computing services from remote providers and only pay for the amount of computing power they actually use .

Many studies show that cloud computing has some distinct benefits such as cost reduction, efficient resource utilisation and flexible and elastic provisioning. Several papers have analysed how attractive cloud computing offerings are for developing countries. For example, [32] has presented several benefits, such as easy access to computing infrastructure with low cost, improving collaboration efforts and access to the latest software and hardware. Overall, access to the latest technologies and having maximum resources, while, at the same time, minimizing costs are considered the main benefits of cloud computing [37] [38], [32] . The advantages cloud computing offers are further elaborated as follows [14], [35], [13]: -

Cost Reduction: This dramatically lowers the cost of entry by cutting the costs of IT infrastructure for firms trying to benefit from the compute-intensive business analytics. This means that there would be no need to purchase new hardware and install up-to-date software. Moreover, the routine maintenance costs and electricity costs would be minimised when migrating to cloud. Cloud computing also represents a huge opportunity to many third-world countries that have been so far left behind in the IT revolution. Developing countries can benefit using up to date technologies without having to purchase their own. It can provide an almost immediate access to hardware resources, with no upfront capital investments for users, leading to faster time to market many businesses. By treating IT as an operational expense as opposed to capital expenditure also helps in dramatically reducing the upfront costs in corporate computing. Cloud computing also makes possible new classes of applications and delivers services that were not possible before [14].

This ensures that the organization is only paying for what they use as opposed to having a whole IT infrastructure that is underutilised. Nevertheless to enjoy the benefits of cloud computing, it is important to select the providers whose offer best fits user's needs. Consideration should be made in terms of characteristics of the service, general terms and conditions of service and service levels that providers ensure before choosing a service provider [39].

Clouds provide a powerful, and often otherwise unattainable, IT infrastructure at a modest cost. In addition, they free individuals and small businesses from worries about quick obsolescence and a lack of flexibility [32].

Cloud computing offers worldwide access to virtually unlimited processing power, new storage capabilities and capabilities that are being used to create virtual web platforms, where humanity today and in the future will live out large parts of their everyday lives, educating, working, shopping and talking to private networks of friends and relatives. It has helped most businesses and organisations to deliver quality services to their customers [40]. Nowhere is this more obvious than in developing nations, where the ability to access resources has often been limited and building out a robust IT infrastructure can be daunting. The emergence of cloud computing changes the stakes for entrepreneurs, small and large businesses, researchers, and governments [32]

The other advantages of cloud computing stated by [34] other than the significant cost reduction include increased flexibility, access anywhere using different computer or move to portable devices, elastic scalability and pay-as-you-go, easy to implement as there is no need to purchase hardware, software licenses or implementation services, software updates are automatic in cloud computing and facilitates group collaboration on documents and projects. In other words, cloud computing can improve data consistency and integrity

among different related organisations and therefore, enable increased collaboration.

Another advantage is that of its being environmentally friendly – Green IT. It takes fewer resources to cloud compute, thus saving energy and also saves the environment from pollution usually caused by inadequate disposal of obsolete computers resources. Also instant test can be done as various tools employed in cloud computing permits users to test things such as a new product, application, feature or upgrade. The infrastructure is quickly available with flexibility and scalability of distributed testing environment [41]. Disaster Recovery in cloud computing is another plus as it can provide mechanisms for automated scheduled network wide backup systems in order to store the data in off-site data centres [35].

The same advantages can be beneficial in the education sector as cloud-type IT solutions lower costs, by sharing equipment and solutions, and through the "consumption" of resources on demand (which allows invoicing for actual usage); a reduction in the technical support provided by each establishment; faster progression of solutions, thereby avoiding the kind of investments that "restrict" an establishment's IT system for a relatively long period of time; and the promotion of exchanges and participative or collaborative methods – between establishments, and among teachers and students. These are some of the benefits the cloud, as applied to the world of education [42]. It also enables all documents – projects, homework, syllabi, and collaborative exercises, for example – to be updated in a centralized and systematic manner and to be modified consistently at a single central point. This helps ensure that these documents are appropriate and relevant and that all the information they contain is identical for all users.

In a nutshell, the cloud offers advantages such as time and location independent whereby information is accessed from anywhere anytime through the internet. Migrating to the cloud as already alluded to greatly reduce costs because it is cutting the cost of I.T. infrastructure, routine maintenance costs and electricity costs. Issues of disaster recovery are transferred to the cloud service provider and also increase the collaboration of organisations to share data and information.

Disadvantages of cloud computing

Although there are many benefits to adopting cloud computing, there are also some significant barriers to its adoption. Highlighting the disadvantages of cloud computing helps organisations to come up with countermeasures and policies so as to prevent the possible losses even as they decide to adopt the cloud. Disadvantages of the cloud as cited by [13], [14] is that the responsibility for data storage and control is in the hands of the provider which gives great uncertainty of the security at all levels (network, host, application and data levels) and the ability to adequately address privacy regulations in cloud computing.

System availability 24/7 is now so critical that they must be reliable and available to support operations throughout. In the event of failure or outages, contingency plans must take effect smoothly, and for disastrous or catastrophic failure, recovery plans must begin with minimum disruption. Some technical challenges relating to the adoption of cloud computing as highlighted by [43] included availability of service and data lock-in. The lack of scalable storage, performance unpredictability and data transfer bottlenecks are also obstacles that could limit the growth of cloud computing [43].

Cloud computing adoption barriers in developing countries have been discussed in general like lack of connectivity, inadequate bandwidth and unstable power supply [37]. There are numerous challenges cited by [40] that hinder the acceptance and uses of cloud computing in Nigeria, prominent among them are: poor quality or unavailability of internet service can hinder prompt availability of data, fear of hackers, companies are not contented that their records will be giving the utmost privacy, lack of technical skills in the deployment of cloud computing service, lack of flexibility of the policy or legal framework for cloud computing is discouraging a number of companies to adopt cloud computing, lack of detailed information and awareness of cloud computing services is hampering more clients going into cloud technologies, the need for current ICT infrastructures and social amenities needed to establish cloud computing data centres across the country and, the current insecurity problem facing the nation will also hinder cloud technologies providers from investing in the country [40]. These challenges are common in many other developing countries as situations are similar.

Security concerns are the main discouraging factor of migrating to cloud for governments and organisations. Compromising the sensitive data which are stored in a virtual server is one of the biggest issues further discussed in the section that follow.

2.3.3 Security in the Cloud

Security threats that are associated with cloud computing is one of the main discouraging factors for organisations migrating to cloud. Organisations like Cloud Security Alliance, devoted in identifying the possible threats of cloud computing, have done much research on identifying security. Cloud Security Alliance (2013) identified top threats such as abuse and nefarious use of cloud

computing, insecure interfaces and Application program interfaces (APIs), malicious insiders, shared technology issues, data loss, data breaches, denial of service, insufficient due diligence and account or service hijacking. Although some of these threats have been around for a long time, they are amplified in case of cloud computing [44].

A joint survey by IEEE/Cloud Security Alliance (CSA) in 2010 also indicated that the need for cloud computing security standards is important and urgent and it is hindering growth of cloud computing. Other security concerns identified as hindering the cloud computing growth are availability of the service or business continuity, data confidentiality and auditability and loss of data and breach of privacy in the cloud [38], [45] .

Highlighting security issues that arise on each layer of the cloud computing environment, [46] declared that deployment models are more concerned with data storage security and for delivery models data transmission security is the main concern. In addition, security needs varies for each deployment or delivery model.

Cloud computing is faced with a number of challenges such as; secure data storage, high-speed access to the internet, and standardisation. Each deployment model and service model seems to have different security concerns [46], [47].

All security issues are mostly influenced by the fact that the CSPs (Cloud Service Providers) are not locally available, hence the lack of specific guarantees and assurances make organizations hesitant to adopt the cloud and trust third parties. Security fears range from the loss of service availability to privacy breach at data centres and how all this affect the final SLA to be signed by both parties. Reasons that may cause service unavailability include security breaches at the physical location of data centres, failure of equipment at data

centres, consumer site equipment failure, connectivity failure – this is a major issue in Africa due to distances between the provider's equipment and consumer site. It is made worse by the lack of reliable internet connectivity in developing economies, since cloud computing relies heavily on network connectivity.

Reputable sites like Google, Amazon, and Microsoft have been known to have been down and unable to provide services for some time. The other issue to be considered is that in moving services to the cloud, the organization or individual no longer retains direct access and control [48]. It is therefore necessary that businesses must have alternative means to deal with such failure if it affects business processes. Ultimately, the risk of security and privacy breaches plays a role in SLA negotiation, so does the reliability of the network connectivity from any computer connected to the Internet using a standard browser, instead of using an application that has been installed on their local computer [49], [46], [50]

In order to protect an application from various types of breaches, it is important to understand the application security policy considerations based on the different cloud deployment models. Table 1 highlights the impact of cloud deployment on application security [51].

Table 1: Cloud Deployment Model Impact on Application Security [51]

Deployment Type	**Application Security Policy Considerations**
Infrastructure as a Service	● The customer has responsibility for deployment of the complete **software** stack - operating system, middleware and application - and for all aspects of security that relate to this stack, including the application of all appropriate security patches.

	● The application security policy should closely mimic the policy of applications hosted internally by the customer.
	● The customer should focus on network, physical environment, auditing, authorisation, and authentication considerations.
	● Appropriate data encryption standards should be applied in the handling of data and to user interaction (e.g., secure browsing) by the application.
	● System assurance principles, and development and testing methods that minimize the risk of introducing vulnerabilities in the code, should be applied even more rigorously than for an on premises application, since the application will reside outside of the customer's security perimeter.
	● If hardware-based trusted computing security measures are available, it is important to consider using them to block root-kits and other hard-to-detect malware.

Platform as a Service	● The customer has responsibility for application deployment and for securing access to the application itself. ● The provider has responsibility for properly securing the infrastructure, operating system and middleware.

	● The customer should focus on audit, authorisation, and authentication considerations. ● Appropriate data encryption and key management standards should be applied. ● The customer needs to define how sensitive data, as part of their data classification, is being handled in general and by configuration options provided by utilised PaaS services. ● In a PaaS model, the customer may or may not have knowledge of the format and location of their data. It is important that they are knowledgeable of how their data may be accessed by individuals with administrative access.
Software as a Service	● Application-tier security policy constraints are mostly the responsibility of the provider and are dependent upon terms in the contract and SLA. The customer must ensure that these terms meet their confidentiality, integrity and availability requirements.
	● It is Important to understand the provider's patching schedule, controls against malware, and release cycle.
	● Scaling policies help deal with fluctuating loads placed on the application. Scaling policies are based on resources, users and data requests.
	● Typically, the customer is only able to modify parameters of the application that have been exposed by the provider. These parameters are likely independent of application security

	configurations, however, the customer should ensure that their configuration changes augment; not inhibit the provider's security model. ● The customer should have knowledge of how their data is protected against administrative access by the provider. In a SaaS model, the customer will likely not be aware of the location and format of the data storage. ● The customer must understand the data encryption standards which are applied to data at rest and in motion. ● The customer needs to be aware of how sensitive data, as defined in their data classification, is being handled in general and by configuration options.

With security concerns being the unanimous barrier holding back the quick cloud adoption, each of the issues represents an opportunity for cloud and technology providers to strengthen their offerings to enable organisations to better leverage the power of cloud computing. The figure below introduces many cloud computing challenges for system and application developers, engineers, system administrators, and service providers [26].

Figure 2: Key open challenges in Cloud computing Source [26]

Big data is the main source for the coming of cloud computing in the show, everyday lots of data in the size of PETA bytes are uploaded in the digital world which required lots of storage and computing resources [52].

2.3.4 Web Application

A web-based application as defined by [53] is any application that uses a website as the interface (the 'front-end'). Users access the application from any computer connected to the internet using a standard browser, instead of using an application that has been installed on their local computer. For example, Microsoft Word, a common word-processing application which is installed on the user's computer while Google Docs is also a word-processing application, but users perform all the functions using any web browser instead of using software installed on their computer.

Web services are standards that integrate Web-based applications through connecting and sharing of business processes across the network where

applications of different vendors, languages, and platforms communicate with each other and with clients. The adoption of a web applications infrastructure can provide vital processes such as transfer of information [53].

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. Web-based systems and applications now deliver a complex array of functionality to a large number of diverse groups of users [54] [55].

These Web-based applications have now become one of the preferable technologies that are used to ease the process of managing data and records. Some of the motivations that contribute to the development of many web-based systems nowadays are because of its efficiency in handling rapid access of documents and its ability in supporting multiusers simultaneously, thus saving a lot of time and hassle free [53] [56]

Web based applications have not just been left to business oriented organisations but all types of organisations like health, education, travel and many others have taken advantage of the benefits web applications offer.

Advantages of web-based systems

Web-based applications offer a range of business advantages over traditional desktop applications. Some of the business advantages mentioned by [53] are outlined below

Cost effective development

The application itself needs only be developed for a single operating system which makes development and troubleshooting much easier.

Accessible anywhere

Web systems are accessible anytime, anywhere, via a computer with an internet connection.

Easily customisable and accessible for a range of devices

The user interface of web-based applications is easier to customise and can be customised for presentation on any device connected to the internet, including personal digital assistants (PDAs) and mobile phones.

Improved interoperability

Web-based architecture makes it possible to rapidly integrate enterprise systems, improving work-flow and other business processes.

Easier installation and maintenance

Installation and maintenance becomes less complicated since once a new version or upgrade is installed on the host server, all users can access it straight away.

Adaptable to increased workload

Increasing processor capacity also becomes a far simpler operation. If an application requires more power to perform tasks, only the server hardware needs to be upgraded.

Flexible core technologies

Any of three core technologies (Java-based solutions (J2EE), Microsoft .NET platform or Open Source platform (predominantly PHP and MySQL)) can be used for building web-based applications, depending on the requirements of the application. Web-based applications are easier to develop, install, maintain and

can be accessed using any standard browser regardless of the development platform.

Limitations of Web Applications

Although there are many advantages of web based systems, it is also important to know the limitations that arise with these systems. Considering the fact that Zambia is a developing nation and has infrastructural problems that these nations face, it becomes necessary to prepare for such so that there is a successful implementation of new systems that require internet connectivity. The following limitations were mentioned by [57]

Connectivity

Web applications rely significantly on internet connectivity and speed. Absence of internet or its poor connectivity can cause performance issues with web applications. For example, if there is too much traffic going through the internet, the performance of the application may be greatly affected thereby frustrating the users. Performance tends to be a significant issue in web applications, especially given the inherent delays associated with the World Wide Web and many users' internet services [58].

Security

Web applications are exposed to more security risks than desktop applications. There is no total control over web applications as they are open to a large number of users in the internet community thus broadening the threat.

Cost

Web application development and its maintenance may involve higher costs that may be recurring in nature [57]. Since web based applications depend on internet

connectivity, such charges are applicable when using a web application. In developing countries where the cost of internet is still high, this expense is more real.

2.3.5 Desktop Applications

Software application development as opined by [59] has evolved from desktop applications, which could be used on standalone machines to web application development gaining importance with the advent of internet. By definition, a desktop application means any software that can be installed on a single computer and used to perform specific tasks [59].

Desktop applications have traditionally been limited by the hardware on which they are run. They must be developed for and installed on a particular operating system, and may have strict hardware requirements that must be met to ensure that they function correctly. Updates to the applications must be applied by the user directly to their installation, and may require hardware upgrades or other changes in order to work.

2.3.6 Desktop Application Versus Web-based Application

While both desktop and web applications have their pros and cons, they are ultimately just the tools that people use to help them solve problems [59]. It can be noted that each type of application has its own benefits and weaknesses and can be utilised best within its own niche. [59] believes that both desktop and web applications will continue to coexist for a long time just as [60] mentioned that ‘Saas and the cloud replace some traditional software products but will not eliminate them anytime soon’. The following is a basic comparison of desktop and web based applications.

Table 2: Desktop Application Versus Web based applications [59]

Desktop Application	**Web-based Application**
1. Limited by the hardware on which they are run.	Not limited by hardware
2. Desktop applications must be developed for and installed on a particular operating system, and may have strict hardware requirements that must be met to ensure that they function correctly.	Can be developed on any platform and accessed using a web browser
3. Updates to the applications must be applied by the user directly to their installation, and may require hardware upgrades or other changes in order to work.	Updates are done only on the server and the clients will have the updated application.
4. Software has to be installed on the computer of the user and use the computer's storage and processing power.	The user accesses the application using the web browser (in effect a stand-in for a client), and works with resources available over the internet, including storage and CPU processing power
5. Uses 'fat client' in most cases though 'thin clients' is somehow being re-introduced to desktop applications as well	This approach allows for "thin clients" (machines with limited hardware capabilities) to provide access to complex applications delivered from a centralised infrastructure.
6. Desktop applications are confined to a physical location and hence have usability constraint.	Web applications on the other hand make it convenient for the users to access the application from any location using the Internet.

7. Security - You can have a total control over the standalone applications and protect it from various vulnerabilities.	Web applications are exposed to more security risks than desktop applications as they are open to a large number of users in the Internet community thus widening the threat.
8. Connectivity - Desktop applications being standalone in nature do not face any hindrances resulting from Internet connectivity which also significantly affects the speed at which desktop and web applications operate.	Web applications rely significantly on Internet connectivity and speed. Absence of Internet or its poor connectivity can cause performance issues with web applications.
9. Cost factor - Desktop applications are purchased one time and there are no continually occurring charges. However, in certain cases, maintenance fees may be charged.	Web application development and its maintenance involve higher costs and mostly recurring in nature.
10. Maintenance - desktop applications are to be installed separately on each computer. Also updating the applications is cumbersome with desktop applications as it needs to be done on every single computer.	Web based applications need to be installed only once and updating the application is only done on the server

Having considered the basics of desktop and web application development, the selection of a suitable type will depend on the business needs and factors discussed in the comparison given above. [57].

Considering that the candidate registration application has to be used by several schools in different locations throughout the country, support and maintenance

becomes easier with a web based application and hence the proposal in this research to implement a web based candidate registration system. According to the ECZ statistical report 2015, there were a total of 9,861 [61] active examination centres while 10, 416 examination centres in 2016 which justifies the need for the proposed system to be web based. Using a desktop application means that each of the over 10, 000 examination centres has to have the application installed on their computers and in case of updates, they have to be sent to all examination centres.

It should be noted that not every application, however, is suitable for deployment to public clouds operated by third party vendors [36]. It is therefore important to weigh what applications would be suitable to stay in the public cloud and what would be reserved for the private cloud. Since the proposed system will contain candidate registration details only, it is proposed that the application developed be deployed in the public cloud to reduce on the costs of purchasing IT infrastructure and also take advantage of latest technologies provided by the cloud service providers.

2.3.7 Web based systems integrated with bulk short message service

The wide use of mobile telecommunications has also brought about the integration of web based systems with mobile telecommunications especially with the GSM being the most successful digital mobile telecommunications used by millions of people in various countries in the world [62].

Use of mobile phone helps to have access to the system or receive alerts from the systems via mobile phone even when you are not connected to the internet. A useful service for very simple message transfer is the short message service (SMS), which can be used for “serious” applications as noted by [62]. The advent of the Short Message Service SMS technology, that allows text messages to be

received and sent over mobile devices, provides a great opportunity to expand the reach to target clients as well as serve them in an effective and efficient manner.

Integrating the bulk SMS with the web-based candidate registration will help take advantage of the benefits of SMS thereby improving the efficiency of the systems.

Bulk SMS as stated by [63] is an entirely web-based application of messaging platform which offers a better solution to easily distribute information instantly and with reliability to multiple cellular users without using complex computer devices. The advantages of bulk SMS can be applied in schools and universities to further develop classroom interactions and set up a virtual community as a public relations system. Moreover, bulk SMS system provides an information service such as sending special announcements, news and interest information for lecturers, students and other related recipients thus raising the importance of instantaneous communication, reaching every mobile user with inexpensive cost. This system can be used in a lot of mobile value added service applications, sending, receiving, group sending and transmitting mobile text messages real-timely and efficiently [64]. An SMS system proposed that intelligently determines a good way to present notifications to the user at a suitable time.

Deployment

As for the web application for candidate registration, the emphasis is on using the cloud model. As for the details of the implementation of which type of cloud computing models and service is beyond the scope of this research. However as already seen in the literature reviewed, providers of cloud services like Amazon, Google Cloud, IBM offer options that can be used for the candidate registration system. Since the web based application will contain candidate's registration details for examinations only it would be reasonable to use a public cloud as this

data will be considered as not being very sensitive. In the meantime, as ECZ expands its systems, they can look into using a hybrid cloud so that the more sensitive information can be kept on a private cloud managed by the vendor.

Deploying cloud applications depends on the service provider's requirements. In more general terms the applications should be ready for deployment having been thoroughly tested offline. Other configurations that need to be done will be as per service provider. This has also been made easy as there are steps to follow to ensure that the application is successfully deployed on the cloud and ready to be used.

2.3.8 Barcode Technology

The use of barcode technology has been around for many years and its use has evolved from simple use of barcodes to their integration in enterprise systems. A barcode is a machine-readable representation of information in a visual format. A bar code consists of a series of parallel, adjacent bars and spaces [65]. Different bars and spaces patterns are used to express different symbols. These symbols 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.

There are two types of Barcode namely; Linear and Matrix or 2D barcodes. Linear (1 D) barcodes are a first generation, "one dimensional" barcode that is made up of lines and spaces of various widths that create specific patterns. Matrix barcodes, also termed as a 2D barcode or simply a 2D code, is a two-dimensional way to represent information. It is similar to a linear (1-dimensional) barcode, but can represent more data per unit area. These barcodes are read using a device called as the barcode scanner.

Figure 3 Types of Barcodes [66]

There are different types of Barcode Scanners:

Pen Type Reader: Pen-type readers consist of a light source and photodiode that are placed next to each other in the tip of a pen or wand. It is the cheapest barcode scanner available in market

Charge Coupled Device (CCD) Reader: CCD readers use an array of hundreds of tiny light sensors lined up in a row in the head of the reader. Each sensor measures the intensity of the light immediately in front of it.

Advantages of using barcode technology

Application of barcode technology is made in fields like supply chain management, libraries and many others with a view to automate the data entry process of circulation system. The use of barcode technology increases efficiency and eliminates human errors as in case of manual data entry, it increases the speed of operations.

Barcode technology has got the following advantages as mentioned by [67]. It increases accuracy of data input (error free), improves efficiency of the staff and quality of services, rapid access to total production costs, increased user satisfaction, reliable statistics for Management Information System (MIS) and

management control, Real time data collection, aid effective management of resources and inventories, highest degree of reliability, saves time, perfect entry and retrieval of data, labour savings by avoiding manual system, low labour cost and improves information availability and data integrity [67].

2.4 Candidate Registration challenges faced by examination bodies

Examination bodies are mandated to conduct examinations in the public interest and one of the first steps in carrying out their mandate is to register prospective candidates for the examinations. Accurate registration of candidates is therefore an important measure to ensure that only qualified candidates are registered [68]. In this section, we review the challenges examination bodies faced in the registration of candidates and the solutions that have been implemented or proposed to mitigate those challenges.

2.4.1 Global perspective

In the developed world, ICTs have been used in education and assessment for a longer time than in developing countries and hence the challenges may be different. A study by JISC Regional Support Centre [69], showed greatly improved timeliness and efficiency of getting learner feedback than the previous paper-based process through the use of ICTs. Their first priority was to use new technologies to reduce transaction costs between the college and the public by getting prospectus online, web based enrolment, web registration, timetable module, online helpdesk and electronic payment. The outcome of this project includes reliable electronic registration linking the student database to finance systems and modules for payroll and staff development which ensured accurate payments and strong financial control [69].

In Saudi Arabia, [70] investigated and identified the challenges that the manual system suffers in registering college students in Jordan such as it being a hard method to communicate between, the unit responsible for running and administering the examinations all over the kingdom and the colleges, inaccurate statistical data gathered from time to time due to its dependence on the time in which it was ordered, not all the colleges fill their students' data correctly or properly in the Excel files; not complying with the predetermined file format and the method of data exchange by e-mail, floppy Diskettes, CD-ROMs, Flash Memories and Papers (Hard Copies) was unsafe, in that the storage media might be susceptible to corruption at any time.

Al-Shaikh proposed an online registration system as the key solution to avoiding the problems mentioned previously, the system which was explicitly used to enrol students to examinations. The benefits realised from this system have eliminated most of the problems that used to be faced by the administration and college registrars as well as students [70]

In a study [56] observed that traditionally, in most of the higher academic institutions in Malaysia, the recording of the students' attendances mainly used manual systems which were prone to human errors that could be happening during or after the process of attendance taking. It was difficult for the management to regularly update the record and manually calculate the percentage of classes attended. The manual processes needed to be improved as using papers was not just inefficient but would require the management of the academic institution to provide a well-managed filing system to cater the attendance records. As a solution, [63] indicated that benefits would be derived from the web based / online system for recording and reporting students' attendances in order to make the process more efficient and time-saving .The system can be easily accessed via the internet where it provides full support for

simultaneous access of multiusers from dispersed locations [56].

2.4.2 Regional Perspective

In Kenya [71]conducted a study where they explain that e-registration emerged because of the problems associated with manual handling of registration and student records which had tremendously increased over the years. Such problems included mismanagement of students' academic records, mismanagement of courses registered for, wear and tear were occasioned during retrieval and handling, and sometimes some of the data was lost. In this form data sharing is difficult and reproduction usually involves high costs per unit [72], [73]. Furthermore [71] goes on to explain that before the introduction of institutional online registration at Kenya National Examinations Council (KNEC), there used to be numerous examination malpractices like impersonation which emanated from registration errors such as multiple registrations in the candidate registration process.

In agreeing with the challenges faced in the candidate registration process, [74] noted that there were concerns over the quality of entry data, duration of processing of entries, security and storage of entry documents/ assessment data, 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. A Becta report on use of ICT stressed that ICT is helpful in supporting management which include analysing of students registration record and all clerical work in school. The use of ICT in School administration has helped in reducing the work load of the teacher [75].

In a study conducted by [68] it was ascertained that both the region and district officers faced challenges with the candidate registration and verification process

of Primary School Leaving Examination (PSLE) such as difficulty in identifying repeaters, sometimes candidates changed their names without permission from relevant authorities; Shortage of registration forms and storage facilities; misspelled names and incorrect entries in some schools; Some candidates intentionally skipped signing, and some head teachers signed on behalf of the candidates; Omissions in entry forms; Missing candidates; The same registration number given to more than one candidate; Incorrect entries in the respective forms among others [68].

A later research by [76] revealed that challenges were noted in the candidate registration procedures for private / external candidates until the online registration which accepts mobile payment for examination fee was introduced. In this research, [76] attributes some of the challenges in the previous registration procedures to delays and lack of verification of registration forms received which resulted in the applicants being denied registration by National Examinations Council of Tanzania (NECTA). In addition there were a lot of unnecessary movements by an applicant between the examination centre and the Post Office.

The challenges experienced by NECTA led to the design and development of new registration procedures which provides an applicant with web access for online registration and accepts mobile payment for examination fee. The system designed by NECTA was mainly for the private candidates who were not attending in regular schools.

Another view of the registration process at the Joint Admissions and Matriculation Board (JAMB) in Nigeria given by [77] where they said that prior to the introduction of e-registration, Optical Mark Read (OMR) registration forms were used in data capture at JAMB. Candidates were required to code the forms using HB pencils and the forms are later scanned. JAMB narrates that the

many problems that were encountered using this system such as re-coding, editing, re-scanning, gave room to fraudulent practices and clerical errors. There were also difficulties of storage and retrieval of data and information.

In another study [78] recounts the difficulties the Ghana National office of West Africa Examinations Council (WAEC) had also been experiencing over the past years with the processing of large numbers for its examinations especially at the pre-examination stage due to poor handling of registration forms. In an attempt to find a lasting solution to these developing phenomena, the piloting of an Online Registration System using the 2005 Senior Secondary School Certificate Examination (SSSCE) for private candidates (PC) examination was undertaken. With the continual increase in candidature, there was a transition of the registration process from the use of manual to electronic.

The study highlighted the acceptance and use of the electronic registration portal for the May/June West African Senior School Certificate Examination (WASSCE). It also sought views and perspectives on the system from stakeholders in order to identify its strengths and weaknesses with a view of improving it.

Still in Ghana, the research and findings of a student registration system at Methodist University College Ghana by [73] where students had to be physically present on their campuses to do registration for the semester presented the following problems inherent with the system and then proposed an online student registration system. Challenges of insufficient online utilities in handling student registration, inability of students to remotely register and access documents like transcript as well as students taking too much time in processing their registration and worse, this could only be done with their physical presence on campus [79] were identified.

Time is one of the major factors in any activity especially in matters of examinations due to their time bound in nature. Therefore reducing the time is of great essence.

Going further in the literature search, the simple web-based Quality Assurance System was an early action that [80] introduced in his study which emerged due to mismanagement of students' academic records such as loss and miscalculation of marks. It established how ICT affected management of students' academic affairs. His findings indicated that internet facilities, computers, management information systems, electronic databases were all available and accessible to administrators, lecturers and students though with restricted access for viewing results, record keeping, setting and marking examinations. ICT for registration was used for tracking students' registration progress by administrators and academic staff, underlining the fact that technology is beneficial to organizations [78] [80].

Although this study focussed on the university student registration, it still brings out the facts that there are challenges in the mass registration or capture of data. Use of ICT and online systems still emerges as one of the best solutions to mitigate the problems.

Similar challenges in the examination registration process were noted at Malawi National Examinations Board (MANEB) such as the longer periods it took the Board to complete capturing the candidate bio data into its computer system, records were getting lost and errors being made by schools on the submissions. One way of mitigating the problem, as indicated by [81]is that the Board engages services of temporary data entry clerks in order to speed up the work and to arrest and correct the errors at an added cost.

After introducing the use of computers in the registration process at a school

level, [82] went further to carry out a comparative study in which the manual system and the newly introduced Excel spreadsheet template used for entering candidate details were compared. The results of the study indicated that the use of the spreadsheet was more efficient than the manual system in that errors were reduced from 8 percent to 1 percent and also, the total time for registration had been greatly reduced by almost half over the three years.

In the paper 'Exploring Innovative Technologies in the conduct of Public Examinations', [83] states that organisation and management of examinations have been a great problem which creates difficulties in management of large number of candidates to be registered, thus leaving room for malpractices and problems of incomplete and inaccurate registration of large number of candidates. Some innovative solutions he suggests that can curb the problem of wrong registration of candidates and impersonation are e-registration. [83] makes the assertion that ICT based systems in the registration process can also curb examination malpractices like impersonation. This assertion ties well with what [71] also alluded to concerning the quality of the registration data in the examinations.

2.4.3 Local Perspective

In Zambia, [84] noted the challenges experienced by the Examinations Council of Zambia related to candidate registration using the Optical Mark Read (OMR) registration forms. Notable among the challenges was the highly centralised nature of the system, many queries related to candidate from the provinces, districts and schools when the results were processed and released by ECZ. The large number of iterations that needed to be gone through to ensure a correct record of those sitting exams at each centre and difficulty in getting exact records of pupils sitting examinations at each school /examination centre were also

mentioned. The fact that the system was largely paper-based and thus much transfer of paper and travel was involved. Also, failure by some candidates to follow instructions to complete the OMR forms contributed to the numerous errors in the registration data [84].

Errors in the candidate registration process were also attributed to be one of the causes of pupil's absenteeism due to multiple registrations [85]. Furthermore, [86] augments the challenges in the registration process with the introduction of an Electronic Candidate Registration System, a desktop application, where centres are able to enter the candidate's details and verified the information which was later processed by the ECZ with minimal administrative costs compared to that which the Council used to incur previously. Although improvements have been recorded with the use of this method of registering candidates, [10] noted problems in the registration process such as disparities in the number of candidates registered between ECZ and the school records, non-registration of candidates, registration of illegal candidates, inaccurate subjects and use of incorrect examination numbers. These challenges mentioned here call for a change in the registration process so as to reduce or eliminate these challenges.

2.5 Related Works

The paradigm shift in the computing world saw the coming of cloud computing which has attracted a lot of research where cloud computing can be applied. Researchers have looked into areas such as the financial field, medical field, transport management, library services and in the education sector among many others. In this section, we review some of the works that have been done related to the study and we see how the cloud technology can be applied to our environment.

2.5.1 Cloud Computing in Automated Banking Systems

Cloud technology offers secure deployment options that can help banks develop new customer experiences, enable effective collaboration and improve speed to market all while increasing IT efficiency. Banks that take advantage of cloud computing are better positioned to respond to economic uncertainties, interconnected global financial systems and demanding customers [87].

Many studies conducted [28] [87] [88] [89], have indicated that Cloud service models offer financial organization the option to move from a capital-intensive way to a more malleable business model that minimise operational wage. The key to achievement lies in choosing the right cloud services model to meet business needs. Banking services organizations are starting to adopt cloud computing technologies in a number of fields, in particular for mobile applications, innovation testing and micro banking.

Mobile banking: Banks are now offering mobile applications to online banking customers and partners for checking balance, order new chequebooks or stop payment orders.

New service R&D: Banking services organizations are also increasingly advancing the computing power that cloud services offer for research and development and testing of new services prior to any attempt at going into production.

Micro banking: Another trend emerging in developing countries of cloud services whereby micro banks are running their entire business on cloud computing [28], [87], [90], [88], [89]

While banks will benefit in a similar way to other cloud users from this particular offering, especially in terms of lower total cost of ownership, enhance their operations and help them develop new offerings with flexibility and a rapid time

to market. Cloud computing may soon prove indispensable as an answer to the daunting new demands for agility, transparency, and efficiency. Shrinking markets and global competition pose numerous challenges for banks – the Cloud offers the speed, flexibility and real-time information needed to meet those challenges on a cost-effective basis.

The question that begs an answer is “Why Cloud Computing for Banks?” Cloud computing can help financial institutions improve performance in a number of ways as mentioned below [91], [28], [33], [92].

Cost Savings and Usage-based Billing

With cloud computing, financial institutions can turn a large up-front capital expenditure into a smaller, on-going operational cost. There is no need for heavy investments in new hardware and software. In addition, the unique nature of cloud computing allows financial institutions to pick and choose the services required on a pay-as-you-go basis.

Business Continuity

With cloud computing, the provider is responsible for managing the technology. Financial firms can gain a higher level of data protection, fault tolerance, and disaster recovery. Cloud computing also provides a high level of redundancy and back-up at lower price than traditional managed solutions.

Business Agility and Focus

The flexibility of cloud-based operating models lets financial institutions experience shorter development cycles for new products. This supports a faster and more efficient response to the needs of banking customers. Since the cloud is available on-demand, less infrastructure investments are required, saving initial set-up time. Cloud computing also allows new product development to move forward without capital investment. Cloud computing also allows businesses to

move non-critical services to the cloud, including software patches, maintenance, and other computing issues. As a result, firms can focus more on the business of financial services, not IT.

Green IT

Organisations can use cloud computing to transfer their services to a virtual environment that reduces the energy consumption and carbon footprint that comes from setting up a physical infrastructure. It also leads to more efficient utilization of computing power and less idle time.

Although big financial, technology and manpower savings sound great to banks, there are still a number of issues to be resolved. Some of them may be regulatory requirements, data privacy and data location. Cloud has not yet been widely accepted as a new IT infrastructure model in banking sector but the situation is slowly changing. Banks will invest much in the cloud in coming years [93]. Many banks, consumers, and companies are missing out on the benefits of cloud computing because they do not have confidence in cloud computing. There is a good opportunity for banks to enter into cloud computing and thus offer better and efficient services to its customers [89].

2.5.2 E-Library Services

Another area where cloud computing has been applied is in the library services. In a study conducted by [94] on cloud computing and its application in library services, they explain that E-library allows users an improved access to library services at the comfort of their homes and offices. E- Library refers to all the library resources that are available online through computers and databases with restricted access. Specific access account given to library patrons to search or make reservation of library materials anywhere and anytime at their conveniences. The study further gives advantages of cloud computing in e-

libraries which include the following: Cost saving, flexibility and innovation, user centric, openness, transparency, interoperability, representation, availability anytime anywhere, connect and converse and create and collaborate.

The advantages have been motivators for applying cloud computing in the library services. Below we take a review of a few areas where libraries are implemented using cloud computing as mentioned by [95], [96]

Online Computer Library Centre (OCLC)

OCLC is one of the cloud computing vendors, providing a platform to access information. It is a research organization designed to reduce the cost of accessing information available globally. In this system, the centralized data is managed by the cataloguing tools over the Internet. By maintaining a centralized data source of catalogue, multiple libraries can access the resources simultaneously, increasing the sharing of resources, hence reducing the time spent in individual cataloguing of new material.

Library Thing Tim Spalding is the originator of Library Thing designed to combine aspects of Cloud computing and social networking. Here people share interests, contribute information and provide suggestions regarding the books, articles and various resources. It allows the different users to interconnect with each other globally. Libraries can access the database regarding the recommendation of users to provide better facility by paying a fee.

Reed Elsevier provides scientific information to medical technicians. Technical manuals, article content are hosted for the medical personnel to get assistance. Data and applications are tied to provide better facilities to practitioners.

CYBRARIAN is a web based library used for automation and management solution. It provides a platform where data is stored in much more updated and secured form. Constant backup of data is maintained at regular interval

automatically. A centralized database is maintained over a remote server. Users can access and run this software, from a normal PC having a browser, to carry out online transactions, management of catalogues and reports, article indexing and many more. Only authorised users can access the library resources.

OPAC Online Public Access catalogue is a general cataloguing service used to maintain data records online. Users can search books and other resources available physically in a library. Other examples are Amazon, Google, Kindle, Mobile Me services, DuraSpace, Chronopolis Project, TerraPod [97]. The figure 4 below shows the architecture of a digital library.

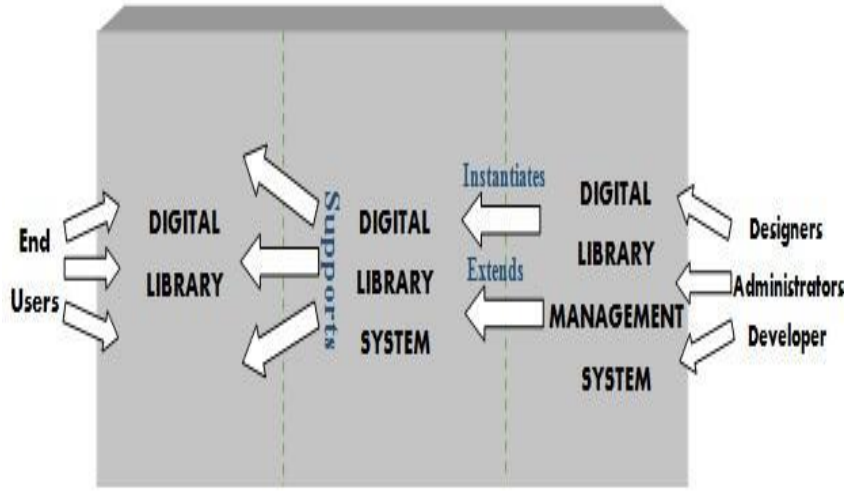

Figure 4: Architecture of a Digital Library System. Source: [95]

As already seen from the reviews above, cloud computing is benefitting the organisations in different ways and it is supporting more innovations because of its existence. More and more libraries may be connected together to share resources, innovations and feedbacks. It becomes feasible for the user to get a vast pool of knowledge with easy accessibility, cost effectiveness and scalability at the time of growing information. Shared data and integrated, well collaborative services have helped libraries to grow and take new leaps.

2.5.3 Cloud Computing in the Health Sector

Cloud computing brings a new business model which enables several advantages that would benefit the general healthcare community. By adopting the cloud in medical services both patients and healthcare organisations would obtain a huge benefit in patient's quality of service, collaboration between healthcare organisations as well as reductions in IT cost in healthcare companies. The current trend of adopting cloud computing in the medical field as suggested by [98] can improve and solve several collaborative information issues in healthcare organizations as well as cost optimisations. Standardised cloud-based applications will bring obvious advantages to patients, physicians, insurance companies, pharmacies, imagining centres, and others when sharing information across medical organisations yielding better results. Challenges such as security concerns and interoperability will rise due to the cloud-computing model making the adoption of the cloud progressing slowly. Through the implementation of best practices in the design, deployment and use of it will hopefully generate a future growth of the cloud-based systems adoption, despite all of the obstacles [98].

Rakibul Hoque et al. suggest that the e-Health has enormous potential to ensure healthcare quality, accessibility, and affordability in developing countries. Over the past decade, the rapid advancement in information and communication technology (ICT) has experienced tremendous change in health sector in many countries. Recent evidence suggests that e-Health is the blessing of ICT and is probably the most prominent service that has a noticeable effect on the development of healthcare sector in developing countries [99]. Research on the adoption of e-Health in developing countries has shown that e-Health can be one solution to provide better access to healthcare facilities for patients, physician, nurses and other healthcare staffs, increase care quality and improve collaboration [100].

An exciting and effective innovation that has been added to the existing e-Health service is complaint-suggestion by SMS. Display boards, describe how to send complaints by SMS for improving service, were added in 800 public hospitals in Bangladesh [99].

An analytical study was conducted by [101] on online appointment scheduling for hospitals. Online appointment scheduling system is a system through which a user or simply, a patient can access the website of the doctor, and through the online software, the patient can easily make their appointments. In addition to that, a patient can also provide additional information to the doctor, making the doctor aware of their situation and giving the doctor time to prepare the necessary information for when the patient arrives.

Compared to the traditional appointment system where a patient has to come to the hospital and queue at the appointment window to make the appointment the patients using this method waste much unnecessary waiting time standing in the queue at the registration window to ensure a successful registration with a certain physician.

In online appointment scheduling system patients are given an appointment number. At the designated appointment time, patients arrive at the hospital and get the registration that is allotted to their appointment number. In this way both direct and indirect waiting time can be minimized and hospital’s valuable resources can be utilised efficiently.

Figure 5 shows the operational flowchart of an online appointment system.

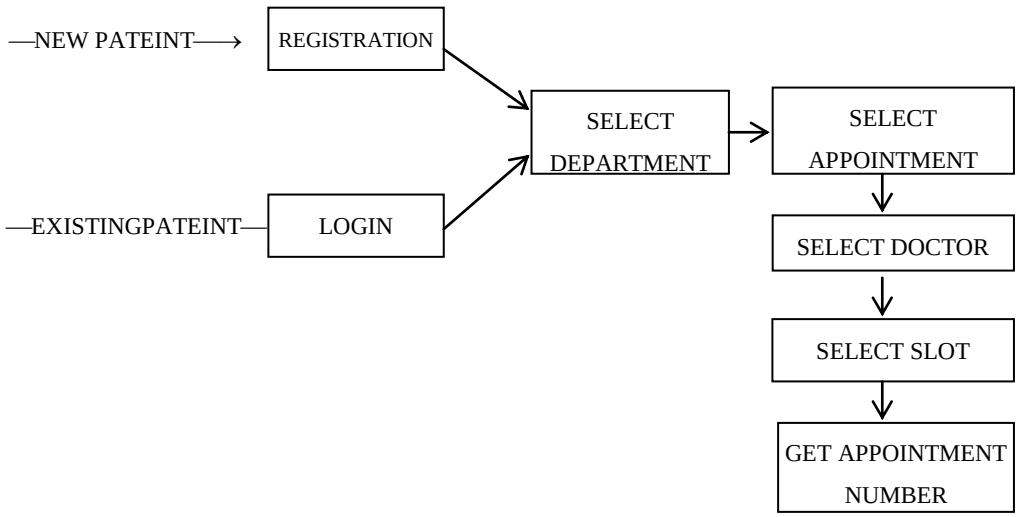

Figure 5: Operational Flowchart [101]

An integrated online patient appointment scheduling approach based on Web-Services architecture enable the establishment of patient-centred health care system easily. The goal of automated patient appointment scheduling process is to integrate distributed clinical systems into a set of consistent and convenient services accessible via a web browser.

Figure 6 shows the 2-Tier System Architecture for Online Appointment System.

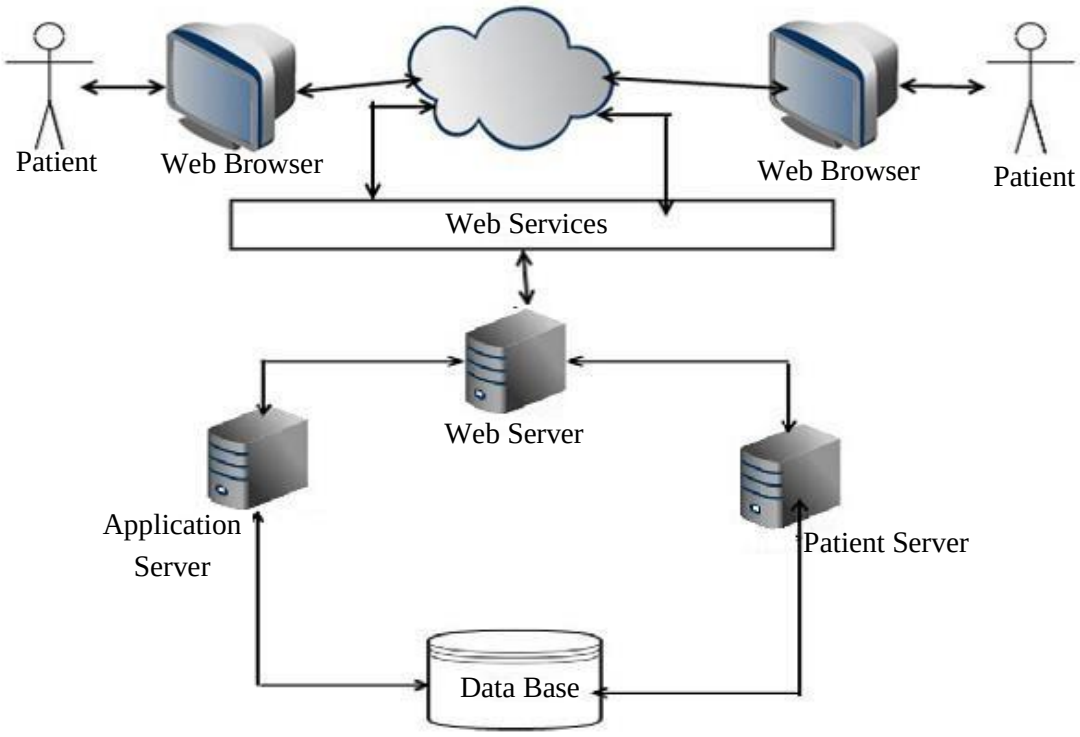

Figure 6: 2-Tier System Architecture for Online Appointment System [101]

The flexibility of online scheduling system enables it to be utilized for a variety of different services and activities thereby improving the health delivery services [101].

2.5.4 MoodleCloud, e-marker, and Grade Maker

Cloud computing has been used in the education sector in different aspects of education. Below we review areas like learning, marking of assessment and authoring or preparing examination test items.

MoodleCloud is a cloud based e-learning platform for creating learning communities around educational subjects and activities. MoodleCloud is software for a "digital learning environment". It allows distributing documents (text, audio, video, etc.) and supporting the interactions between teachers and

students, using a variety of communication tools, evaluation and management. It also allows educators to deploy their own server in the cloud [103].

e-Marker is a cloud based platform for on screen marking of examination scripts provided by DRS (Data Research and Services Plc). As a pioneer of electronic marking solutions, DRS' e-Marker offers a variety of electronic marking approaches for awarding and professional bodies that is already well established in the UK, Africa and India. Paper examination scripts are scanned and images are presented to markers to mark on-screen using the DRS cloud solution. DRS' e-Marker significantly improves security, data accuracy, and speed of marking, integrity and reliability. When moving from traditional pen and paper marking to electronic marking methods, e-Marker is proven to bring improvements in marking quality by reducing bias, real-time marker monitoring and proactive malpractice management [104].

GradeMaker is a simple and intelligent technical solution to deliver cutting edge assessment services. It allows authoring of test items online with a secure cloud based system enabling quick search, tag, analyse, commission and author. It can also deliver rich support to schools using the secure channel provided. The software is cloud based and supports many examination bodies to have an interaction with their centres for revision questions etc. Access to these test items is restricted to users that have access to the software [105]. Figure 7 shows an overview of the system components.

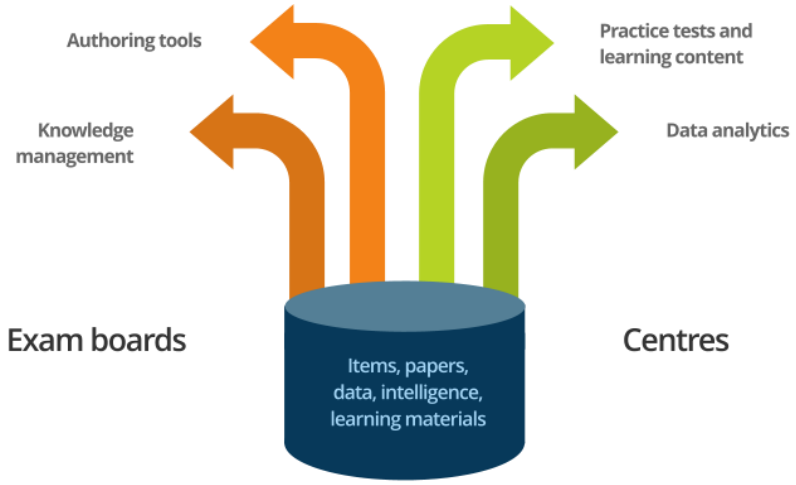

Figure 7 GradeMaker [105]

2.5.5 Education Cloud Computing Applications

The role of technology in education cannot be overemphasised. It is hard to imagine education in the 21st century without technology for they are intertwined. Technology is important in the entire education process as a tool for enhancing the processes. The education sector has not been left behind in the use of technology and has also been supported by IT companies that provide cloud services. According to [52] educational cloud computing services represent a growing variety of useful services available on the internet, and the most innovative and rapidly developing element of technology and education. The role of cloud computing in education should not be underestimated, as it can provide important gains in offering direct access to a wide range of different academic resources, research applications and educational tools.

More cloud computing based platforms, applications and services are being developed for academic cloud computing some of which are already being used by students and researchers. Furthermore, these applications are heavily investing in cloud computing as being the future of the academic cloud computing. IT companies are eager to encourage educational adoption of cloud

computing by providing services for free or at a discounted rate. Some of these applications are Microsoft, Google, IBM, HP, Amazon and Sales force.com [52].

Amazon Education Cloud Computing

To assist educators in providing cloud computing instruction, Amazon Web Services (AWS) offer teaching grants supporting free usage of AWS for students in eligible courses. AWS provide a highly scalable cloud computing platform for schools and universities which encompasses high availability, dependability, and the flexibility to enable the faculty, students and researchers to build a wide range of applications. With AWS, students and others can requisition compute power, storage, and other services gaining access to a suite of elastic IT infrastructure services for educational purposes [52].

Microsoft Education Cloud Computing

Microsoft cloud services give students and researchers the ability to make full use of the same Microsoft technologies in the educational institution. These services offer greater financial flexibility to educational institutions and enable lower costs to develop, scale, operate and migrate the systems that are distributed between the cloud and the data centre. For example Microsoft Live@edu which provides a set of hosted collaboration services for the educations institutions is intended for educational needs. By means of free registration process universities, colleges and schools can enrol in the program. Microsoft Live@edu is mainly for the institutions for enabling facilities for their academic activities [52].

Google Applications for Educational Cloud Computing

Google App Education (GAE) as a new generation of cloud computing-based Web application development platform, enables its users such as the faculty, researchers and students to operate Web applications within the Google

Infrastructure. GAE is available at no cost to institutions, universities and education community. The teachers, students, and staff can share ideas more rapidly and get things done more adequately they have got an efficient communication and sharing tools. [106]

IBM Cloud Services to Education

The IBM SmartCloud for Education is a set of cloud services and offerings designed to help education systems leverage predictive analytic to get realtime insights on educators and institutional performance, enhance researcher effectiveness, and alleviate constrained lab resources for learning. By using the IBM Smart Cloud for Education services, schools and higher education institutions can address the significant challenges they face.

Salesforce.com Cloud Computing In Education

Salesforce is a trusted leader in cloud computing and customer relationship management, as well as a respected pioneer in the educational institutes. As part of these philanthropic efforts, the Salesforce.com Foundation makes its products available at the educational institutes at a big discount. Salesforce is being used by higher institutions of all sizes and across all sectors to: a) Work more efficiently, b) Deepen engagement with constituents, c) Measure and share impact and success d) Work more collaboratively, e) Deliver programs and services in innovative new ways. Higher education institutions are using the Salesforce.com cloud computing platform for its instant scalability, ease of configuration, and support for multiple functional roles. [52]

2.5.6 Application of barcode technology

Nearly every type of industry is using barcode technology to replace keyboard data entry because bar coding is much faster and more accurate than keyboard data entry. A bar code is a piece of Automatic Identification Technology (Auto

ID) that stores real time data. The circulation work in an automated library involves keying in a large amount of data and sometimes, the library staff at the counter has to retype the same information due to error in data entry. A bar code reader decodes a bar code by scanning a light source across the bar code and measuring the intensity of light reflected back by the white spaces.

2.6 Summary

The reviewed literature mainly dealt with cloud computing and its applications in education, challenges with registration of candidates, a comparison on web based and desktop applications and their pros and cons as well as related works on applications of cloud computing. It is clear from the literature reviewed that challenges faced with the registrations of candidates are similar in other examination bodies and the solutions used utilised technology. The comparison between desktop and web applications gives an insight that it is more advantageous to use a web application for registration of candidates because of the large numbers of examination centres involved as well as candidature.

Applications of cloud computing in education, health care, libraries, vehicle tracking and financial services are many and varied. In the educational sector, cloud computing application has been used especially in learning and testing although their uses in many areas of education are still in their infancy.

The literature has revealed that cloud computing is in a period of strong growth, but cloud technology is still somewhat immature and will take another few years to mature. The real value of cloud computing is that it makes software and data available transparently and everywhere – include the mobile environment. One of the key elements of a stateless computing environment is a networked storage system that enables ubiquitous availability of software, making the cloud the ideal environment to enable mobile smart phone users to access its powerful

computing power remotely. As with any other technology going through a period of rapid growth, the stronger players will survive and the weaker players will be driven out of the market [89].

Examination bodies may argue where their data are more secure, on the local hard disk or on high security servers in the cloud. As cloud technology matures, more and more services will be cloud based and choosing the right cloud service is what will matter most.

Chapter Three

3.0 Methodology

3.1 Introduction

This chapter describes the research strategies, methods and research design that were employed to collect the desired data in the study. In particular, it concentrates on the research design, target population, sample size and sampling procedure, research instruments, data collection procedure and analysis thereafter. Details of the data analysis procedures that were employed in the research are also discussed. This is followed by the methodology used to design the models, development and implementation of the prototype. Finally, a summary of the key issues discussed in the methodology chapter is presented.

3.2 Baseline Study

The purpose of the baseline study was to establish the challenges faced by the ECZ regarding the registration of candidates for school examinations. The methodology that guided this research was twofold. In the initial phase, a mixed methods research design using both qualitative and quantitative designs was used to collect data on the challenges in the candidate registration process. A Mixed Methods Research methodology comprises a combination of qualitative and quantitative research types [107]. This methodology combines diverse types of data which provides the best understanding of a research problem. It is useful when either the qualitative or quantitative approach by itself is inadequate to best understand a research problem. Alternatively, it can be used when the strengths of both qualitative and quantitative research can provide the best understanding.

In order to ascertain the challenges faced by ECZ in the candidate registration process, descriptive research design was used. A descriptive research design involves describing the state of affairs as they exist at present [107]. The choice of this research design helps to describe the characteristics of the target population and determine relationships between variables and make specific predictions for solving research problems [108].

3.2.1 Study Setting

This study was conducted in all the ten (10) provinces of the country comprising 10 provincial educations offices, 62 district education offices and 50 schools out of which 75percent were secondary schools and 25 percent were primary schools. The rationale behind having this proportion of schools is that secondary schools conduct up to three (3) examinations namely Junior Secondary School Leaving Examination (Grade 9), School Certificate (Grade 12) and General Certificate of Education (GCE) while primary schools mainly have only one examination at Grade 7 level called Grade 7 Composite Examination.

3.2.2 Sampling

The sample for this study was purposively sampled. Non-probability sampling technique was used for all respondents by virtue of their specialised knowledge in the subject area. This approach was preferred as the research required information from those who were responsible for registering candidates for examinations at school and district levels and supervising the registration process at the provincial level. In addition employees of ECZ who were responsible for handling the candidate registration data received from the provinces were interviewed. This implies that by choosing participants purposively, it is possible to get people who have experience in the phenomenon and have first-hand information pertinent to the study.

In each of the fifty (50) sampled schools, the guidance teacher responded to the questionnaire because these were the people responsible for entering candidate registration details at the school level. At the district and province, the Education Standards Officer – General Inspections and Senior Education Standards Officer – Examinations respectively responded to the questionnaire.

An interview guide was used to gather information from ECZ employees who were directly responsible for handling and processing the candidate registration data received from the provinces.

3.2.3 Inclusion Criteria

The study population included ECZ members of staff who were responsible for receiving, checking and processing the candidate registration data received from the provinces.

3.2.4 Data Collection

The period for data collection was from mid-April 2016 up to the last week of June 2016, which lasted for ten (10) weeks. The questionnaire was distributed to the respondents in the provinces and the districts. Forty (40) percent of the data was collected during a review meeting of the 2015 examinations held in the second week of April 2016 which comprised participants from the Districts, Provinces and Schools. As for the other sixty (60) percent of the data, the provincial education offices were requested to administer the questionnaire in the sampled schools and districts in their respective provinces.

The researcher conducted interviews with the Data Controller, Computer Operators, Programmer and Senior Examinations Officer at ECZ. The interview guide being part of the research instrument, the interview questions were prepared in advance to keep the interview in focus. The responses were recorded

in script for future analysis and clarity was sought whenever further explanations were needed.

3.2.5 Data Processing and Analysis

Descriptive statistical analysis technique was used to analyse the data obtained from the questionnaire. Qualitative data were analysed by bringing out emerging themes that were categorised and interpreted. These responses were grouped according to themes of the questions.

Furthermore, quantitative data were analysed using IBM SPSS Statistics software. Descriptive statistics were applied to the processed data by showing variable frequency distributions from the responses obtained. Data were presented using graphs, charts, tables and percentages.

3.2.6 Ethical Consideration

Since the respondents were purposively sampled and the identities of the respondents can easily be traced, the respondents were assured of confidentiality and non-persecution arising from their responses as this was to be used for academic purposes.

3.2.7 Limitations of the Baseline Study

The researcher did not have sufficient time and money to carry out the study since the researcher is in full time employment and not granted study leave and also funding her own training and research. Furthermore the period of data collection coincided with the time when teachers were on holiday and the researcher depended on the Provincial officers to distribute and collect the questionnaires from the schools sampled. It was therefore difficult to get back all the questionnaires distributed and on time.

3.2.7 Presentation of Findings

Graphs, charts, tables and percentages were generated from the quantitative data obtained using questionnaires. Qualitative data obtained from interviews and open ended questions from the questionnaires were analysed by coding and categorizing the emerging themes accordingly.

3.3 System Automation

The results of the baseline study were used to come up with a conceptual model for registering candidates for national examinations. The proposed model developed utilises the cloud model to be used to register candidates for school examinations in Zambia. The proposed cloud model system is expected to reduce cost and the time it takes to register candidates and ensure that the registration data are centrally stored. In addition it is expected to reduce the movements to and from the examination centre, district, province and Examinations Council of Zambia to submit the CDs containing the candidate registration data.

Qualitative data obtained from both the questionnaire and the interviews was used to come up with the system requirements and model design of the system in the study. In addition, the current registration system was reviewed to have a full understanding of the candidate registration business process.

This study employed some of the diagrammatic representations that are existent in the Unified Modelling Language (UML) to envisage the system from various perspectives. The approach that was used in the system development process is one that is Use Case driven.

3.3.1 Current Examinations Council of Zambia Business Processes

The whole examination process cycle that was described by the ECZ staff is

presented below. A brief of all the processes that ECZ undertake is shown in Figure 8 of the examinations cycle for School Examinations. The main focus of this research is on the candidate registration process which is described in detail in this section. The candidate registration process includes registration of the examination centres, pre-entry processing, distribution of the candidate registration software, entering candidate details at the school or centre, consolidation of registration data at the district office, submission to the PEO's Office and finally submission to ECZ.

3.3.2 Registration of Examination Centres

Before a school can register candidates for examinations, the school or college should be registered as an examination centre. An examination centre is a school or institution which has been approved by the Examinations Council of Zambia to conduct examinations, has been allocated an examination centre code and has been included in the examinations centres database as being available for registration of candidates.

The examination centre registration process begins with the school applying using the prescribed application form which is submitted to the District Education Board Secretary's (DEBS) Office. The DEBS office inspects the school and makes recommendations and submits the application to the Provincial Education Officer (PEO) who also conducts an independent inspection of the school. When the PEO has inspected and recommended the school for consideration for award of examination centre status, the application is submitted to ECZ where it is considered by the relevant Council Committee. The examination centre code is only allocated after the Council Committee has approved that the school is eligible to conduct examinations. After the centre code has been allocated, the school is now registered/ entered in the

examinations system and is now counted as one of the approved examination centres. Thereafter, feedback is given to the school on the outcome of the application, be it negative or positive.

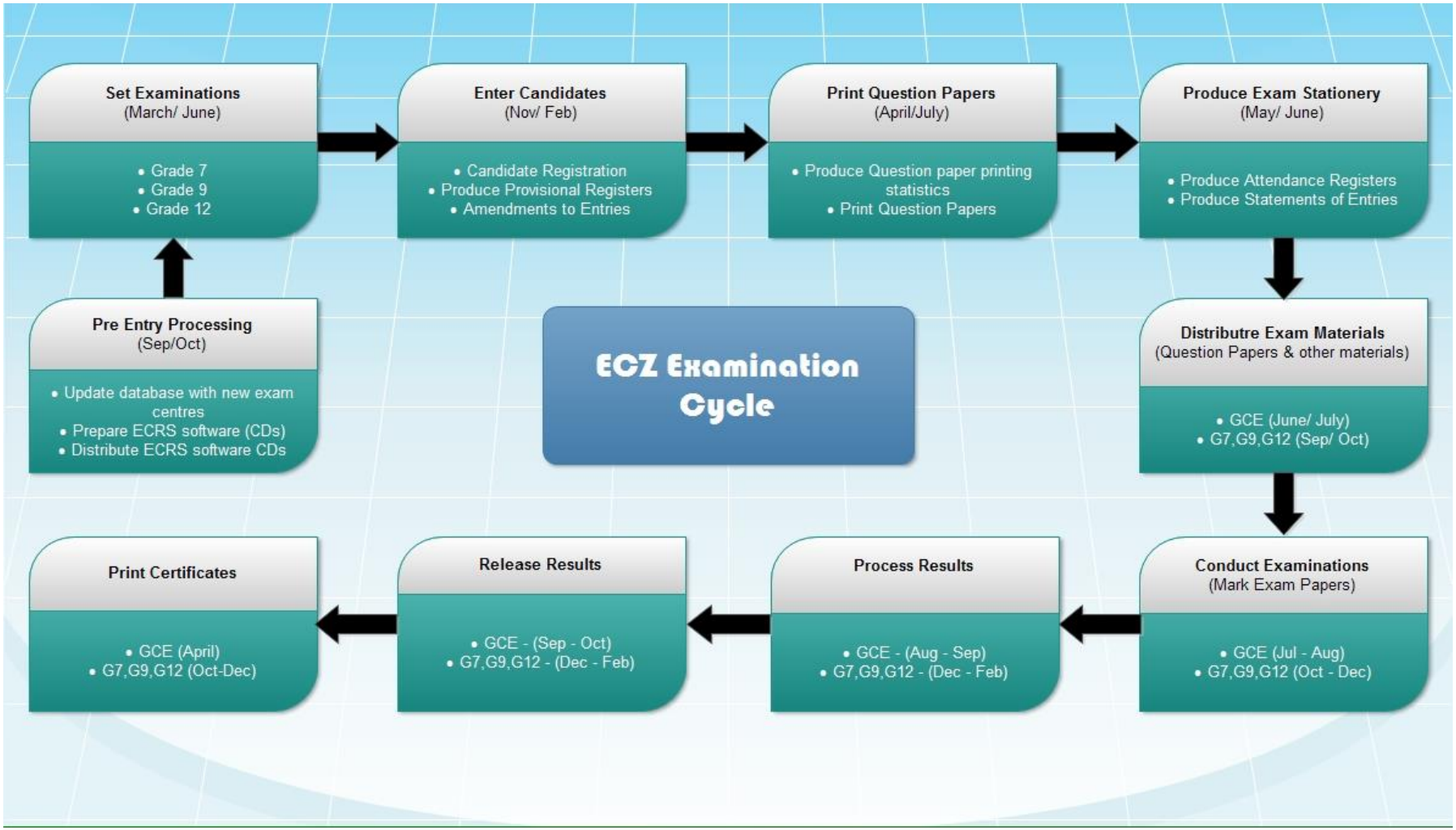

Figure 8: Examinations Cycle for School Examinations

3.3.3 The Candidate Registration methods used by Examinations Council of Zambia

The Manual Candidate Registration Process

The Examinations Council of Zambia became operational in 1987 from which time registration of candidates was achieved through the use of manual processes. Candidate and subject details were written onto a form and thereafter the details were then manually keyed into the computer system. Challenges such as data entry errors and the slow process associated with manual processes were faced during this period.

Figure 9 shows the manual candidate registration process information flow which was used up to 1997.

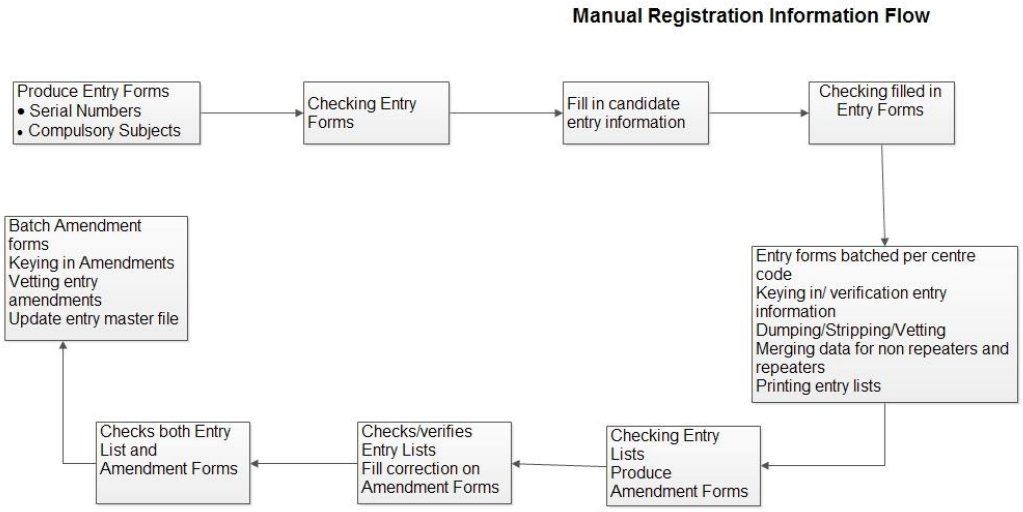

Figure 9: Manual Process information flow chart

The optical mark read (OMR) Registration System

The registration of candidates for all school examinations from 1997 when the ECZ started processing results in-house, to 2011 was achieved through using the optical mark read (OMR) registration forms which were distributed to examination centres and would be candidates were required to complete their examination entry details by shading in the provided spaces. These forms were

in turn submitted to the Examinations Council of Zambia by Schools/Centres where they were scanned and data loaded into the examinations processing system and later generate the provisional registers, entry statistics and pre exam documents [109]. Figures 10 shows the processes involved with using OMR forms for candidate registration, answersheets and marksheets. The back and forth movement made this process take longer than expected due to high scanning rejection rate.

The scanning process involved three stages. The preparation stage involved stacking the entry forms for scanning and the manual editing of the rejected OMR forms. The second stage involved the actual scanning of the OMR forms with an operator manning the OMR machine. During scanning, the good forms were thrown in the accepted hopper while the forms with scanning errors are thrown in the rejected hopper. The scanned images were then processed as the final stage where all the information was stored in the database and reports were produced.

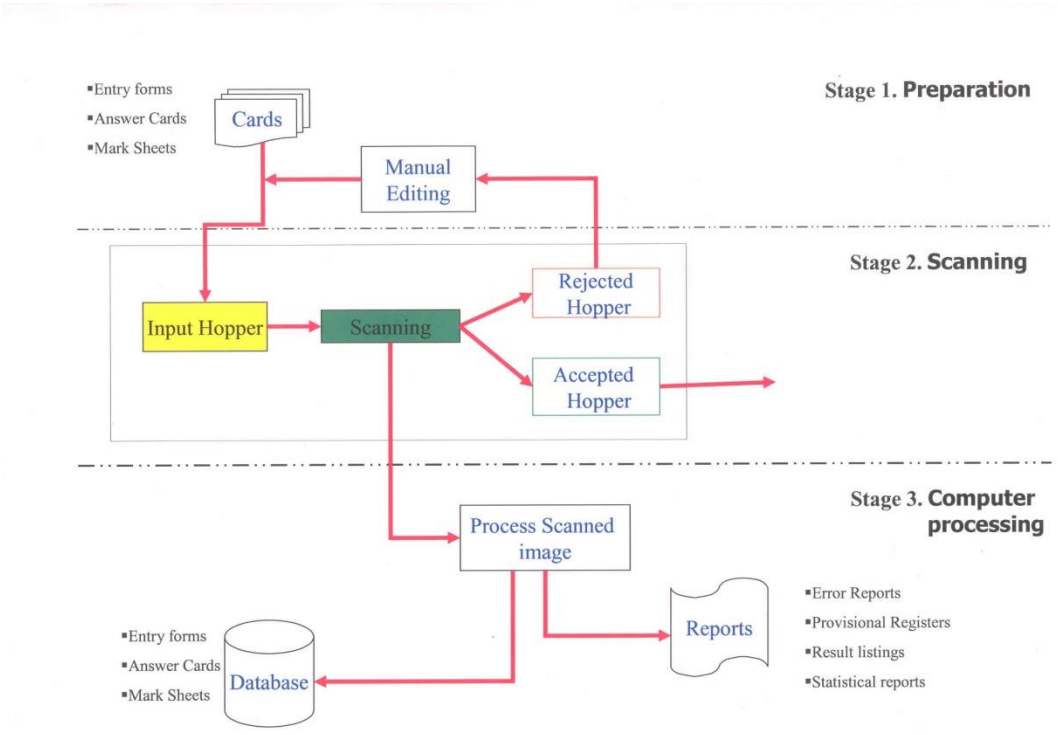

Figure 10: The OMR Scanning process

Figures 11, 12, and 13 show the OMR forms that were used at different Grades (levels) of the examinations for registration of candidates.

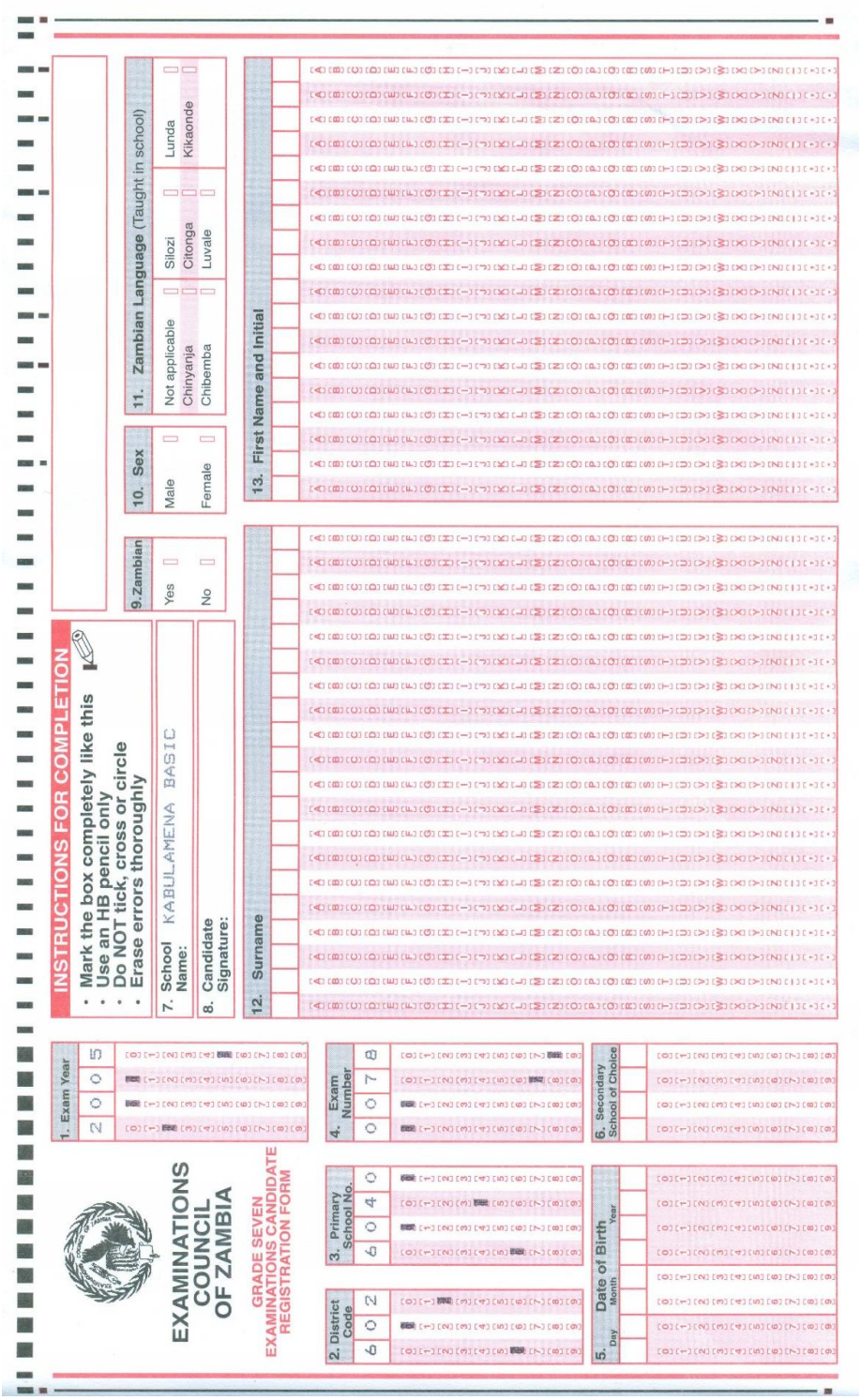

Figure 11: Grade 7 Examinations Candidate Registration Form (1997-2010)

Figure 12: Grade 9 Examinations Candidate Registration Form (1998-2009)

EXAMINATIONS COUNCIL OF ZAMBIA

GRADE TWELVE EXAMINATIONS CANDIDATE REGISTRATION FORM

INSTRUCTIONS FOR COMPLETION

1. Mark the box completely like this ■
2. Use an HB pencil ONLY
3. Do NOT tick, cross or circle
4. Erase all errors thoroughly

10. Subjects Entered

Group I	English Language							
Group II	Literature in English		Relig. Educ. (2044)		Relig. Educ. (2046)		History	Geography
Group III	French	Lunda	Luvale	Kikaonde	Bemba	Chitonga	Nyanja/Chichewa	Silozi
Group IV	Mathematics		Additional Mathematics					
Group V	Agric. Science	Physics	Chemistry	Biology	Human & Soc. Biology		Science	Combined Sc.
Group VI	Art	Paper 1	Paper 2		Paper 4		Paper 6	
	Music	Paper 1	Paper 2		Paper 3		Paper 4	
	Woodwork	Metalwork	Metalwork (Eng)	Fashion & Fabrics	Food & Nutrition		Home Management	
Group VII	Computer Studies	Geometrical & Mechanical Drawing		Commerce			Principles of Accounts	

1. School Name: MPELEMBE SECONDARY SCHOOL

2. Exam Year: 2007

3. School Code: 50502

4. Examination Number

11. Surname

12. First Name and Initial

5. Date of Birth (Day, Month, Year)

6. Zambian: Yes / No

7. Sex: Male / Female

8. Entry Type: Internal / A. P. U. / External

9. Candidate Signature: 137

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Figure 13: Grade 12 Examinations Candidate Registration Form (1998-2008)

Table 3 gives a summary of the processes involved with the OMR registration forms and the short comings of each process.

Table 3: Challenges in examination registration – Optical Mark Reader (OMR) Forms

Process	**Shortcoming**
Procure OMR Registration Forms from the United Kingdom (UK)	Costly(require expensive OMR Scanning machines to process)
Transport OMR forms to examination centres countrywide	Costly, risky and time consuming
Shading of forms at the examination centres.	Delicate, handling and shading instructions not followed.
Transport shaded OMR forms to ECZ	Costly, risky and time consuming
Scan the shaded OMR forms	Costly, time consuming, some forms incorrectly shaded or improvised while others found missing, high scanning rejection rate
Load captured data and print provisional registers	Costly, data errors
Transport printed provisional registers to examination centres countrywide for verification and correction	Costly and Risky
Candidate verification and correction of information at centres	Time Consuming
Transport corrected and verified provisional registers back to ECZ	Costly and Risky
Amend candidate details on examination management system arising from the correction on received provisional registers	Time consuming, Costly and some provisional registers not received back

The challenges and data errors encountered with the OMR method of registration which made the operations of ECZ very difficult were the cost of high-tech equipment and stationery, high scanning rejection rate, partial or non-registration of candidates for the examinations, misspelt names, multiple shadings, wrong subjects entered by candidates, registration forms received late or not received at all. This resulted in a lot of complaints from candidates and parents. Additionally, delayed receipt of registration forms also delayed the subsequent process of procuring examination materials for candidates [9].

Consequently, the anticipated omission of candidates resulted into ECZ procuring unwanted quantities of examination materials under the Headquarters' stock to mitigate the shortfalls that would be experienced by the Schools/Centres during examinations. Also, too much time, money, and human resources were spent resolving these errors which delayed the final release of results.

The previously named challenges generally impacted the whole examination system such that there was delayed acquisition of vital information which in turn would delay the ordering of examination materials. This and other variables in the complete process ultimately delayed the release of examination results which before the year 2008 would be around February and March. This consequently resulted in the reduction of the first term of the school calendar year from the normal three (3) months to just about a month only thereby applying pressure on teachers and pupils in completing the academic syllabi in an a short time.

The ECZ being desirous of improving efficiency explored the use of ICTs in the registration process [84]. As a result, the ECZ introduced the Electronic Candidate Registration System (ECRS) in 2009 at Grade 12 and GCE levels, a system of registering candidates by centres which replaced the use of OMR registration forms. This candidate registration system, the ECRS, allows centres to enter candidate registration data and able to print various reports for checking

the completeness of data before submitting to ECZ on a compact disk (CD) [110]. The system also has some inbuilt tools for checking and validating the data entered such that some of the errors encountered with the OMR registration system were greatly reduced.

Although the Electronic Registration system saw a reduction in most of these errors, this system of registering candidates also has had its own challenges. The process described above involves third party handling of candidate registration data whereby this registration data is consolidated at the district for all schools [110] in each district after schools have finished entering their candidate details. In addition, the system is a standalone system / desktop application such that at the stage of merging data from various districts and centres, errors like duplicated examination numbers at Grade 12 level where the same examination number allocated at Grade 9 is used again are noted. Among other errors associated with this system is omission of candidates, inaccurate candidates' details captured and low user ICT levels [111].

3.3.4 The Registration Process: Electronic Candidate Registration System (ECRS)

The candidate registration system that the ECZ has been using is called the Electronic Candidate Registration System (ECRS), an in-house developed desktop application system using the Microsoft Access database management system. The ECRS is a desktop application and below is a brief description of the registration process using the same system, ECRS.

The process begins by ECZ updating the software with new examination centre every year as well as the software whenever there are changes requested for. Once the software has been updated, it has to be copied onto approximately 10,000 CDs by ECZ staff for each examination centre at Grades 7, 9, 12 and General Certificate of Education (GCE) level. The ECRS software CDs are sent to each province, provincial education office, by ECZ where they are then sent to the District Education Board Secretary's (DEBS) office for distribution to the

various examination centres in the district. The district remains with a copy of the ECRS software which is also installed on their computers that would be used for consolidation of entries for the district.

At the school, the software is installed on the computers that would be used for registration of candidates and candidate details are entered by the school guidance teacher on the individual computers where the application is installed. At the end of registration, candidates are asked to verify their registration details and if all the details are confirmed correct the final provisional register is printed and signed by all the candidates to authenticate their entry details. The registration data for the centre are exported onto a CD that is eventually submitted to the DEBS office where the data for all the schools in the respective districts are consolidated. Once the data consolidation is completed at the DEBS office, the data for the whole district are again exported onto a CD which is submitted to the Provincial Education Officer's (PEO's) office for onward submission to ECZ. At ECZ the received data are checked and processed. Figure 14 shows the diagrammatical representation of the candidate registration process using the desktop application.

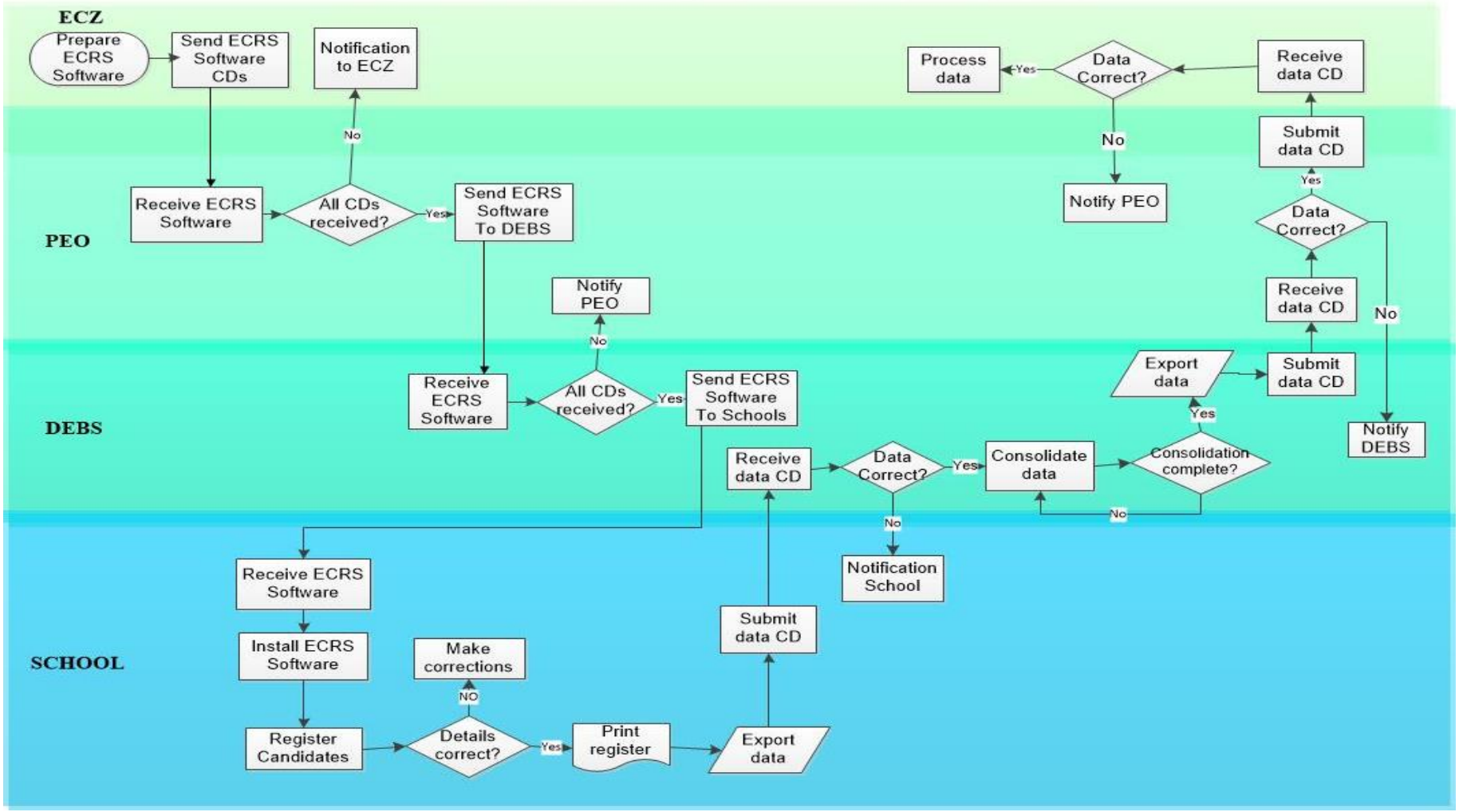


Figure 14: Candidate Registration Process flow diagram

3.3.5 Candidate Registration Process

According to the ECZ Guidelines on the Management and Administration of Examinations in Zambia, 'The Head of the School/Principal of the College is responsible for registration of eligible candidates for examinations at all levels' [110].

Pre-entry Processing at ECZ

The registration process begins with the pre-entry processing stage which involves the database setup for a new examination session cycle which contains newly approved examination centres, updating the ECRS software and verification of registered examination centres before the centres are loaded into the ECRS. Once the software has been updated with all the relevant information for the session, updated software CDs are prepared for each examination centre and the DEBS Office. The registration guidelines and the circular on registration is also prepared alongside. An approximation of 10,000 ECRS software CDs are prepared by the Information Technology department which are later handed over to the Examinations Administration department for distribution to the PEO's office who later distribute to the DEBS and then the district distributes to the Schools.

At the Examination Centre (School)

Candidates are registered using the Electronic candidate registration system that is provided by the Examinations Council of Zambia to all registered examination centres. When the school receives the updated ECRS software, it is installed on the computer that would be used for registering candidates. The school guidance teacher is responsible for entering candidates for examinations at the school as delegated by the Head Teacher. Upon completion of entering all eligible candidates for examinations the candidate registration data is exported and written onto a CD which is submitted to the DEBS office. All entries are submitted on CD and not any other media.

At the District

The DEBS has to ensure that all candidates have been registered in line with the ECRS upon receipt of the candidate entries data on CD. The received CD is checked to ensure that it contains the correct export file(s). Where the CD received does not contain the correct export file or is blank, it is returned to the school/college for corrections and the school has to resubmit.

The entries / data received from the schools are consolidated for the whole district. After consolidation, an export summary report is produced to ensure that all entries have been included. The DEBS then prints and distribute the provisional registers to schools to check and make corrections such as misspelt names, missing subjects, omitted candidates, wrong school of choice, invalid date of birth, and wrong subject entry among others. The DEBS ensures that all the provisional registers received back from the schools are dully signed by the candidates and the head of school.

The consolidated entries for the district are written onto one CD which is submitted to the PEO. The DEBS delivers the entries to the PEO together with any accompanying documents. The DEBs office is given two (2) weeks after close of registration within which to complete the data consolidation, printing of registers and making corrections wherever necessary.

At the Province

The PEO receives entries on CDs from the DEBS with accompanying documents. At the PEO's office, the PEO checks to ensure that all CDs received have the correct export file(s). Where the CD received does not contain the correct export file or is blank, the PEOs sends it back to the DEBS to re-run and resubmit the export file. There is no consolidation at the PEO's office. The PEO delivers the entries on CD to ECZ. The PEO's office is given one (1) week to submit entries to ECZ. Figure 15 shows the registration data CDs that are submitted to ECZ.

Figure 15: Registration Data CDs from Provinces

At Examinations Council of Zambia

Entries on CD from the Province are handed over to the Examinations Administration Department (EAD) at ECZ for checking to ensure that all CDs received from the province have the correct export files. After the CD is checked and confirmed to have the correct export file(s), the data is copied to one computer as a backup. The received entries on CD are thereafter submitted to the Information Technology Department (ITD) where the entries are processed and reports are printed which are used for verification of the entries.

This whole process between the close of registration and receipt of entries from the province to ECZ takes about a month as other processes have to happen before the final submission of the registration data. Figure 16 shows the candidate registration process flow.

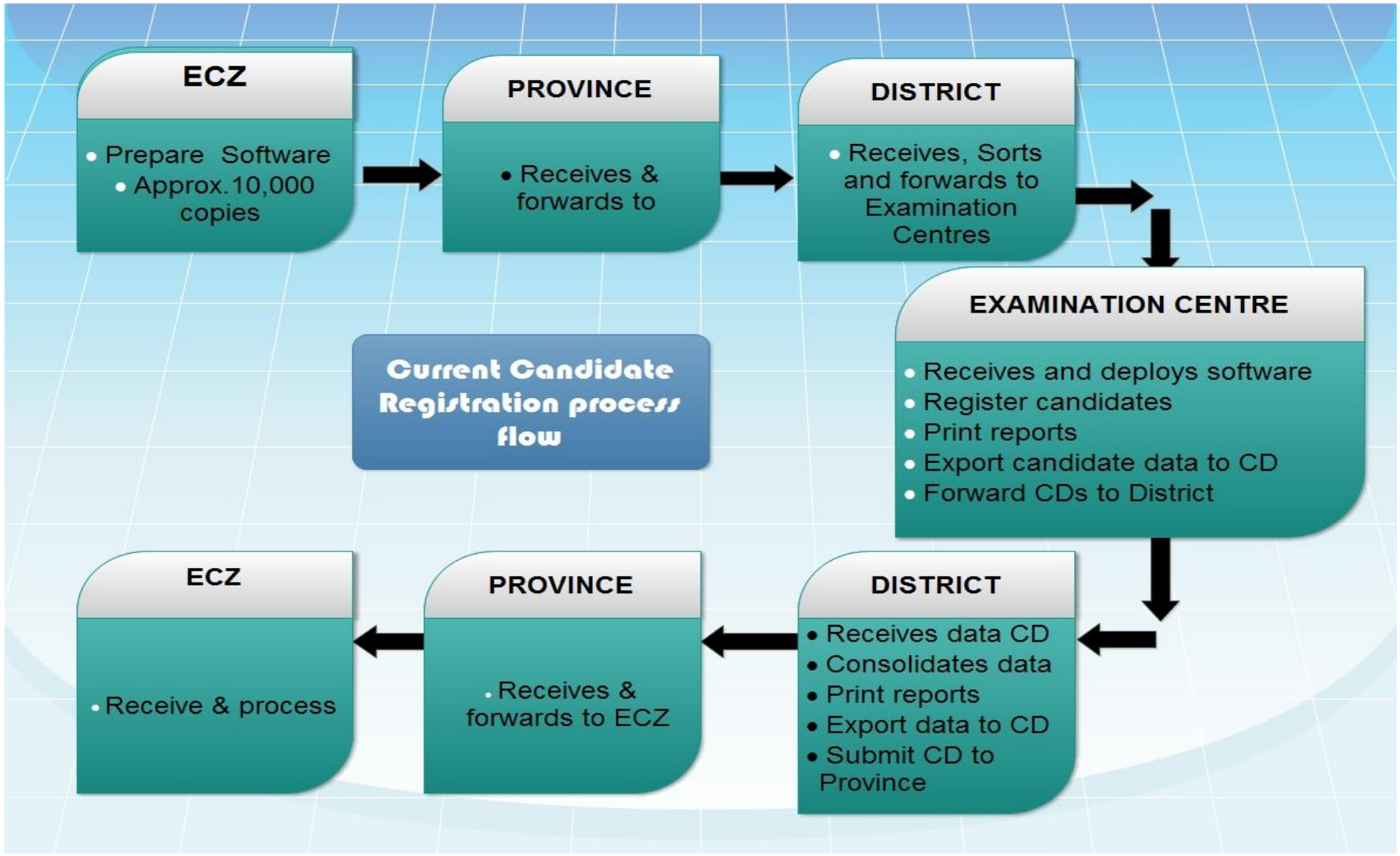


Figure 16: ECZ's Candidate Registration Process

3.3.7 Proposed ECZ Web based Candidate Registration Process based on the Cloud Model

Web based Candidate Registration Process Flow based on Cloud Model

The Web based candidate registration process presented here is derived from the registration process described in sections 3.3.4 to 3.3.5 and their subsections. Although this registration process is somewhat automated, there are still a number of inefficiencies and manual processes that have to be undertaken and from the baseline study, challenges with the desktop application registration system were noted. Developing a web based candidate registration system that utilises the cloud model to replace the Microsoft Access based registration system which is a desktop application is what was highly recommended by the respondents. Below is a description of the web based candidate registration system that utilises the cloud model and integrates bulk SMS as well as barcode technology as shown in Figure 18.

The registration of candidates as indicated in the guidelines for Management and Administration of Examinations in Zambia is a responsibility of the examination centre that presents candidates for examinations [110]. This being the case the web based candidate registration system will be used by the Guidance Teachers who are given this responsibility at school level. The system will enable candidates to check their details and verify, if there are any corrections they will get in touch with the Guidance Teacher to effect the amendments before the close of the registration period.

Registration of candidates for examinations takes place at the school. At the beginning of the registration period, the system administrator for the Web based registration system will open the registration link. At this point the Province, District and examination centres will be notified through the integrated bulk SMS system. Once the examination centre receives the SMS, they will begin registering candidates for examinations. The Province and District users will be monitoring the registration process by logging into the system, they can be able to view and generate statistical reports on the candidates registered.

After the school has completed registration of their candidates, they can generate and view reports of the registered candidates which they can print and also keep soft copies of the same reports as these reports will be in PDF format.

Upon successful registration of the candidate, an examination number is assigned to a candidate at Grade 7 and GCE levels where as at Grade 12 level the same number used at Grade 9 is used for registration as an internal candidate and the subjects registered for are saved in the system. As for Grade 7 registration, there is no selection of the subjects because all subjects are compulsory except the Zambian Language. Therefore, the system automatically assigns the compulsory subjects to the candidate. Even on the provisional register, only the Zambian Language appears. The system will also capture a candidate or guardian's cell phone number so that upon successful registration, a notification is sent to the phone number which shows the examination registration details such as subjects registered for and the examination date of each subject and paper. The candidate will be advised to contact their school should they have any queries on their registration.

In this system we propose the integration of barcode technology such that after the whole process of registration and the candidate has been successfully registered with all amendments completed, the school will be able to issue a token in the form of a card that will have a barcode bearing a candidate's credentials.

What should be in the barcode?

The barcode will contain the candidate's examination number, the name of the candidate, Date of birth, sex and National Registration Card (NRC) number where applicable. These details shall be linked to their examination entry details. We do not want to include the subjects in the barcode because of the following reasons:-

(i) The card issued should be used throughout the period that the candidate will be writing examinations conducted by ECZ from Grade 7 up to Grade 12 or tertiary for those that may sit the ECZ examinations at this level.

(ii) For the subsequent examination registration, the candidate will be expected to present the ID card which the system should just read the barcode and the candidate details will be retrieved. All that will need to be done is to add the subjects the candidate is registering for at that level. With this card, the candidate will carry on with one examination number from Grade 7 to Grade 12 or tertiary level. Having this one examination number will help trace candidates from Grade 7 as they progress to the other levels in their education. Profiling of students will be easier. Figure 17 shows a sample of the proposed candidate's identity card with a barcode to be printed from the system.

Figure 17: Sample Identity card with barcode

(iii) For the future, the ID cards can have RFID so that as the system progresses, the RFID can be activated to be used during examinations to mark the candidate's attendance. An RFID reader can be installed at the entrances of the examination rooms so that as the candidates enter the examination room they are being marked as present for the examination.

(iv) How do examination centres acquire the RFID readers? In the current setup as defined in section 3.3.1.1 for a centre to be approved as an examination centre, they need to fulfil certain requirements. Having to install RFID readers can be one of the conditions/ requirements for examination centre status, a school should have installed RFID readers at the entrances of the examination rooms. This would ensure that only

centres that have the required facilities would be allowed to conduct the examination offered by ECZ.

3.3.8 Proposed Security features of the web based candidate registration

One of the major concerns that cloud computing poses is security. When systems are in the cloud they become more vulnerable to attackers as they are in the public than desktop applications that are only available to local users. Our highest priority in the proposed system is confirmation that the person accessing this system is authorised to do so. A user should be able to validate who they are before accessing the system. The system can identify a user as being authorised in one of the three ways- what you know, what you have or who you are [112]. The most widely used method being 'what you know', passwords and other personal information. Some of the security features that we consider the system should have are described as below.

In the proposed system, we will start with 'what you know' where the user will be created by the District Administrator who will create users for all the schools in their district with a default password and each user account will be linked to their school and the level or Grade that they want to register candidates for. At first login, the user will be prompted to change their password before they can access the system modules. After successful change of the password, the user is automatically logged out of the system so that they can login with their new password. These users will be restricted to only registering candidates for their centre and the grade. In addition, the district system administrator will only perform administrative works on the system and not register any candidate as these do not belong to any school but instead are the overseers in their respective districts.

When the users are created, their credentials will be communicated via bulk SMS or email. For email, we propose that all users should have email addresses with the ECZ domain name having an email address with ECZ domain name domain name will help to easily monitor the activities of the email addresses.

Use of Biometrics

We will also consider use of biometrics for accessing the web based candidate registration system. Biometrics is a field of technology which is being used in the identification of individuals based on some physical attribute [112]. The following four factors of physical attributes have been widely used in the biometric authentication as indicated by [112].

(i) Finger print scans, which have been in use for many years by law enforcement and other government agencies and is regarded as a reliable, unique identifier.

(ii) Retina or iris scans, which have been used to confirm a person's identity by analysing the arrangement of blood vessels in the retina or patterns of colour in the iris

(iii) Voice recognition, which uses a voice print that analyses how a person says a particular word or sequence of words unique to that individual.

(iv) Facial recognition, which use unique facial features to identify an individual.

In the web based candidate registration system, we will consider use of finger print and face recognition at the time of login. The system will have a first level authentication where the guidance teacher will login the system using their username and password. The next level will be where they are asked to use their fingerprint or face to access the system modules for them to begin registering candidates. The system modules will only be accessed for registration if the fingerprint matches the other user credentials. Other than the fingerprint, facial recognition can also be used so that we are sure that the user entering the data is the one authorised to do so and not an impersonator.

GPS/GIS Location

Another consideration that we make is to make use of the GPS/GIS location by ensuring that all registered examination centres locations are captured in the system so that if anyone is trying to register candidates from a location that is not recognised in the system, alerts would be sent and deny a user in a strange

location from registering any candidates. Since nowadays GPS receivers can be found in phones, tablets, computers and a wide variety of other devices, the proposed system can make use of the tablets for registration of candidates or computers used should have GPS receivers.

In addition to using the GPS / GIS, the system can specifically take note of the devices being used either the tablets or computers so that their IP addresses are captured in the system. This would ensure that only the registered devices are used for registering candidates for examinations. It would even become easier trace where and when the registration took place.

Use of CCTV (closed-circuit television) Camera in the Registration Room

The proposed system can also take advantage of using CCTV camera in the registration room to monitor where the registration is taking place and who is registering candidates. The camera can be installed in the registration room such that the registration can only happen if the camera is on. If the camera is switched off, the machine should not power on until the camera is switched on. The system should be recording and sending data to the cloud on the activities in the registration room. This way it would prevent unauthorised users from registering candidates in unauthorised locations.

Offline System

In the design include an offline system that schools can use so that they can just go and upload the data on the internet without having to stay online for a long time.

The Offline then Online system is used mainly for those examination centres which are located where there is no internet connection. The offline client computer has its own database where the candidates records are initially inserted. Whenever the computer has the chance to connect to internet connection then the server database is updated with client database. After this process, client database is cleared according to the insertion succession. However, if the insertion is not successful then it does not delete the records.

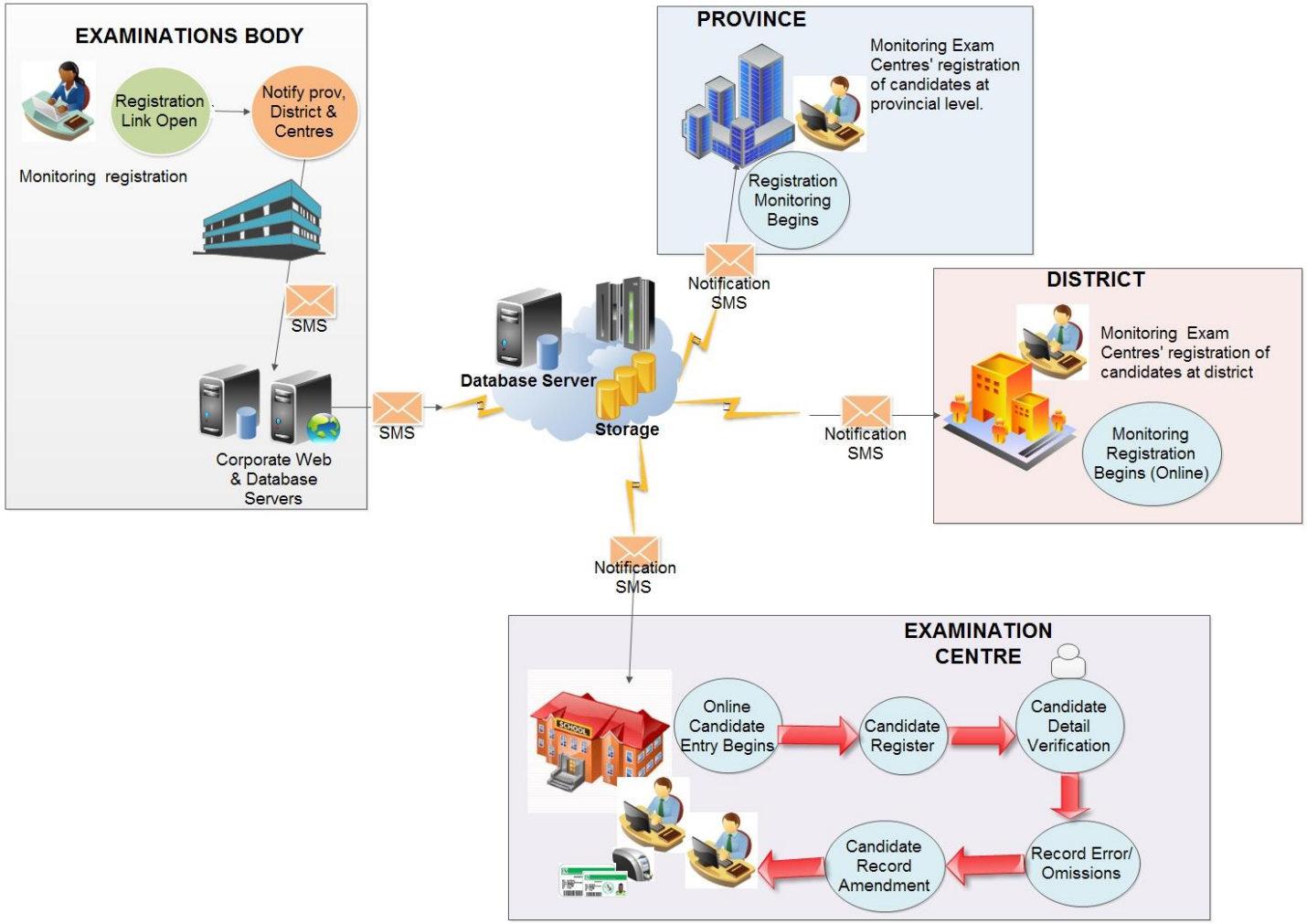


Figure 18: Proposed Web based Candidate Registration process diagram

3.3.9 System Architecture

The diagrammatic representation of the system architecture of the Web based Candidate Registration System (WCRS) for ECZ is shown in Figure 19.

The architecture has the following components comprising the ECZ corporate network where the administrator opens the registration link and bulk SMS sent to all PEOs, DEBS and Examination centre coordinators to inform them that the registration has opened. The other local networks are at the provincial education office, District Education board secretary's office and the examination centres, the cloud service constituting database storage and user application. The local service constituting database storage and user application as a backup measure is located at ECZ HQ. The Mobile Service Provider which is integrated with the web based application for sending and receiving the SMS is included.

As shown in the diagram, the administrator at ECZ sends an SMS to all concerned parties in the registration process so that they could begin the registration. The web based candidate registration system is accessed using a web browser. The local backup server also exists as a backup measure in case of failures in the cloud. The local and cloud servers constantly synchronise to ensure data integrity and completeness.

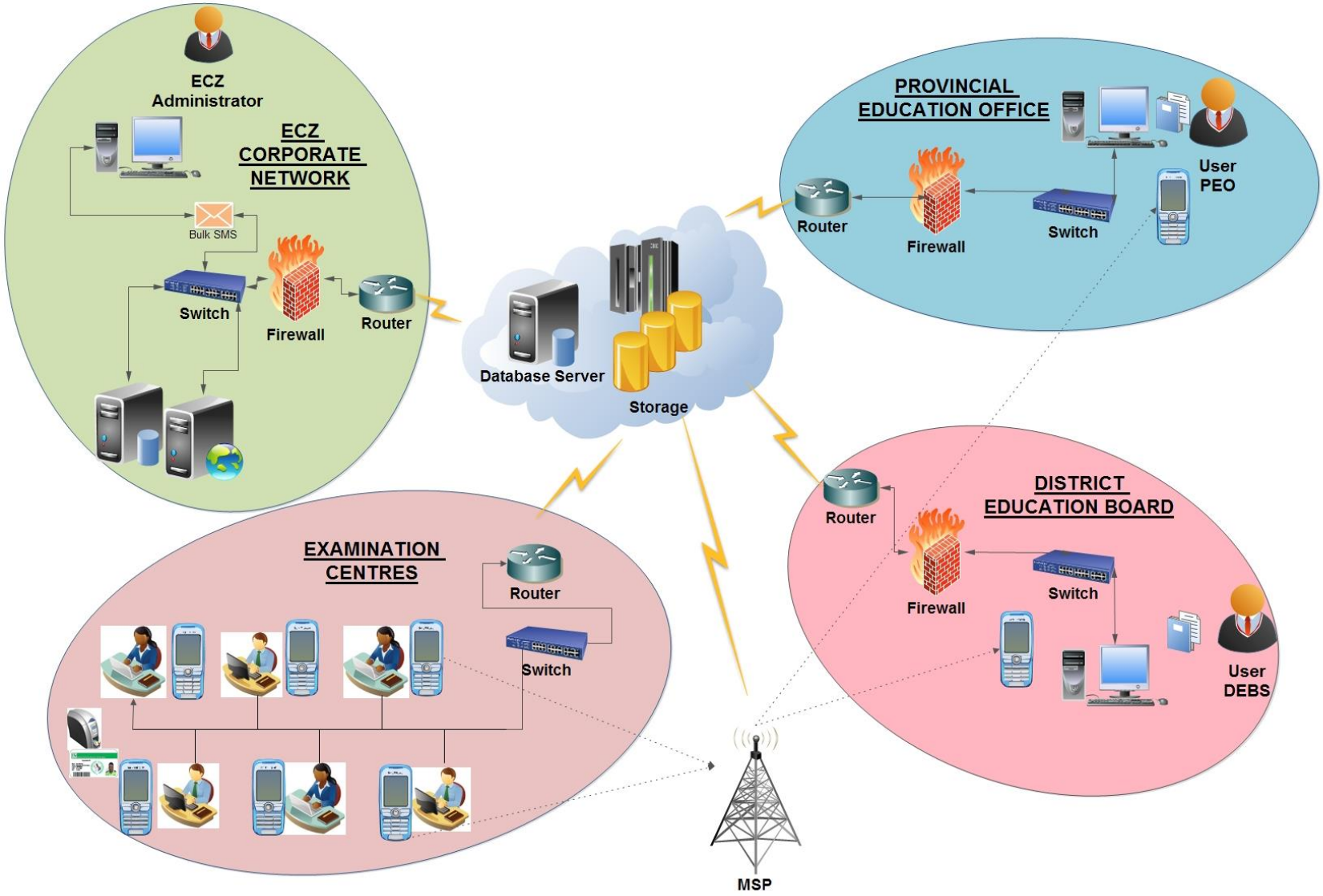


Figure 19: Web based Candidate Registration System Architecture

3.3.9 System Requirements Specification

Functional requirements specification is the documentation that describes the requested behaviour of the system. How the system should react and respond to particular inputs by the user and how the system responds to particular situations. A non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviours. Broadly, functional requirements define what a system is supposed to do and non-functional requirements define how a system is supposed to be [113]

The plan for implementing functional requirements is detailed in the system design whereas the plan for implementing non-functional requirements is detailed in the system architecture. Functional requirements drive the application architecture of a system while non-functional requirements drive the technical architecture of a system.

This section on system requirements specification provides a description of the functionalities and specifications for ECZ's web based candidate registration system.

Functional Requirements

Table 4 gives the details of the functional requirements required for the system.

Table 4 Functional requirements

FR1	*Users with the relevant access rights can create records of all candidates intending to sit for the examination in a particular year at a particular examination centre.* (Such users may include a School Guidance Teacher or any other person assigned to perform this role at the school level).
FR2	*Users with the relevant access rights can update candidate records both personal details and subject details.* (Such users may include a School Guidance Teacher or any other person assigned to perform this role at the school level).

FR3	*Users with the relevant access rights can delete candidate records both personal details and subject details.* (Such users may include a School Guidance Teacher or any other person assigned to perform this role at the school level).
FR4	*Users shall be able to generate reports whenever required of all registered candidates such as Provisional Registers, Payment schedules, entry statistics by gender, subject and summary reports for a school, province or district.*
FR5	*The user with relevant access rights can change their password at any given time.*
FR6	*Users shall be able to view candidate registration data. Such users shall include the guidance teacher, candidate, Education Standard Officers at both district and provincial level.*
FR7	*The User with relevant permissions shall be able to generate a barcode from the system.*
FR8	*The User with relevant permissions shall can generate and print a candidate's identity card with a barcode on it.*
FR9	*The system administrator can create a new system user.*
FR10	*The system administrator can delete a user from the system.*
FR11	*The system administrator can update a user's system access properties/ permissions.*
FR12	*The System administrator can view all system users or selected users.*
FR13	*The System Administrator can invalidate an examination number that conflicts in the system*
FR14	*The System Administrator can create a session for a new examination cycle*

Non-Functional Requirements

Table 5 gives details of the non-functional requirements the system shall assume.

Table 5 Non-functional requirements

NFR1	*The software shall take optimal advantage of all language, compiler, and system computational features and resources to reduce run times to the minimum practical level.*
NFR2	*All input and output, and storage and retrieval operations shall take optimal advantage of all system resources to reduce overhead and latency to the minimal practical level.*
NFR3	*Operating system, message passing, and programming language(s) used shall follow industry standards and be commonly available and widely used.*
NFR4	*The system shall perform bulk SMS integration and control.*
NFR5	*The system shall be user-friendly.* Context sensitive help screens, prompts and meaningful error messages shall be provided. Drop down boxes will be available for some static data.
NFR6	*The system shall be operating online mode*
NFR7	*System failure shall not compromise data integrity.*
NFR8	*All software application modules shall be debuggable.*
NFR9	*All users using the system shall login using some form of unique identification* (e.g., username and password)
NFR10	*All login attempts shall be done in a secure manner.*
NFR11	*A system administrator shall have unrestricted access to all aspects of the system except for creating candidate records in the system.*
NFR12	*Each user shall have a set of system access properties that defines the user's privileges within the system*. For example, a candidate can only view their details and not for another candidate.

NFR13	*Encryption shall be ensured at all interfaces where data could be intercepted or transmitted. A* SSL digitally signed certificate which ensures the true identity of the server shall be obtained and also an encrypted transmission of data.
NFR14	*Full documentation for all functionality and any user maintenance of the system shall be provided.*
NFR15	*Any future upgrades to the system shall be accompanied by full explanatory documentation.*
NFR16	*The software system and application code shall be well documented and written in a generally familiar language. Software shall be written in a style that is easily readable and using practices that allow for minimal confusion.*
NFR17	*The user manual or Help shall be available on the system – online.*
NFR18	*The application shall be hosted in the cloud to reduce on infrastructure costs and maintenance.*

3.3.10 System Modelling and Design

To design the system models for the Web based candidate registration System, Object-Oriented Design (OOD) was used.

An overview of the used Unified Modelling Language (UML) diagrams

UML includes a set of graphical notation techniques to create visual models of software-intensive systems. In the following only the UML diagrams which were used in our proposed approach are presented as described by [114] .

Use case diagram

A UML use case diagram is a type of behavioural diagram defined by and created from a Use-case analysis. It defines the system frontiers with the actors that interact with the system and it defines in the outside the set of the system functionalities structured by use case which are eventually related to each other

with inclusion, extension or generalisation. The main purpose of a use case diagram is to show what system functions are offered to actor. Roles of the actors in the system can be depicted.

Sequence diagram

A Sequence diagram on the other hand, shows how objects operate with one another and in what order. It is a construct of a message sequence chart. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realisations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios [115]

Communication Diagram

A Communication diagram corresponds (i.e. could be converted to/from or replaced by) to a simple sequence diagram without structuring mechanisms such as interaction uses and combined fragments. It is also assumed that message overtaking (i.e., the order of the receptions are different from the order of sending of a given set of messages) will not take place or is irrelevant [116]

Class diagram

A UML class diagram represents the static structure that describes the structure of a system by showing the system's classes, their features, and the relationships between the classes [114].

Use Cases

The Use case diagram is an illustration of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved. A use case diagram can identify the different types of users of a system and the different use cases and will often be accompanied by other types

of diagrams as well. A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved [117].

The main actors in the candidate registration system are the system administrator and the user (Guidance Teacher). The other actors are the candidate and the provincial or district monitors of the registration process. Table 6 shows the actors and description of each actor in the Web based candidate registration.

Table 6 Web based candidate registration Actors and Actor Descriptions

Actor	**Description**
Guidance Teacher	The Guidance Teacher is responsible for entering candidate details for examinations.
Education Standards Officer – General Inspections (ESO-GI)	The ESO-GI supervises the candidate registration process in their respective district and reports to the Senior Education Standards Officer – Examinations at the Province. ESO-GI therefore monitors the registration process for the district and is restricted to logging in, viewing registered candidates for the district, and generate statistical reports
Senior Education Standards Officer – Examinations (SESO-Exams)	The SESO-Exams supervises the candidate registration process in their respective provinces. SESO-Exams therefore monitors the registration process for the province and is restricted to logging in, viewing registered candidates for the province, and generate statistical reports.
Candidate	The Candidate is the one who is going to sit the examination in the subjects registered for. Candidate is restricted to logging in and viewing only their details by supplying their examination number
Administrator	The Administrator is responsible for the administration of the entire system.

Figure 20 shows the different actions that the System Administrator does with the system. These are the graphical representation of how the administrator interacts with the system.

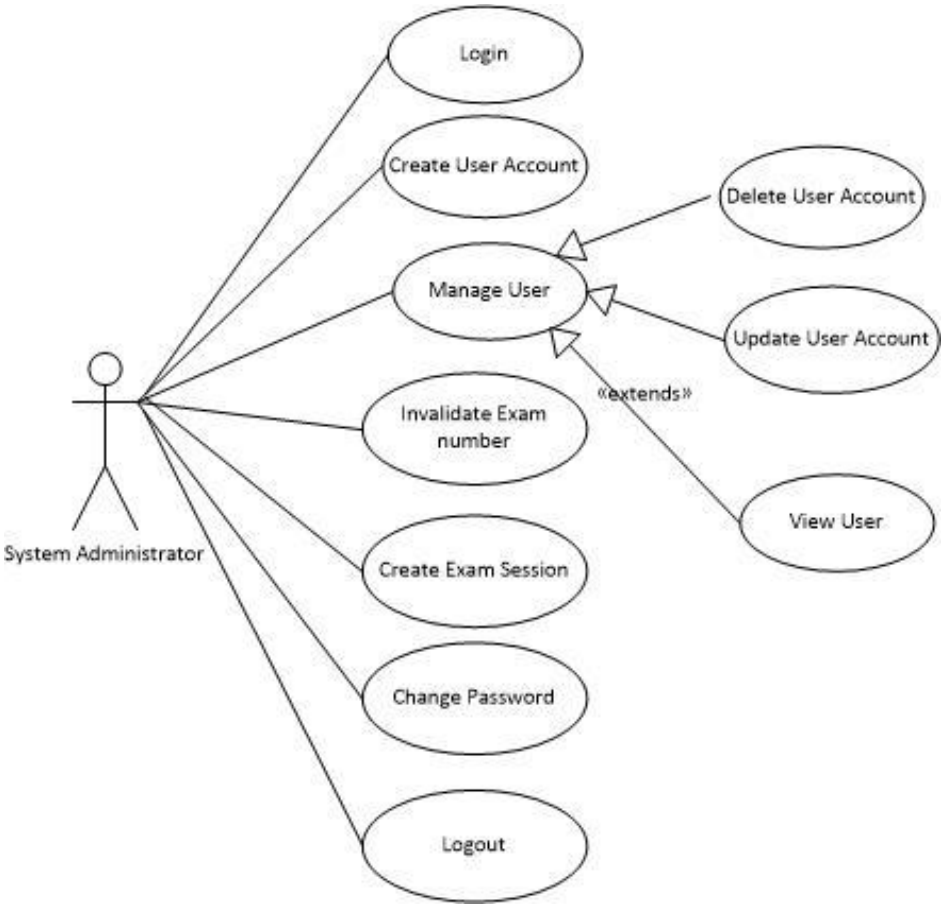


Figure 20: System Administrator activities use case diagrams

The interaction of the actor with the system is through the web application by the client. The different use cases associated with the actor are presented in Table 7.

Table 7: Use case description – System Administrator

Use case Name	**Actor**	**Description**
Login	Administrator	Validates user credentials and opens the appropriate page
Create User Account	Administrator	Enter user details in the system. When a new school is approved as an examination centre, the school details and the associated user details are added in the system by the system administrator. A new user is created and added to the list of users in the database
Manage User	Administrator	Manage user accounts
Delete user account	Administrator	Delete a user account from the system. When a Teacher no longer works as Guidance Teacher, the administrator may delete him from the list of active users in the database.
Update user account	Administrator	Edit user account details when there are changes
View user	Administrator	View user account details that are in the system
Invalidate Examination Number	Administrator	Remove the examination number from the database that was wrongly used in a previous examination.
Create Exam Session	Administrator	Creates a new examination session year to enable users register candidates for that particular year.
Change Password	Administrator	Enables change of password
Logout	Administrator	Logs out the user to close the opened session

User Activities

The figure 21 below is a diagrammatical representation of the actor – User and the use cases associated to this actor.

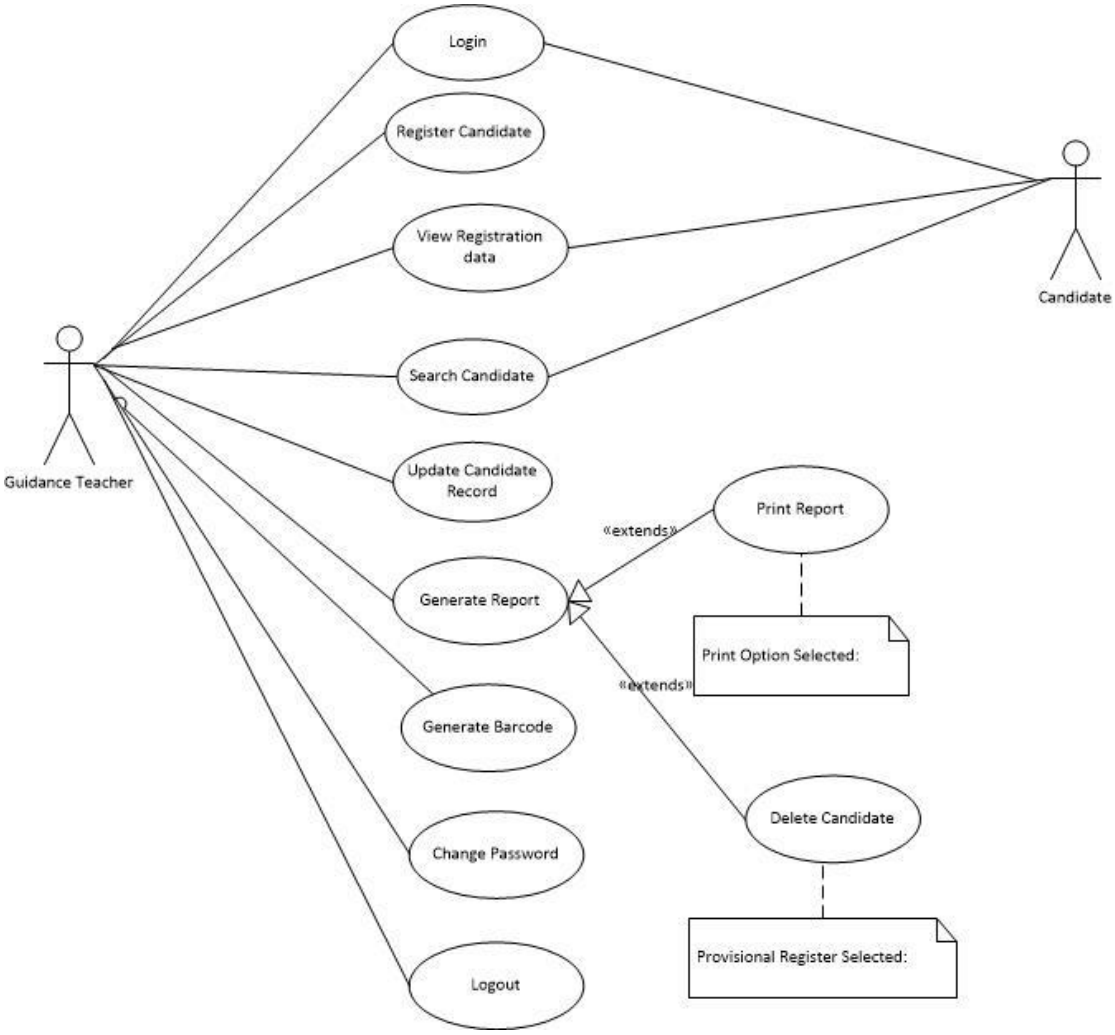


Figure 21: Guidance Teacher (User) activities Use case diagram

Table 8: Use case descriptions

Use Case	Actor	Description
Login	User	A registered user is able to login to access system functionality according to his or her access rights using his or her authentication details.
Register Candidate	User	Users with the relevant access rights can enter candidate details such as such candidate name, date of birth, sex, subjects entered for, school of choice where applicable.
Search Candidate	User	All logged in users with relevant access rights are able to search the database for registered candidate by entering a valid examination number through a user interface.
Update Candidate Details	User	Users with the appropriate access rights can update details pertaining to a registered candidate such as candidate name, date of birth, sex, subjects, nationality, and school of choice where applicable.
View Registration data	User	All logged in users are able to view specific candidate information stored in the database through a user interface based on their access rights. For example, a Guidance Teacher will only view candidate details for their school (s), the ESO-GI will view for all schools in their district and the SESO-Exams will view for all schools in their respective province and a candidate will view only their own details.
Generate Reports	User	Users with the relevant access rights can generate and print various reports about registered candidates.
Generate Barcode	User	Users with the appropriate permissions can generate barcodes of the registered candidates for their centre.

Change Password	User	All users defined in the system can change their password at anytime.
Logout	User	Logs out the user to close the opened session.

Use Case Analysis

This section gives a narrative of the actors involved and the main flow of events – actor action and system response.

Use-case Register Candidate

Table 9 Use-case Register Candidate (Grade 12)

Use case Number	UC-01(a)	
Use case Name	Register Candidate	
Priority	High	
Actors	Guidance Teacher (G12 Internal)	
Description	This use-case allows the guidance teacher to register Grade 12 Internal candidates for examinations	
Typical Course of events	**Actor Action** 1. User enters candidates examination number 3. User enters receipt number and applicable special education needs (SEN) details. 5. User selects subjects the candidate intends to register for. 7. User clicks the *'Complete Registration'* button to complete the candidate registration process	**System Response** 2. The System checks for the validity of the examination number and retrieves the candidate's details 4. The System checks for the validity of the receipt number, saves candidate details and displays the subject selection page 5. System checks for validity of the number of subjects and subject combinations

		8. System saves the selected subjects in database 9. Use case ends.
Alternate course of action	If either examination number or receipt number or number of subjects selected is not valid, candidate registration is aborted	
Precondition	User already logged in	
Post condition	Candidate registered	
Assumptions	User already logged in and has accessed the home page	

Table 10: Use-case Register Candidate (Grade 7)

Use case Number	UC-01(b)	
Use case Name	Register Candidate	
Priority	High	
Actors	Guidance Teacher (Grade 7)	
Description	This use-case allows the guidance teacher to register Grade 7 candidates for examinations	
Typical Course of events	**Actor Action** 1. User selects option to register candidates. 3. User enters all the candidate details and applicable special education needs (SEN). 4. User selects School of Choice. 5. User clicks the *'Complete Registration'* button to complete the candidate registration process	**System Response** 2. The System generates an examination number and displays the screen for entering candidate details 6. The System checks for the validity of the candidate details entered and save candidate details. 7. System responds by 'Candidate

		Successfully Registered’ 8. Use case ends.
Alternate course of action	If any candidate details are not correct, candidate registration is aborted or user requested to enter correct details	
Precondition	User already logged in	
Post condition	Candidate registered	
Assumptions	User already logged in and has accessed the home page	

Use-case Update Candidate Record

Table 11 Use-case Update Candidate Record

Use case Number	UC-02	
Use case Name	Update Candidate Record	
Priority	Medium	
Actors	Guidance Teacher	
Description	This use-case allows the guidance teacher to edit candidate record	
Typical Course of events	**Actor Action** 1. User enters examination number for the candidate to be edited *3.* User makes changes to candidate details and clicks the *Save and Continue button* 4. User amends subjects	**System Response** 2. System retrieves candidate details 5. System saves changes 6. Use case ends.
Alternate course of action		
Preconditions	1. User already logged in 2. Candidate already registered	
Post condition	Candidate details updated	
Assumptions	User already logged in	

Use-case Delete Candidate Record

Table 12 Use-case Delete Candidate Record

Use case Number	UC-03	
Use case Name	Delete Candidate Record	
Priority	Medium	
Actors	Guidance Teacher	
Description	This use-case allows the guidance teacher to delete a candidate record	
Typical Course of events	**Actor Action** 1. User clicks on the *Delete Candidate link*	**System Response** 2. System deletes candidate 3. Use case ends
Alternate course of action		
Preconditions	1. User logged in 2. Candidate registered 3. Provisional register viewed	
Post condition	Candidate deleted	
Assumptions	User already logged in	

Use-case Generate Report

Table 13 Use-case Generate Report

Use case Number	UC-04	
Use case Name	Generate Report	
Priority	Medium	
Actors	Guidance Teacher	
Description	This use-case allows the guidance teacher to view and generate reports	
Typical Course of events	**Actor Action** 1. User specifies report parameters 3. user clicks on the Generate Report link	**System Response** 2. System displays report 4. System generates PDF report 5. Use case ends
Alternate course of action		
Preconditions	1. User logged in 2. Candidate registered	
Post condition	Report Generated	
Assumptions	User already logged in	

Use-case Change Password

Table 14 Use-case Change Password

Use case Number	UC-05	
Use case Name	Change Password	
Priority	Medium	
Actors	Guidance Teacher, System Administrator	
Description	This use-case allows guidance teacher and System Administrator to change password	
Typical Course of events	**Actor Action** 2. User enters new password	**System Response** 1. System prompts user to enter new password 3. System checks for password complexity and saves new password 4. Use case ends.
Alternate course of action	System does not change password if new password does not meet password complexity or does not match	
Preconditions	User already logged in	
Post condition	Password Changed	
Assumptions	User already logged in	

Use-case View Registration Data

Table 15: Use-case View Registration Data

Use case Number	UC-06	
Use case Name	View Registration Data	
Priority	High	
Actors	Candidate, Guidance Teacher	
Description	This use-case allows a candidate to check registration data	
Typical Course of events	**Actor Action** 1. System prompts User to enter centre code or examination number	**System Response** 2. System checks if centre code or examination is correct. 3. If details correct, System displays candidates registration data 4. 4. Use case ends.
Alternate course of action	System aborts if supplied details are not correct	
Preconditions	User already logged in Candidate Record already created	
Post condition	Registration data viewed	
Assumptions	User already logged in	

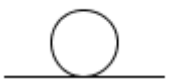
Interaction Models – Communication and sequence diagrams

Communication diagram (called collaboration diagram in UML) is a kind of UML interaction diagram which shows interactions between objects and/or parts (represented as lifelines) using sequenced messages in a free-form arrangement.

A UML sequence diagram is a kind of interaction diagram that shows the dynamic side of the system [114].

The section that follows provides information on the communication and sequence diagrams for each Use Case represented in Figures 24 and 25. Table 15 gives a description of each of the three symbols used in the communication diagrams.

Table 16 Communication and sequence diagram symbols [118]

Symbol	**Description**
	Boundary object: Objects that interface with system actors (e.g. a user or external service). Windows, screens and menus are examples of boundaries that interface with users.
	Control object: Objects that mediate between boundaries and entities. These serve as the glue between boundary elements and entity elements, implementing the logic required to manage the various elements and their interactions.
	Entity object: Objects representing system data, often from the domain model.

Login

In Figure 22, the sign in user interface (UI) is started. The control object prompts the user for signing in credentials and authenticates the user upon providing the correct login credentials. It then asks User entity object to get the user account

from the database. The control object finally asks the boundary object to display the welcome screen to the user at the application interface.

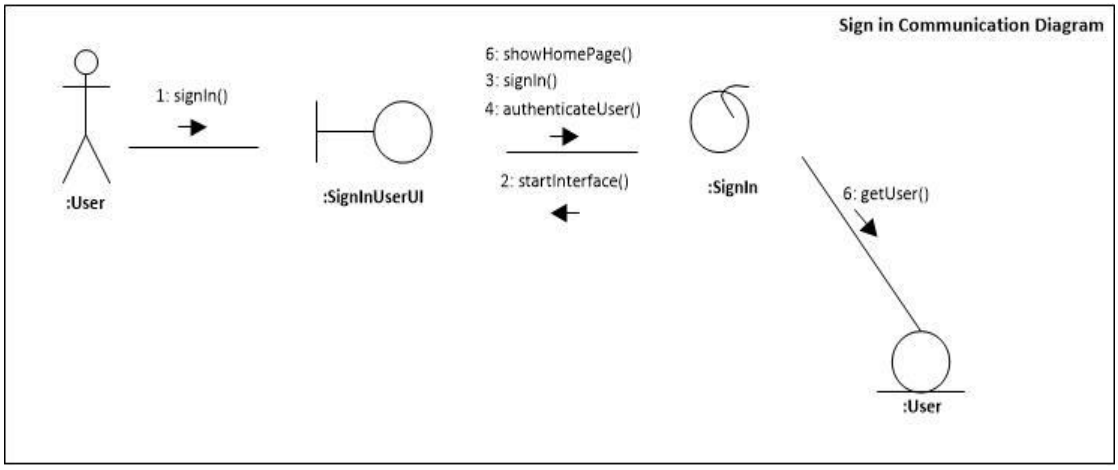


Figure 22 Sign in communication diagram

The sequence diagram in Figure 23 is a synchronization of the communication diagram in Figure 22. The sequence of events for the Sign in Use Case is shown in Figure 23.

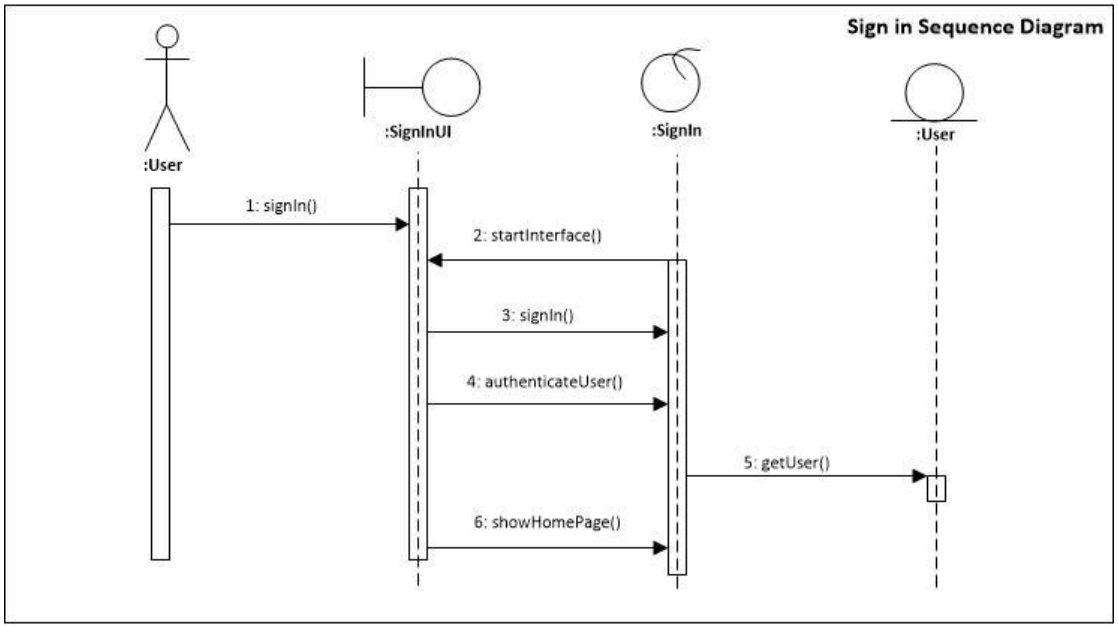


Figure 23: Sign in sequence diagram

Update Candidate Details

In Figure 24, the user interface (UI) is started and then the control object is instantiated. The control object gets the candidate records from the candidate entity object. The User selects the candidate examination number they want to

edit, User modifies the details and then the control object executes the update candidate transaction.

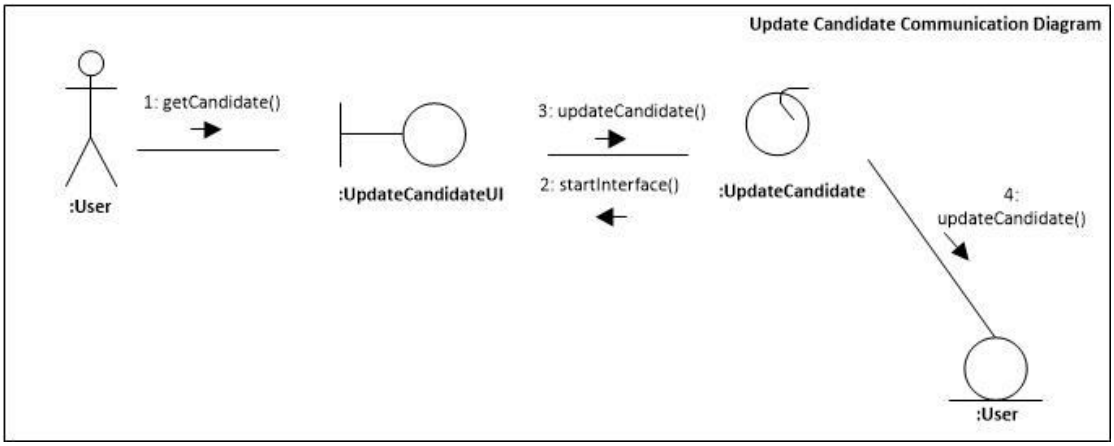


Figure 24: Update Candidate communication diagram

The sequence diagram in Figure 25 is a synchronisation of the communication diagram in Figure 24. The sequence of events for the Update Candidate details Use Case is shown in figure 25.

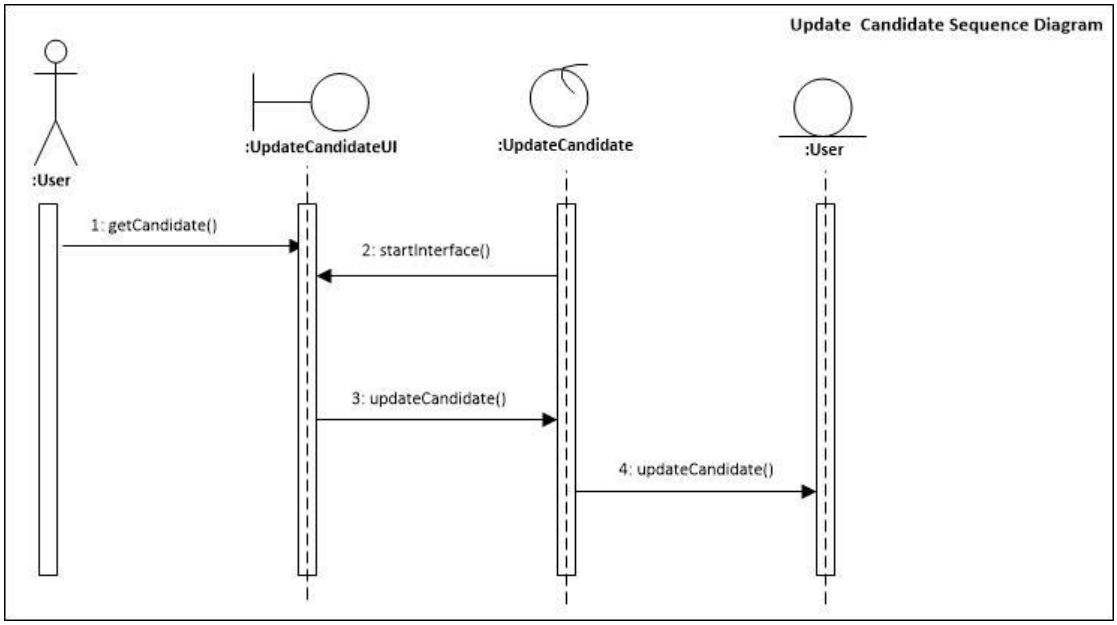


Figure 25: Update Candidate sequence diagram

Register Candidate

In Figure 26, User selects the centre code they want to register candidates for. The user interface (UI) is started and then the control object is instantiated. User enters the examination number and then the control object validates the

examination number and retrieves the candidate's personal details or automatically generates an examination number for user to enter candidate personal details. User then enters the subject details. The control object finally asks the boundary object to display candidate registered successfully.

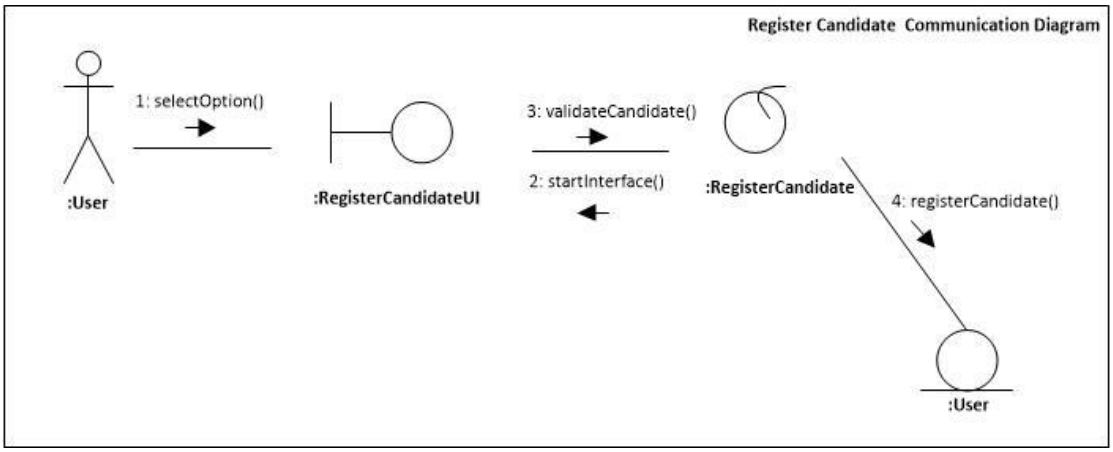


Figure 26 : Register Candidate communication diagram

The sequence diagram in Figure 27 is a synchronization of the communication diagram in Figure 26. The sequence of events for the Register Candidate Use Case is shown below.

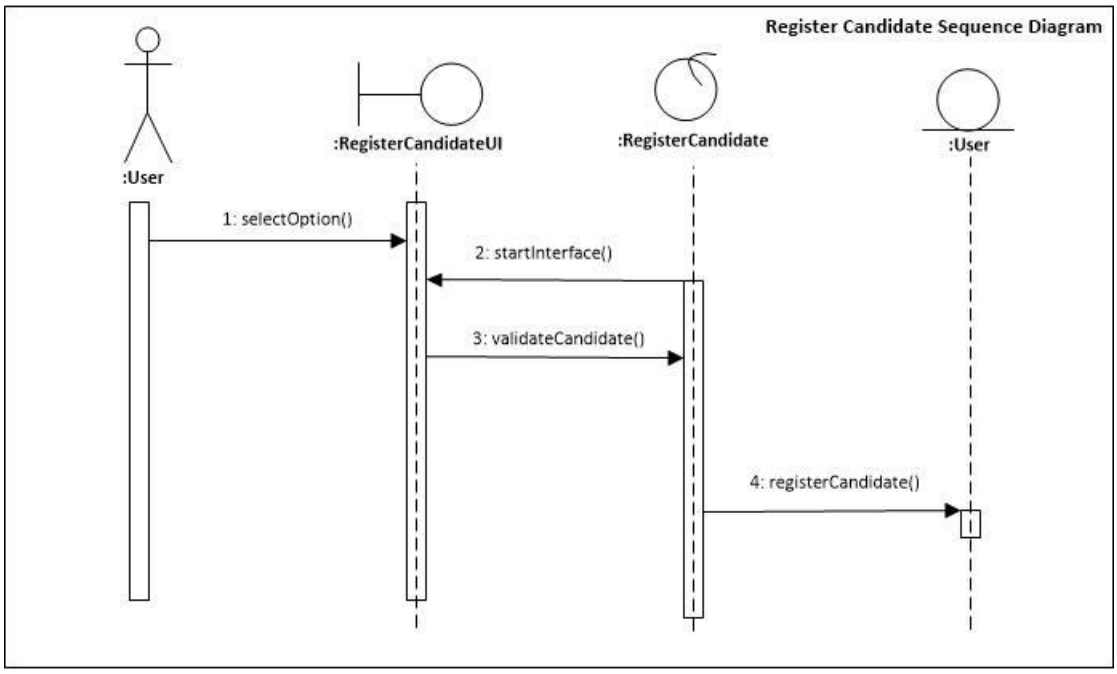


Figure 27: Register Candidate sequence diagram

Generate Report

In Figure 28, the User selects the report type they want to generate. The user interface (UI) is started and then the control object is instantiated. The control object executes the generate report. The control object then asks to create the report requested for. The control object finally asks the boundary object to display the generated report.

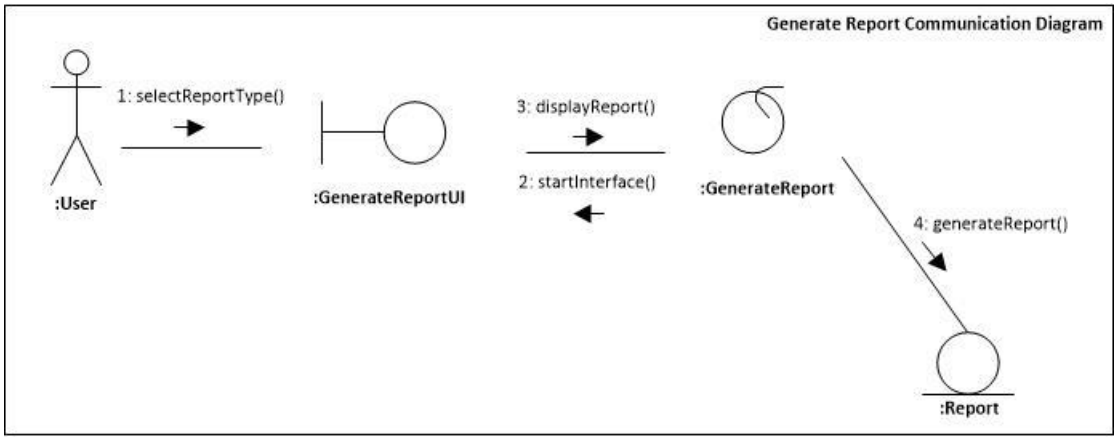


Figure 28: Generate report communication diagram

The sequence diagram in Figure 29 is a synchronization of the communication diagram in Figure 28. The sequence of events for the Generate Report Use Case are shown in Figure 29.

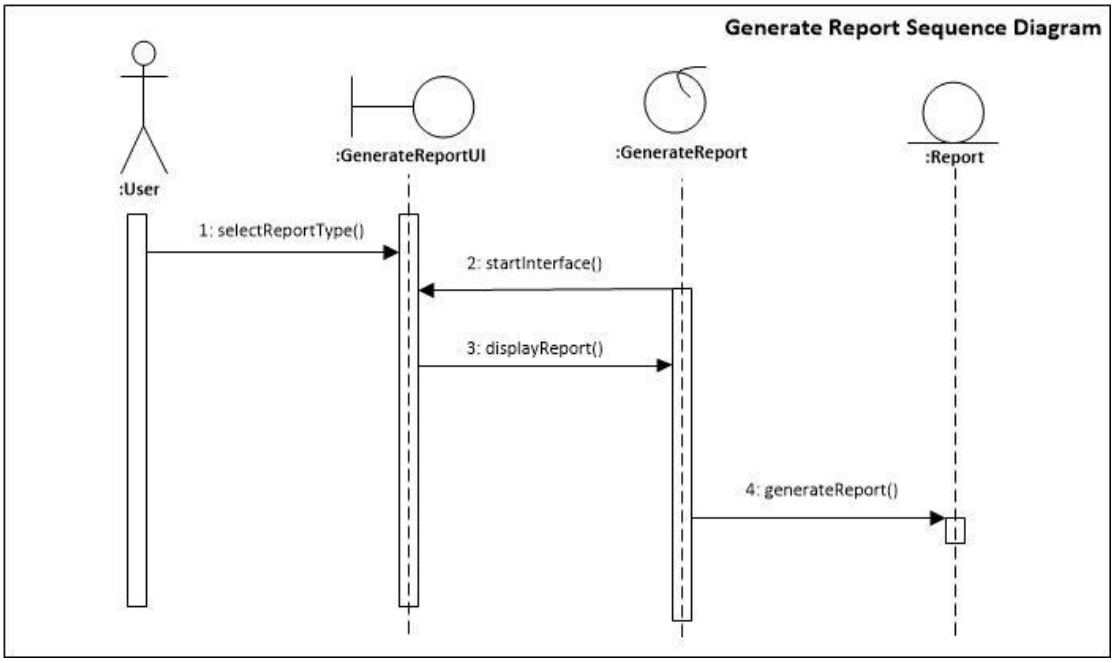


Figure 29 : Generate report sequence diagram

Delete Candidate

In Figure 30, the user interface (UI) is started and then the control object is instantiated. User selects the Generate Provisional Register report and then the control object displays the provisional register and user selects the candidate they want to delete, confirms delete and control object executes the delete candidate transaction. The control object finally asks the boundary object to remove the deleted candidate record.

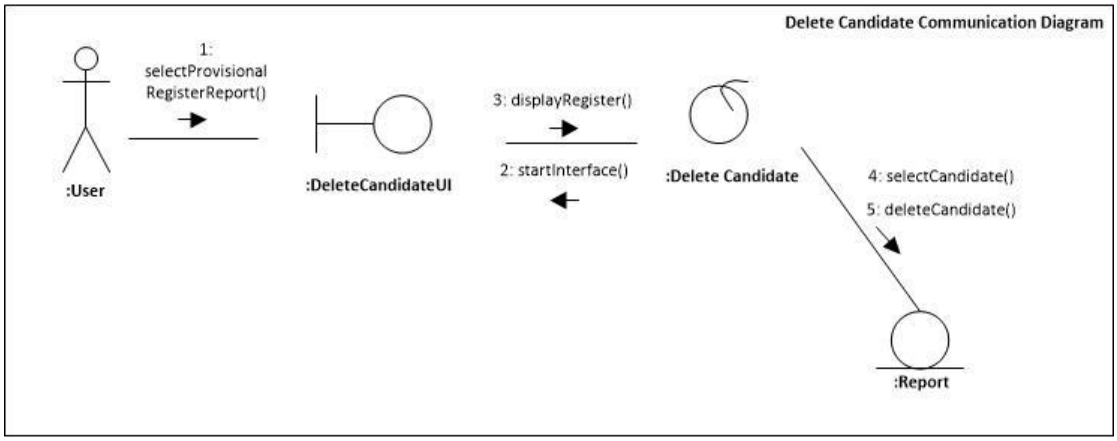


Figure 30: Delete Candidate record communication diagram

The sequence diagram in Figure 31 is a synchronization of the communication diagram in Figure 30. The sequence of events for the Delete Candidate Record Use Case is shown in figure 31.

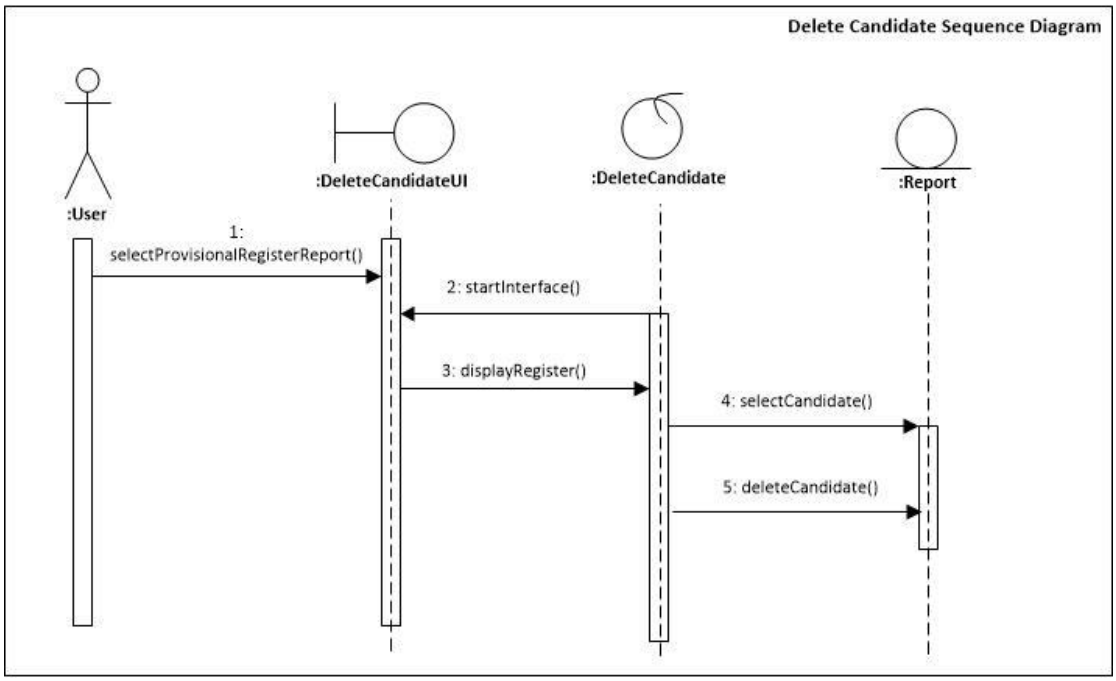


Figure 31: Delete Candidate record sequence diagram

Create User Account

In Figure 32, the user interface (UI) is started and then the control object is instantiated. User enters user details and then the control object executes the create user account transaction. The control object then asks User to create a user account. The control object finally asks the boundary object to display the newly created user account.

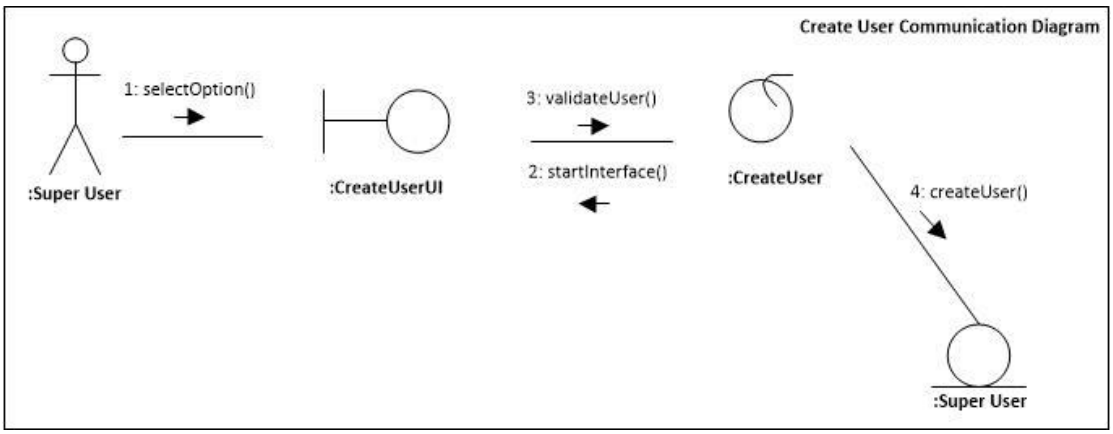


Figure 32: Create user communication diagram

The sequence diagram in Figure 33 is a synchronization of the communication diagram in Figure 32. The sequence of events for the Create User Account Use Case is shown in Figure 33.

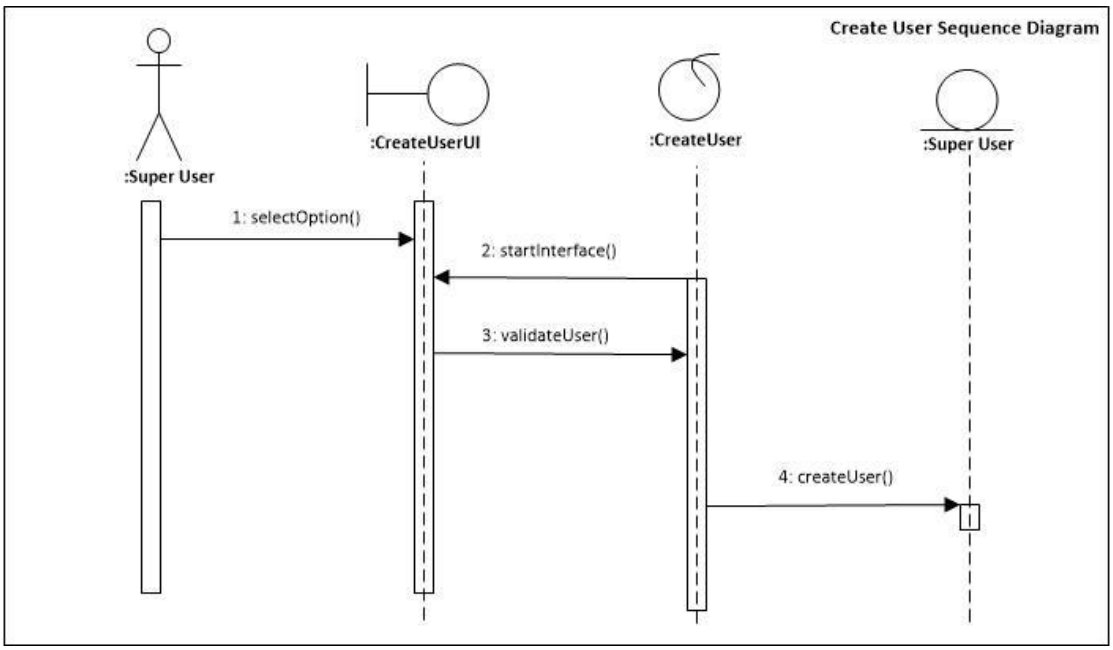


Figure 33: Add user sequence diagram

Update User

In Figure 34, the user interface (UI) is started and then the control object is instantiated. The control object gets the user records from the User entity object. The User selects the user record they want to update, User modifies the details and then the control object executes the update user transaction. The control object then asks User to update the user record.

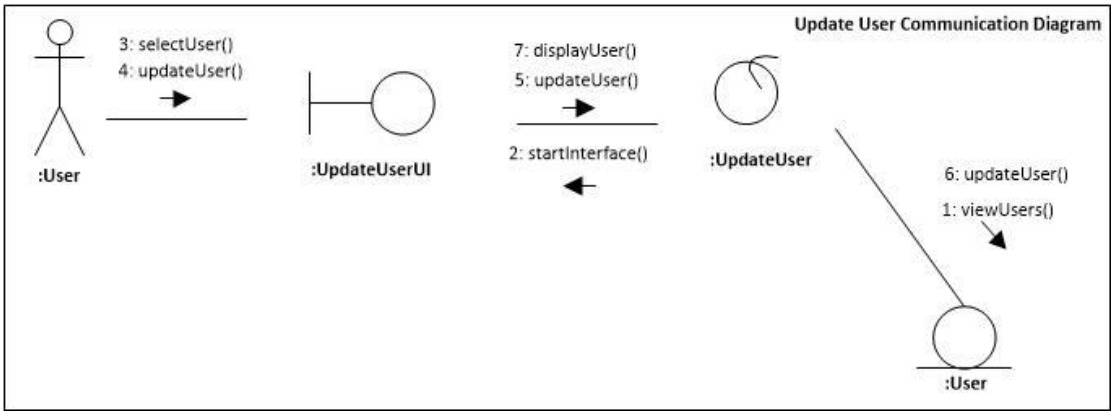


Figure 34 : Update user communication diagram

The sequence diagram in Figure 35 is a synchronization of the communication diagram in Figure 34. The sequence of events for the Update User Use Case are shown in Figure 35.

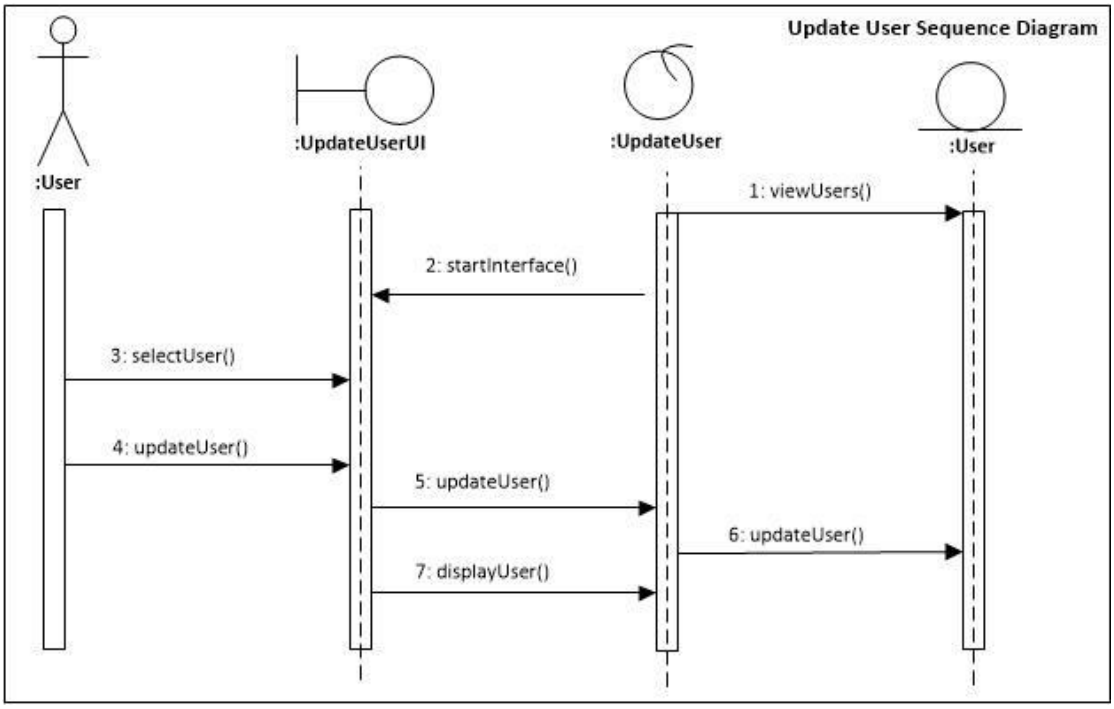


Figure 35 : Update user sequence diagram

Delete User

In Figure 36, the user interface (UI) is started and then the control object is instantiated. The control object gets the user records from the User entity object. The User selects the user record they want to delete, then the control object executes delete user transaction. The control object then asks User to delete the user account. The control object finally asks the boundary object to remove the user records.

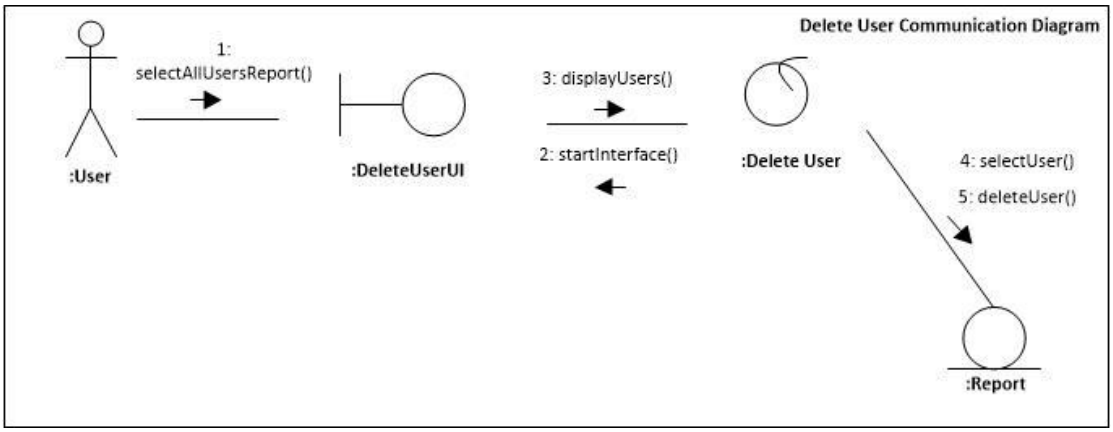


Figure 36: Delete user communication diagram

The sequence diagram in Figure 37 is a synchronization of the communication diagram in Figure 38. The sequence of events for the Delete User Use Case are shown in Figure 37.

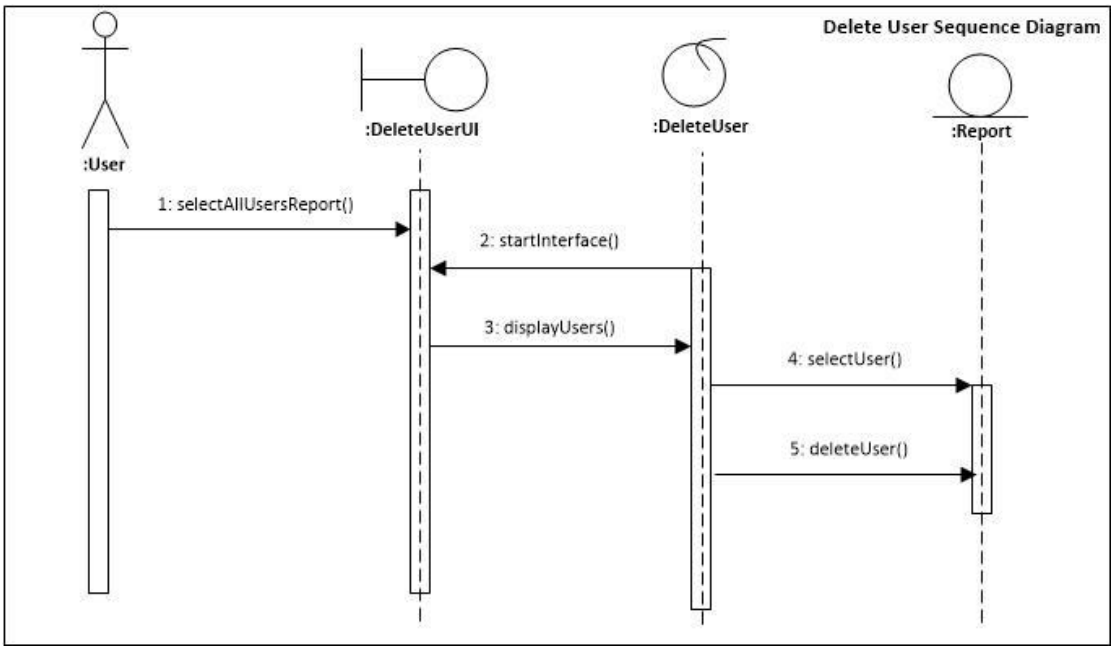


Figure 37: Delete user sequence diagram

Class Diagram

A UML Class diagram describes the object and its static structure, in particular, the things that exist (such as classes and types), their internal structure, and their relationships to other things. The UML class diagram for our candidate registration system is represented in Figure 38.

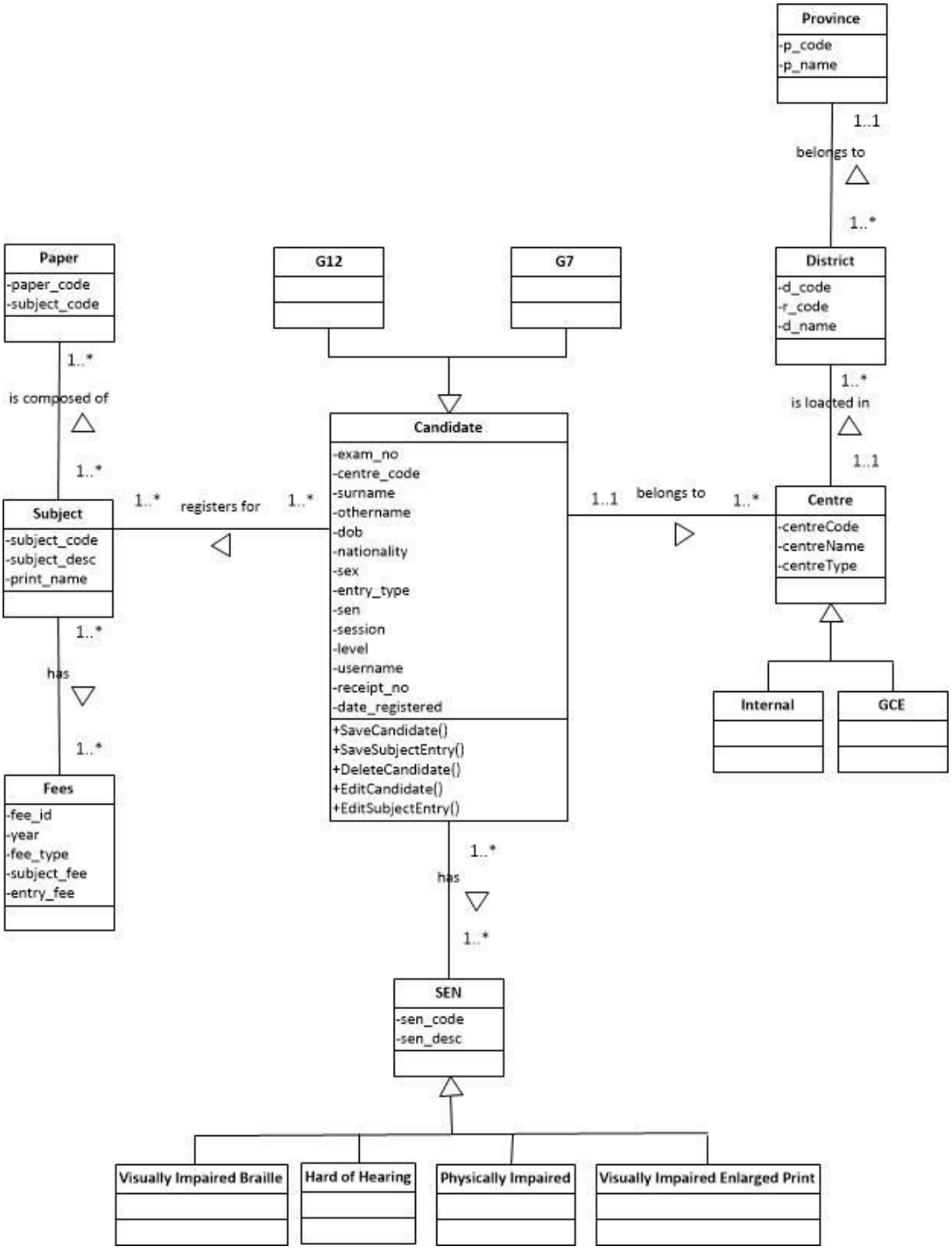


Figure 38: Web based candidate registration system class diagram

Data Models

The entity-relationship E-R data model uses a collection of basic objects, called entities, and relationships among these objects. Entities are a collection of objects or concepts that are identified by an enterprise as having an independent existence and share common characteristics.

The ER diagram in Figure 39 for the Web based candidate registration system is presented. It shows how the system's tables are linked to interact with one another to store and retrieve data from the database.

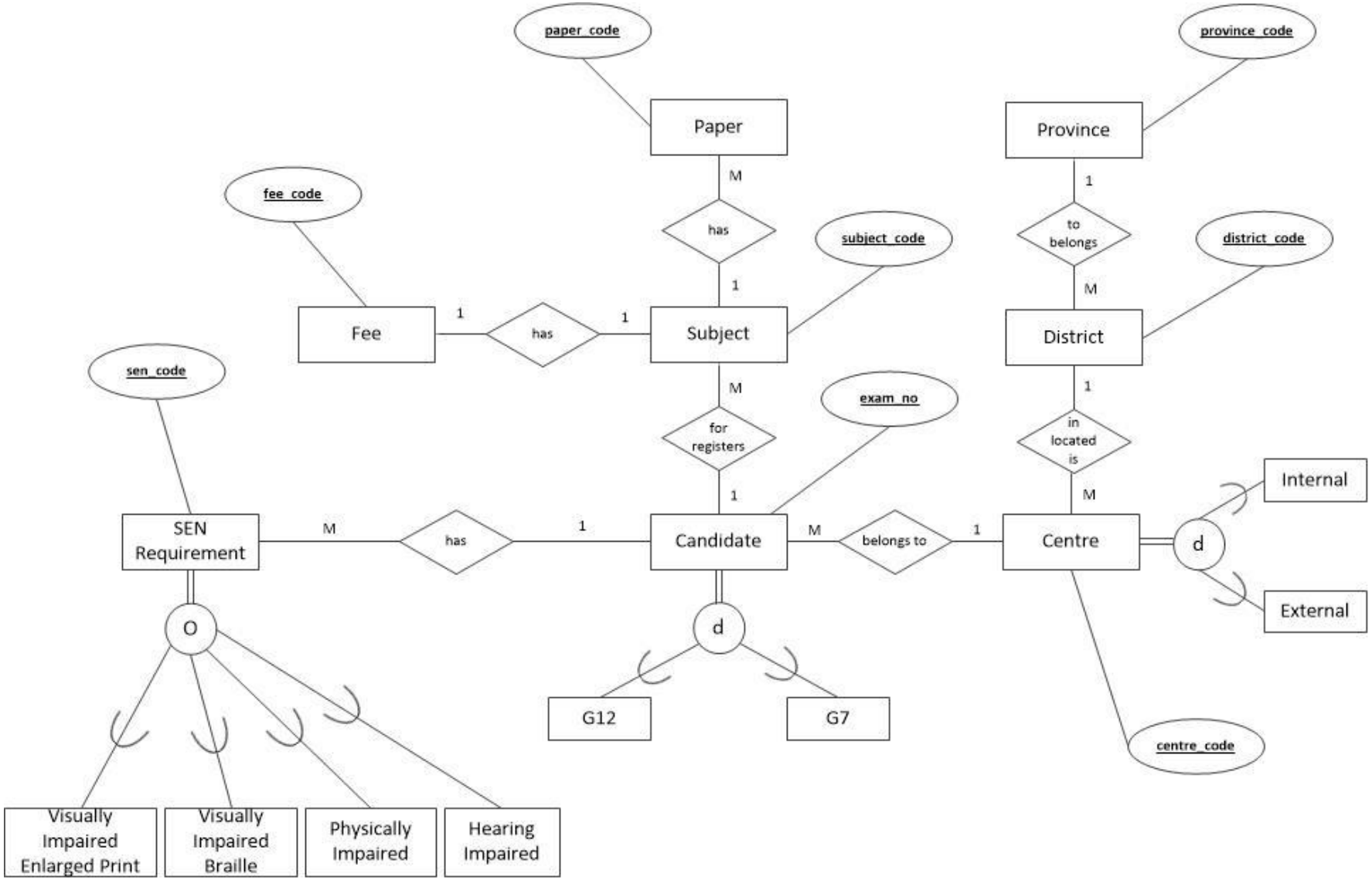


Figure 39 : Web-based Candidate Registration ER diagram

The entities and attributes that constituted the web based candidate registration system are tabulated in Tables 17 to 18.

Table 17 Candidate

ENTITY : Candidate		
DESCRIPTION : This entity Stores data about candidates		
Attribute	**Description**	**Data Type**
Exam_no (Primary Key)	Unique identifier for candidate	VARCHAR(12)
centre_code	Unique identifier for centre	VARCHAR(6)
Surname	Candidate's lastname	VARCHAR(45)
Othername	Candidate's forenames	VARCHAR(45)
dob	Candidate's Date of Birth	VARCHAR(45)
nationality	Candidate's Nationality	VARCHAR(45)
sex	Candidate's sex	VARCHAR(45)
entry_type	Centre entry type e.g Internal or External	VARCHAR(45)
sen	Candidate's Special Education Needs Requirement	VARCHAR(45)
session	Year of examination	VARCHAR(45)
level	Candidate's Grade e.g Grade 7, Grade 12	VARCHAR(45)
username	Name of user entering candidates	VARCHAR(45)
receipt_no	Receipt number for candidate	VARCHAR(45)
Date_registered	Date candidate was registered	VARCHAR(45)
ENTITY : Centre		
DESCRIPTION : This entity Stores data about approved Examination centres		
ATTRIBUTE	**DESCRIPTION**	
Centre_code (Primary Key)	Unique identifier for a centre	VARCHAR(45)
Centre_name	Name of examination centre	VARCHAR(45)
Centre_type	Type of centre e.g. Internal or External	VARCHAR(45)

d_code	District name	VARCHAR(45)

Table 18 Province

ENTITY : Province		
DESCRIPTION : This entity Stores data about Provinces		
Attribute	**Description**	
p_code (Primary Key)	Unique province identifier	VARCHAR(45)
p_name	Full Province name	VARCHAR(45)
ENTITY : District		
DESCRIPTION : This entity Stores data about districts		
Attribute	**Description**	
d_code (Primary Key)	Unique district identifier	VARCHAR(45)
r_code	Province code	VARCHAR(45)
d_name	Full district name	VARCHAR(45)
ENTITY : SEN		
DESCRIPTION : This entity Stores data Special Education Needs		
ATTRIBUTE	**DESCRIPTION**	
sen_code (Primary Key)	Unique Special Education Needs identifier	VARCHAR(45)
Sen_desc	Full Special Education Needs name	VARCHAR(45)
ENTITY : Fees		
DESCRIPTION : This entity Stores data about fees for subjects		
Attribute	**Description**	
fee_id (Primary Key)	Unique fee identifier	VARCHAR(45)
Year	Year of fee	VARCHAR(45)
Fee_type	Type of fee e.g. entry fee or subject fee	VARCHAR(45)

Subject_fee	Actual fee for subject	VARCHAR(45)
Entry_fee	Actual fee for exam entry	VARCHAR(45)
ENTITY : Paper		
DESCRIPTION : This entity Stores data about subject paper		
ATTRIBUTE	**DESCRIPTION**	
paper_code (Primary Key)	Unique identifier for papers	VARCHAR(45)
Subject_code	Unique identifier for subjects	VARCHAR(45)
Paper_name	Short name of paper	VARCHAR(45)

ENTITY : Subject		
DESCRIPTION : This entity Stores data about subjects		
ATTRIBUTE	**DESCRIPTION**	
Subject_code (Primary Key)	Unique identifier for subjects	VARCHAR(45)
Subject_desc	Full subject name	VARCHAR(45)
print_name	Short subject name to display on report	VARCHAR(45)

3.3.11 System Implementation

The web based candidate registration solution development platform used was XHTML, JavaScript, CSS, PHP, Apache Webserver and MySQL.

Development Tools and platform

Apache Server

Apache has been the most popular web server on the internet since April of 1996. The majority of the web sites on the internet are using Apache, thus making it the most widely used web server. Apache is based on open source multi-platform

web server. The web applications are implemented in high-level languages as Java, Perl, C++, PHP. In our work the PHP and JavaScripts are running on the Apache Web server.

PHP

PHP (Hypertext Preprocessor) is an open-source server-side scripting language for developing dynamic web applications. It is suitable for the development of Web applications and allows programmers to embed PHP commands right in the HTML page. The choice of PHP was that it is easy to use and one can build interactive and dynamic websites. It is also compatible with the Apache webserver that was used and also supports MySQL database which we have used for our web-based system.

Javascript

JavaScript is considered to be one of the most famous scripting languages of all time that offers interactivity in the web pages. JavaScript, by definition, is a scripting Language of the World Wide Web. The main usage of JavaScript is to add various web functionalities, web form validations, browser detections, creation of cookies and so on. JavaScript is one of the most popular scripting languages and that is why it is supported by almost all web browsers available today [102].

XHTML

XHTML is an Extensible HyperText Markup Language used to describe the formatting of text in a document which is in reality the backbone of any website. It is useful in that it allows text to be structured according to its purpose like heading, paragraph. No web page can be structured without the knowledge of HTML.

SQL

Structured Query Language (SQL) allows us to access and manipulate the database. With SQL we can execute queries on the database, retrieve data or

delete records from the database, insert or update records in a database, create new database, create new tables, create stored procedures create views in a database, set permissions on tables, procedures and views. [102]

CSS

CSS Stands for "Cascading Style Sheet." Cascading style sheets are used to format the layout of Web pages. CSS was used to define text styles, table sizes, and other aspects of web pages that previously could be defined in a page's HTML. The basic purpose of CSS is to separate the content of a web document from its presentation. There are lots of benefits that one can extract through CSS like improved content accessibility, better flexibility and moreover, CSS gives a level of control over various presentation characteristics of the document. It also helps in reducing the complexity and helps in saving overall presentation time. CSS gives the option of selecting various style schemes and rules according to the requirements and it also allows the same HTML document to be presented in more than one varying style.

MySQL Database

MySQL is an open source relational database management system which is widely used around the world for storing and analysing data. MySQL is easy to use and also platform independent, meaning that it can run on most operating systems.

Hardware Components for the web based registration system

The table 19 below describes the hardware components for the web based candidate registration system

Table 19 Web based registration system Hardware Components

Component Name	Description
Firewall	Protects servers from unauthorized access by filtering incoming and outgoing communication
Webserver	The server supporting the web based system. This is where the candidate registration system will actually run from.
Database Server	The server that supports the database software.
Cloud Infrastructure	Cloud Infrastructure will be used to host the web application and storage of data.

3.3.12 Limitations of the Prototype Development

The bulk SMS integration module was designed but not fully developed together with the event notification service due to time constraint as it required further investigations by the researcher.

3.2.13 Summary

In this chapter, the materials and methods that were used in the baseline study were discussed and the system design and architecture of the web based system. The methodology used for the baseline study which was a mixed methods was discussed. The various methods previously used for candidate registration from the time ECZ became operational were reviewed in order to have a clear understanding of the whole process to enable a mapping of the business process. The proposed business process models for ECZ were presented after analysing the previous and current candidate registration process.

Chapter Four

4.0 Results

4.1 Introduction

This chapter present the results of the baseline study whose objective was to establish the challenges faced by the ECZ regarding the registration of candidates for school examinations. Results of the system implementation are also presented in this chapter.

4.2 Baseline Study

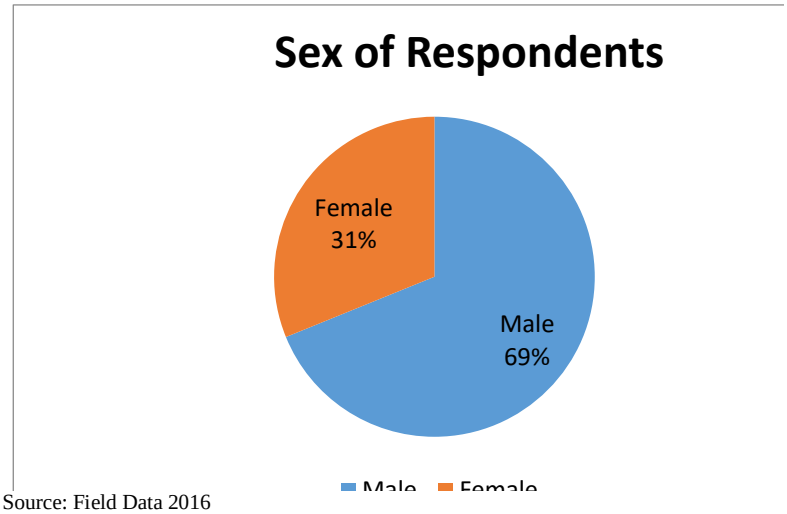
In this section the findings of the baseline study presented are as derived from the analysis of the questionnaire and interview guide. Challenges faced in the registration of candidates for national examinations and the possible solutions to the challenges are presented. The findings from both key informants and respondents were grouped together according to the themes on the qualitative data.

4.2.1 Demographic Information

This section presents data on the study participants' demographic information. These include sex, age, level of education, occupation, institution category and the province the respondents were coming from.

Distribution of Respondents by Sex

The information collected from the respondents as shown in Figure 40, showed that there were thirty-eight (38) females representing 31 percent and eighty-four (84) males representing 69 percent of the respondents. This shows that there were more males who participated in the study than females.



Source: Field Data 2016

Figure 40: Sex of Respondents

Distribution of Respondents by Age

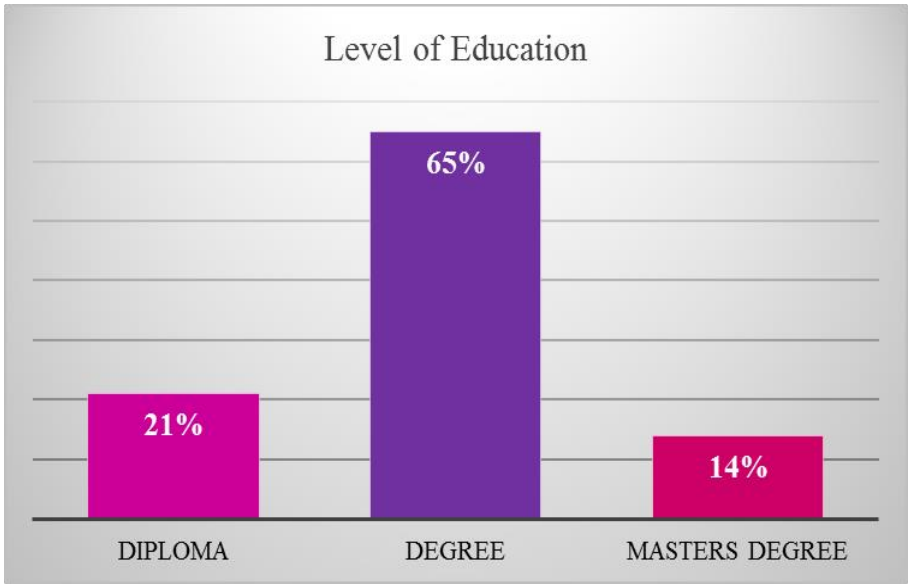
On age distribution, it was found that, four (4) respondents were between 20 and 29 years of age representing 3.5 per cent of the respondents. Thirty-three (33) of the respondents came from 30-39 age group indicating 27 percent and sixty-two (62) respondents from 40 – 49 age groups corresponding to 50.8 percent. Furthermore, twenty-two (22) respondents representing 18 percent came from 50-59 age groups. One (1) respondent representing 0.8 percent did not indicate their age (see Table 20). The information on age was crucial because it helped the researcher to know the computer literacy levels and how easily respondents would be able to learn computers to effectively use the web-based registration system.

Table 20 Age of Respondents

S/N	Age Category (years)	N	Percentage (%)
1	20 - 29	4	3.3
2	30 - 39	33	27.0
3	40 - 49	62	50.8
4	50 - 59	22	18.0
5	Non response	1	0.8
	Total	122	100

Source: Field Data 2016

Distribution of Respondents by Level of Education

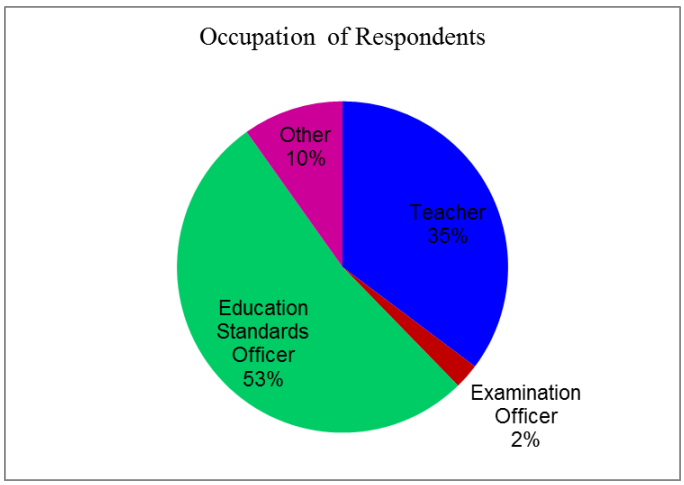


Source: Field Data 2016

Figure 41: Level of Education

The bar chart represented in Figure 41 shows the highest level of educational of the respondents. Twenty five respondents representing 21percent (n=25) were diploma holders, 65 percent (n= 79) were degree holders and 14 percent (n=17) were master's degree holders. Educational levels were important because they influenced the respondents' ways of analysing issues.

Distribution of Respondents by Occupations

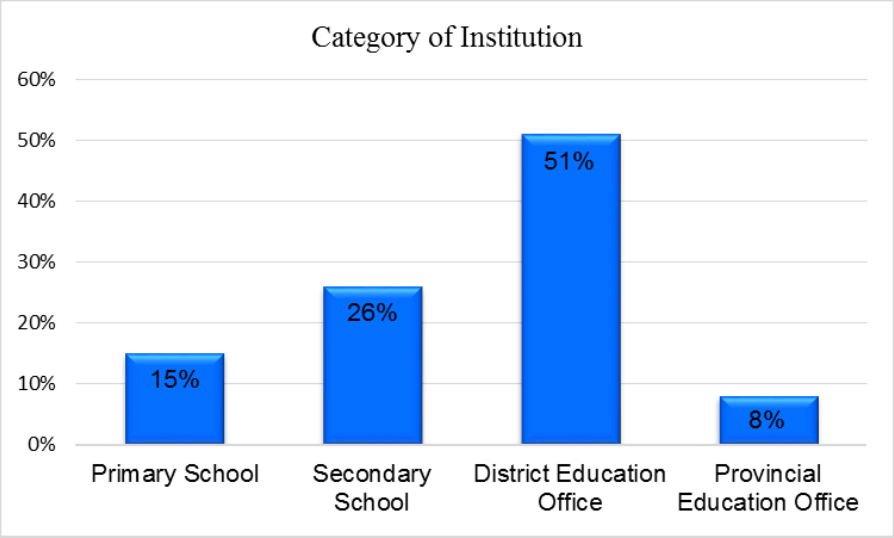


Source: Field Data 2016

Figure 42: Occupation of Respondents

Figure 42 shows the findings on the occupations of the respondents. Out of 122 respondents 35 percent (n=43) of the respondents were teachers, while 2 percent (n=3) of the respondents were examination officers, 53 percent (n=64) of the respondents were education standard officers and 10 percent (n=12) had other occupations, these with other occupations work within the Ministry of General Education like Accountants, Secretaries and Statisticians who are used in the process of registering candidates like the accounts receive the examination fees while Secretaries and Statisticians assist with entering and consolidating candidate registration details. The occupations of respondents were crucial in establishing the level of involvement of various people in the candidate registration process.

Category of Institution

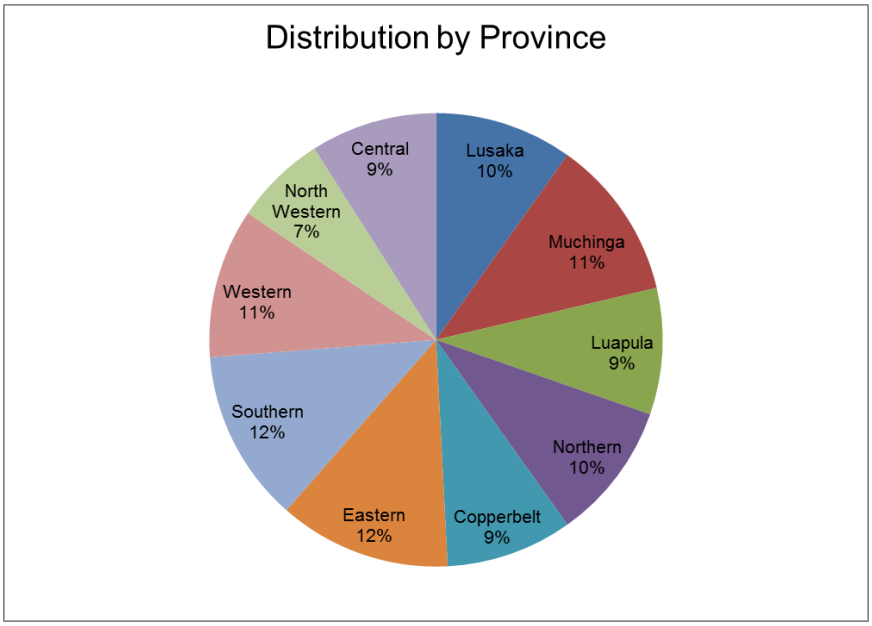


Source: Filed Data 2016

Figure 43: Category of Institution

The findings on the institutional category the respondents belong to as presented in Figure 43 shows that the respondents belong to the provincial education office 8 percent (n=10), primary school 15 percent (n=18), secondary school 26 percent (n=32) and district education office 51 percent (n=62). These 51 percent from the district education office and the 8 percent from the province deal with examination centres directly and are the ones that are charged with the responsibility to supervising the whole examination process including the candidate registration process in their respective districts and provinces.

Distribution of respondents by Province



Source: Field Data 2016

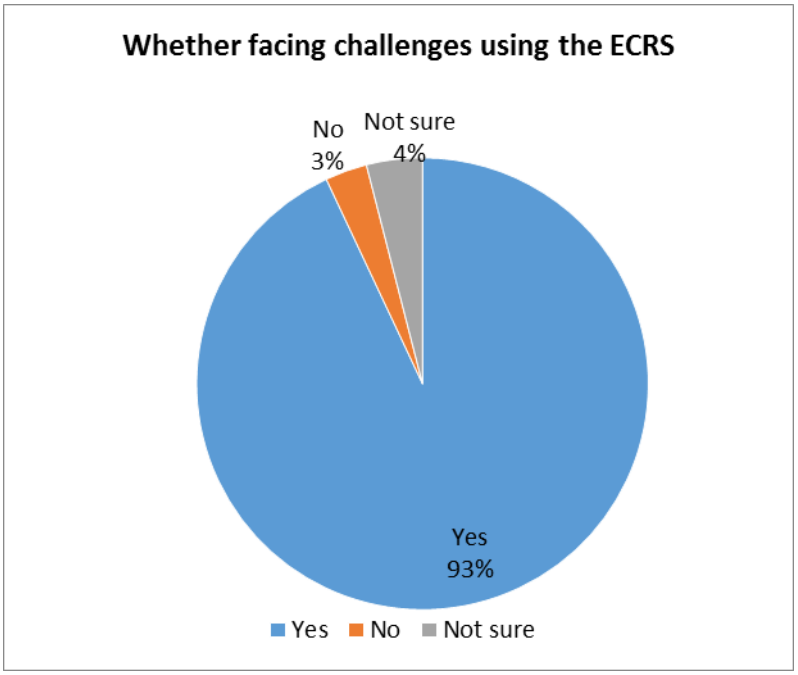
Figure 44: Location of Respondents

Figure 44 shows that the distribution of respondents in provinces ranged from 7 percent to 12 percent indicating that there was an even distribution of where the respondents were coming from. This is indicative that the sample was representative of all the ten (10) provinces in Zambia.

4.2.2 Challenges with the desktop application registration system

This section addresses the second objective of the study which was to establish the challenges faced by ECZ in the registration of candidates for national examinations. This objective is very important as it serves as a backbone for the research study. The results are as presented and discussed below.

The started by finding out whether the respondents were really having challenges registering candidates for school examinations using the desktop application, the Electronic Candidate Registration System (ECRS). The results are presented in Figure 45.

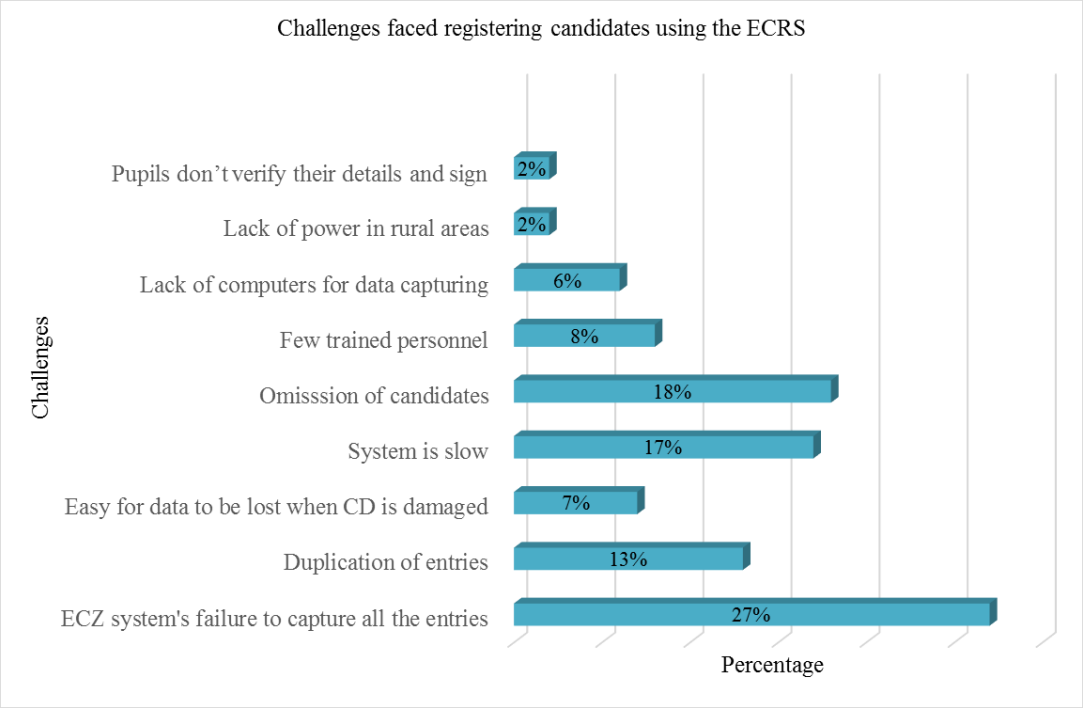


Source: Field Data 2016

Figure 45: Whether Facing Challenges with ECRS

Figure 45 shows that 93 percent (n=113) said yes they were facing challenges with the desktop application system of registering candidates, 3 percent (n=4) said no while 4 percent (n=5) said they were not sure. This shows that most of the respondents were indeed facing challenges with the desktop application system of registering candidates.

Having established that there were indeed challenges with the registration of candidates, the researcher went ahead to find out what those challenges were. The challenges mentioned by the respondents are shown in the diagram in Figure 46.



Source: Field data 2016

Figure 46: Candidate Registration Challenges

The research findings confirm that there were challenges in the system for registering candidates for national examinations in Zambia. As indicated in Figure 46 the respondents mentioned challenges faced such as omission of candidates which accounted for 18 percent while 27 percent said ECZ systems failure to capture all entries, 6 percent said that it was lack of computers for data capturing, 2 percent said it was lack of power in rural areas , 2 percent said pupils do not verify their details and sign, 7 percent said it was easy for data to be lost when CD is damaged, 17 percent said the system was slow while 8 percent said it there were few trained personnel.

To confirm some of the challenges highlighted by the respondents, key informants from Examinations Council of Zambia also said the following as some of the challenges faced in the registration of candidates for national examinations; "Data consolidation has in most cases proved to be a challenge, some centre/provinces have presented blank CDs because they lack computer literacy, mass omission of candidates which is quite difficult to resolve''; "required data to be consolidated afterwards by the district office from all the schools, if not done properly data would be lost along the way, Candidates

supplying wrong examination numbers resulting in duplicate numbers, Possibility of some candidates at Grade 12 supplying different names from those supplied when in Grade 9, Prone to data loss when editing a record and if data is not saved properly, Allowed candidates not eligible to register for examinations".

In addition other challenges include "the drop down menu contains data that may not be easy to find/locate leading to wrong selection of data in the forms within the system, there is too much free typing in the system instead of the system providing a mirror to already existing data, provisional registers are printed prematurely before data is completely captured, reduced performance of the system when the database grows due to the nature of the jet database, and one person signing for all candidates on the provisional register". All of these challenges regarding the desktop application combined with manual systems indicate the need to improve the candidate registration process for school examinations in Zambia.

A key informant at the ECZ in an interview alluded to the following as the challenges: "the software requires date setting on the computer to be in United Kingdom format DD/MM/YYYY which creates problems when they are not set according to the required date setting by the ECRS, CD creation is another challenge in some cases shortcuts are written onto CDs, Cost of transporting the CD data from the source to the District, the province and finally to ECZ, data is subjected too much handling, Not adhering to the required data format where there is mixture of the data formats in one file which pose a problem when uploading data to the examination processing system, actual databases are submitted to Examinations Council to extract the data from them which is time consuming and if you have a lot of this type it will slow down the process of registration, Partial submission of data also creates serious challenges of duplication of entries".

4.2.3 Suggested solutions by the Respondents

After establishing the challenges, respondents were also asked to recommend some solutions that they perceived would help in reducing the challenges that were mentioned. Both respondents and the ECZ staff interviewed made their suggested solutions to the registration challenges.

Table 21 Proposed Solutions by Respondents

S/N	Proposed Solution	N	Percentage (%)
1	Resolve issues of shared numbers	7	5.7
2	Updating of the system regularly by ECZ	21	17.2
3	Online registration	57	46.7
4	Guidance Teachers should have less number of periods	3	2.5
5	Train more personnel	22	18.0
6	Provision of computers to needy schools	9	7.4
7	ECZ should consider two deadlines for payment and registration	2	1.6
8	Non response	1	.8
	Total	122	100

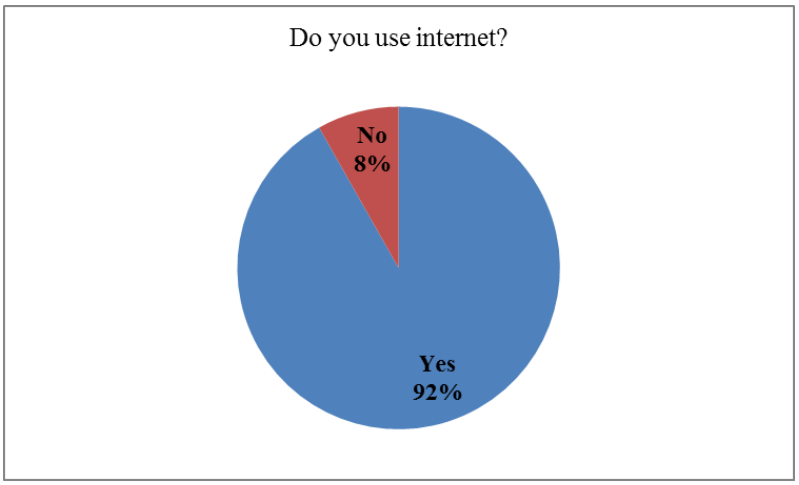
Source: Field Data 2016

As shown in Table 21, out of 122 respondents, 1.6 percent (n=2) said that the ECZ should consider coming up with two deadlines for payment of fees and registration, 7.4 percent (n=9) said that computers should be provided to needy schools, 18 percent (n=22) said personnel should be trained, 2.5 percent (n=3) said guidance teachers should have less numbers of period to teach, 46.7 percent (n=57) said the system should be replaced by an online registration system, 17.2 percent (n=21) said updating the system regularly by ECZ and 5.7 percent (n=7) said resolving the issues of shared numbers.

The key informants from the Examination Council of Zambia alluded to the following as some of the possible solutions to the challenges faced in registering candidates for national examinations: "Continuous training and Trainees should be Users of the system and not representatives who do not use the system at all or are unable to adequately train the other users", "migrating to an online registration system that; does not require data to be consolidated, able to detect wrong examination numbers supplied by some candidates, candidates' registration data at Grade 12 is retrieved from the Grade 9 data and no amendments on names is possible and is able to detect that candidates registering at Grade 12 have Grade9 certificates", "Developing an online system with a central database that would sort out problems of shared numbers and completely cutting off consolidation of candidate entries at the districts".

From the responses by the respondents and the ECZ staff interviewed, it is clear that the majority were in support of a web based system where data would be centrally stored and previous candidates' data would be easily retrieved to avoid errors.

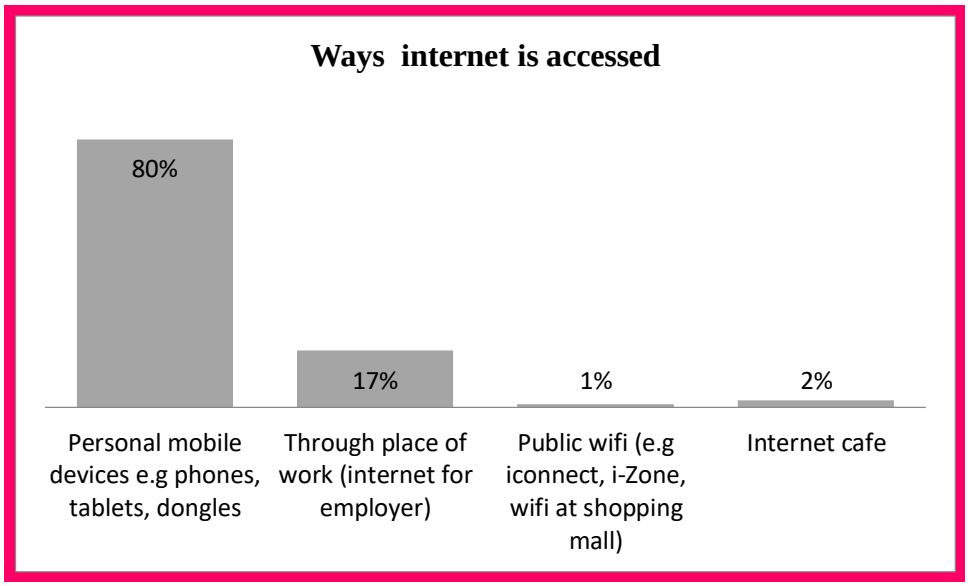
4.2.4 Access to Internet



Source: Field Data 2016

Figure 47: Use of internet

The pie chart in Figure 47 shows the usage of internet by the respondents. Out of the 122 respondents 92 percent (n=112) of the respondents said yes the use internet while only 8 percent (n=10) said that they do not use internet.

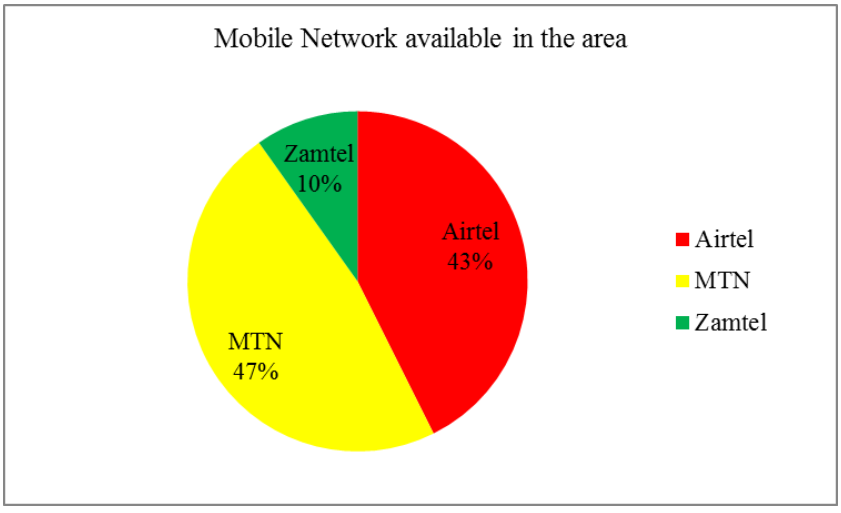


Source: Field Data 2016

Figure 48: Ways internet is accessed

According to Figure 48, the following were the ways in which the 122 respondents access internet. 80 percent (n=97) access internet through their personal mobile devices, like phones, tablets or dongles, 17 percent (n=21) said they accessed internet from their work place which is provided by their employers, while 1 percent (n=1) said that they access internet through public wifi like iconnect, i-Zone or wifi at shopping malls and 2 percent (n=3) said they accessed it through internet cafes. This means that people

Availability of Mobile phone service



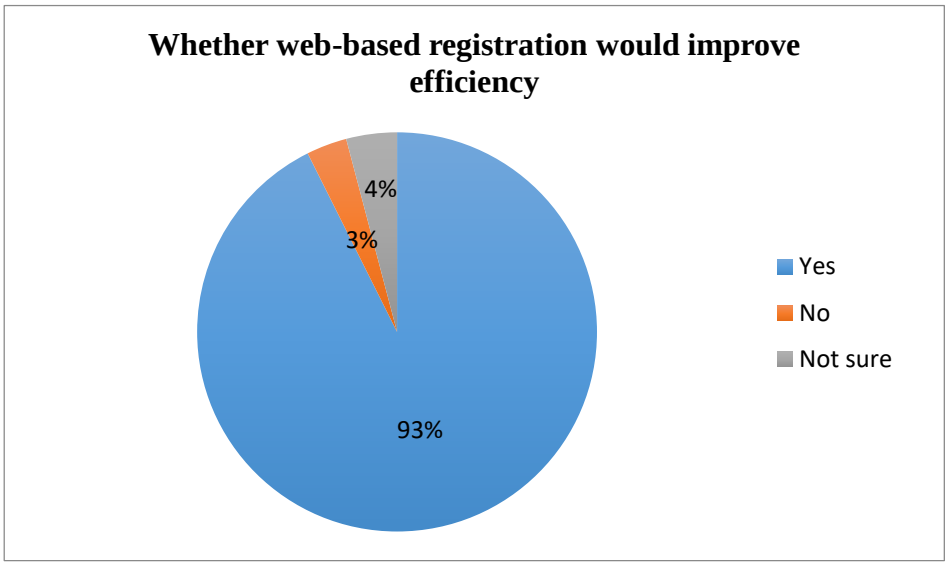
Source: Field Data 2016

Figure 49: Mobile Service Provider Available

The participants also indicated the mobile network available in their area. The above pie chart in Figure 49 shows that there is at least one mobile service provider in the area making it possible to for them to have access to internet services via the mobile service providers.

4.2.5 Benefits of a web-based candidate registration system

This section presents the findings on whether developing a web-based candidate registration would be a solution to mitigate the challenges in the current registration process. The results show that most of the respondents the recommended a web-based candidate registration system.



Source: Field Data 2016

Figure 50: Whether web based registration would improve efficiency

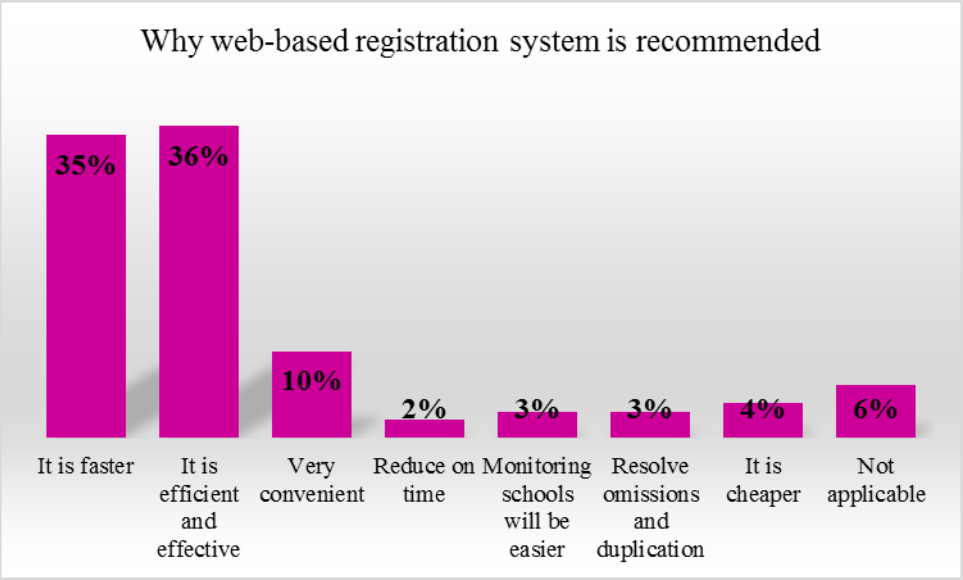
Figure 50 shows that out of the 122 respondent 93 percent (n=113) of them said that yes they think that a web-based registration system will improve efficiency in registering candidates for national examinations, while 3 percent (n=4) said no it will not improve efficiency and 4 percent (n=5) were not sure whether or not it will improve efficiency.

Table 22: Whether to recommend using a web-based system for registering candidates

Stimuli	N	Percentage (%)
Yes	114	93.4
No	5	4.1
Not sure	3	2.5
Total	122	18.0

Source: Field Data 2016

The table 22 shows that 93.4 percent (n=114) of the respondents recommended using a web-based candidate registration system for registering candidates for school examinations, 4.1 percent (n=5) said they would not recommend it while 2.5 percent (n=3) were not sure. From the findings, it is clear that a web based candidate registration system is highly recommended. The reasons why respondents recommend a web-based system are indicated in Figure 51.



Source: Field Data 2016

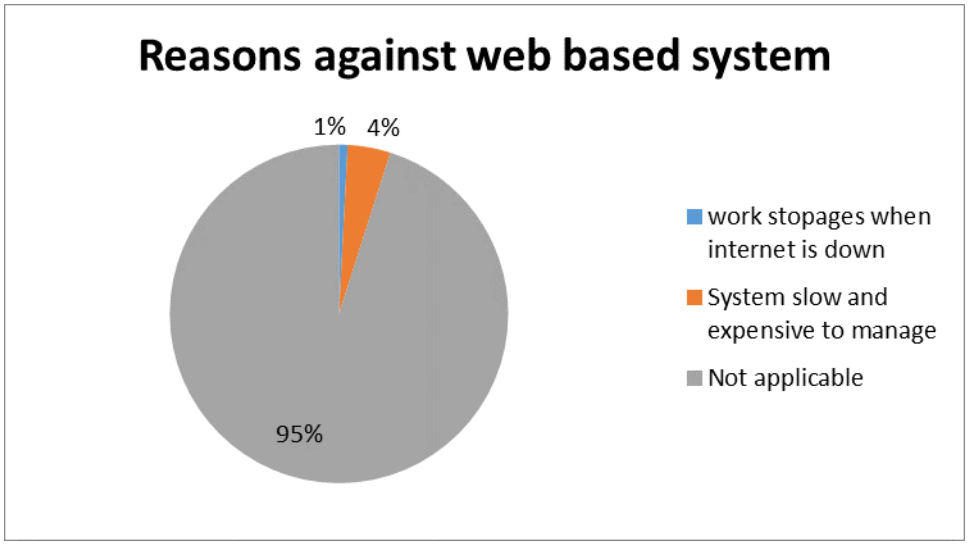
Figure 51: Perceived Benefits of a web application

The bar chart in Figure 52 shows the perceived positives that the 122 respondents gave as to why it was necessary to use a web-based registration system. 6 percent (n=7) of them said it was not applicable, 4 percent (n=5) of them said that it was cheaper, 3 percent (n=4) of the respondents said that it will resolve the problems of omissions and duplication of entries, 3 percent (n=4) of the respondents said that it will make monitoring schools easier, 2 percent (n=3) respondents said that

it will reduce on the time taken, 10 percent (n=12) said that it will be very convenient, 36 percent (n=44) said that it will become more efficient and effective and lastly 35 percent (n=43) of the respondents said it would be faster to do the registration of candidates for national examinations. From the findings mentioned above, we can see that there are several merits as to why a web-based registration system should be developed.

Therefore, from the above submissions it can be seen that indeed there is need for a long lasting solution to the challenges that are being faced and that the solution is a web-based registration system as three of the ECZ staff have mentioned it in their recommended solutions. Furthermore, all of these key informants agree to the fact that a web-based registration system will curb most of these challenges that the registration system is facing as they responded yes to the question "do you think it is necessary for ECZ to develop a web based candidate registration system. They also said some of the features they would want the system to have included the system being able to detect wrong entries and duplications, able to retrieve from previous data for returning students at Grade 12 and system should allow candidates to verify their details online on their own.

On the other hand, there was a minority that were against a web-based registration system and their reasons are shown in the figure 52.



Source: Field Data 2016

Figure 52: Reasons against a web based registration system

Figure 52 shows why some of the respondents do not think a web-based registration system would improve the efficiency of registering candidates for national examinations. Out of the 122 respondents, 95 percent (n=116) said that it is not applicable (this is because most of the respondents recommended a web-based registration system), while 4 percent (n=5) said that they anticipate that the system would be slow and expensive and 1percent (n=1) said that there could be work stoppages when internet was down. Those who were not for the idea of a web-based system had fears of technology failing at some point.

4.3 System Implementation

This section describes the implementation of a web-based candidate registration system. A representation of the screen shots of the developed system is shown.

4.3.2 Levels of Users

In Chapter 3, four types of users of the system were identified, namely System Administrator, Guidance Teacher, Standards Officer and the Candidate. Below we discuss the responsibilities of these users in detail and show what the system has provided for each of the users.

4.3.3 Administrator Login and User Creation

The system administrator is responsible for managing users in the system. For a user to be able to access the web based system modules, they must be registered in the system. All the data entered into the system should be able to be traced to the user that entered and that is why every user of the system should have been registered in the system.

To create a new user account in the system, the administrator must log in and then enter the details of the User that are shown in the screen shot in Figure 53.

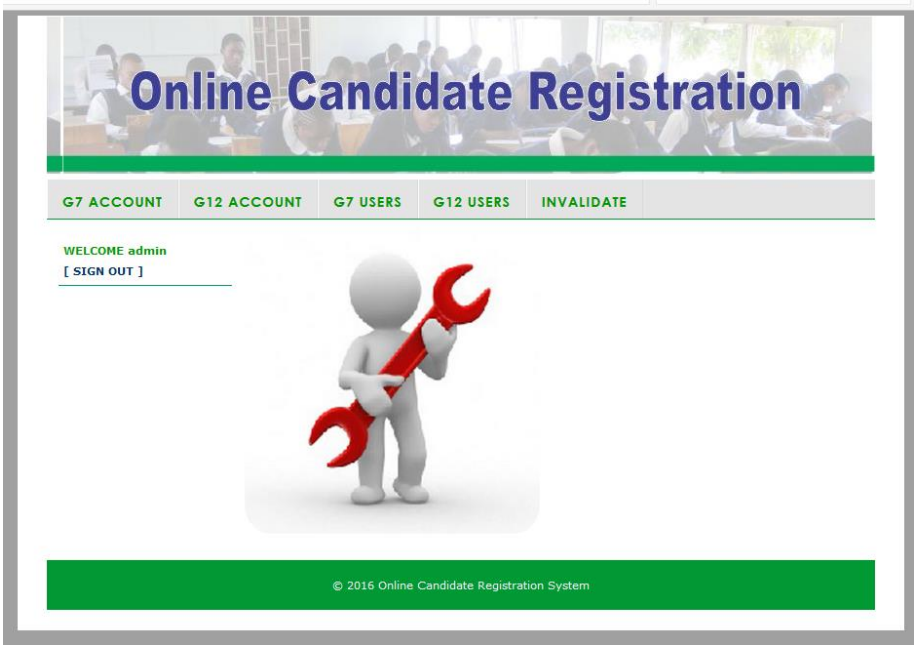


Figure 53: Administrator Sign in home page

The user names are created for each Guidance Teacher in the school and it is the responsibility of the Administrator at District level to create users in the system. Each user created is attached to a particular examination centre and can only register candidates for that particular school. Figure 54 shows the different categories of users sign in page.

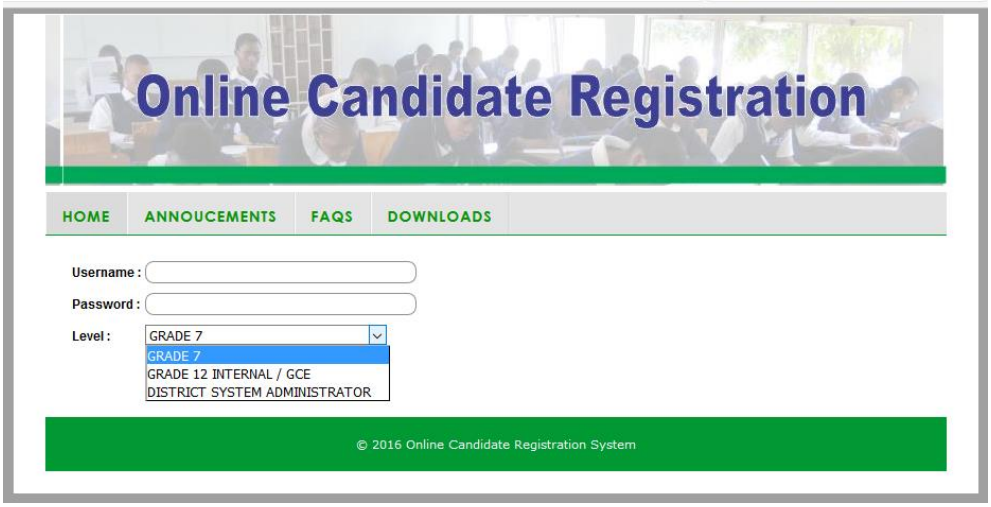


Figure 54: Sign in page

The Figure 55 shows the user account creation page where the users details are entered by the administrator.

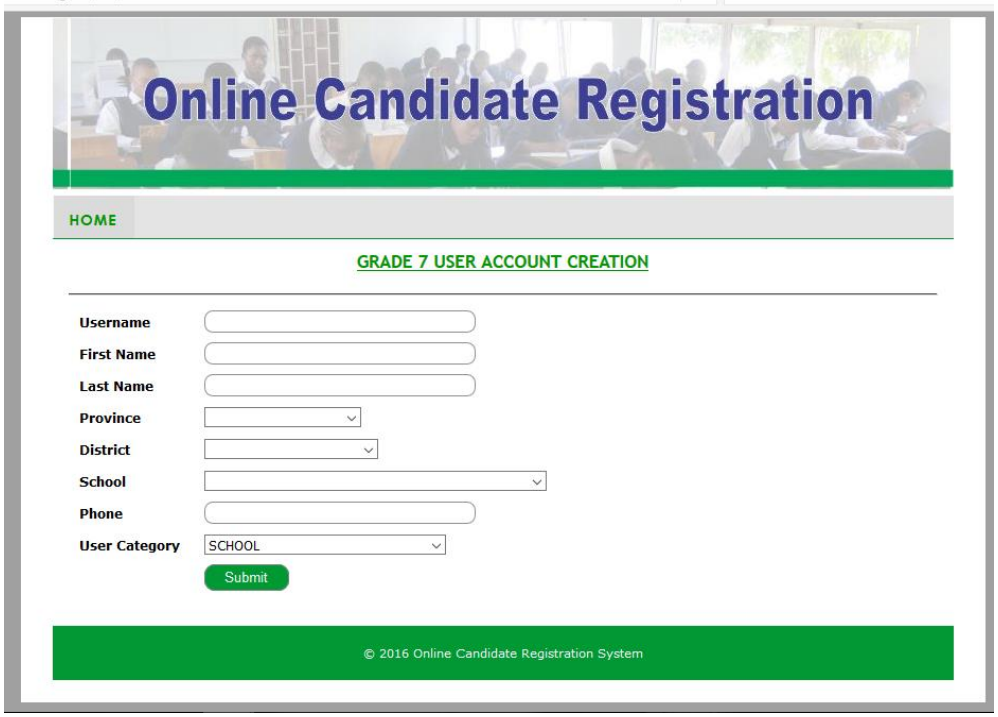


Figure 55: User Creation Page

When the user is created, a default password is also created which a user would have to change at first login before they can proceed to do anything in the system. Figure 56 shows the user management page for the administrator.

Figure 56: User Management Page

4.3.4 Registering Candidates

The School guidance teacher is responsible for registering candidates at a school level. They will be able to add a candidate, update candidate details or delete a candidate record. Before they can do this, they have to login in the system. The screen in Figure 57 shows the sign in page for the user registering candidates.

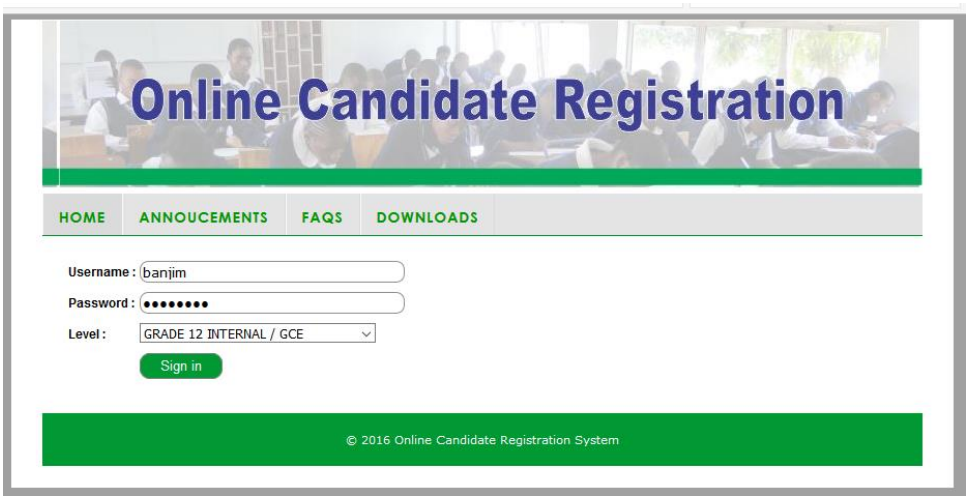


Figure 57: Sign in page

The Figure 58 shows the school home page once the user successfully logs in the system showing the centre/ school the user belongs.

Figure 58: School Home page

4.3.5 Adding a Candidate Record

To register a Grade 7 candidate, you have to log on as a Grade 7 user and the following screen in Figure 59 shows in order for the user to select the centre code and year of examination.

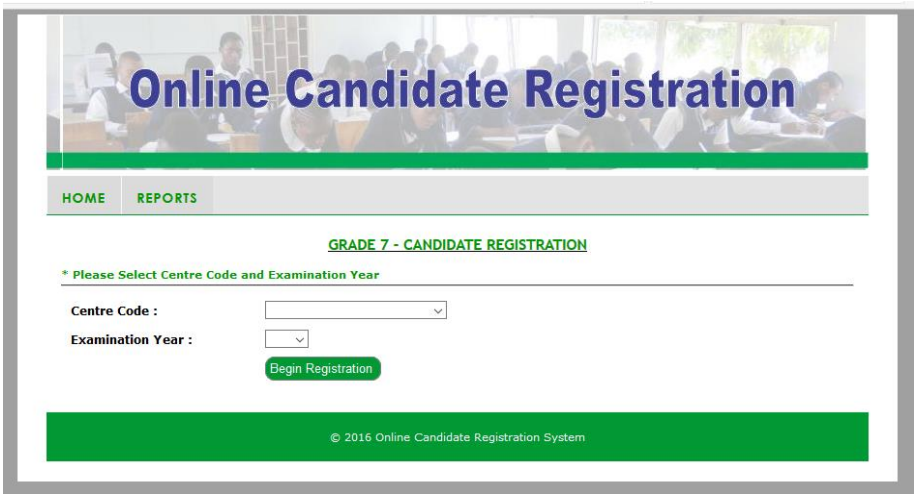


Figure 59: Grade 7 Candidate Registration

After selecting the correct details, the candidate's examination number is automatically generated and the user can enter all the candidate details as shown in Figure 60.

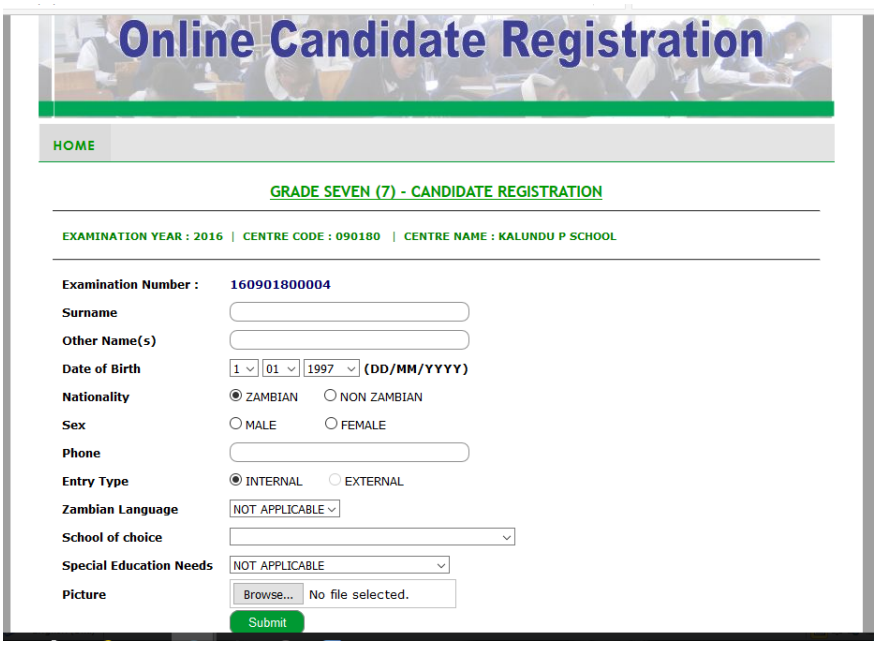


Figure 60: Grade 7 Candidate Entry details Screen

Adding a Grade 12 Internal candidate Record

To add a candidate record for G12 Internal candidate, the user has to enter a valid Grade 9 examination number and the personal details for the candidate are displayed on the page as shown in Figure 62. This is because the Grade 12 Internal candidates use the same examination number that was allocated to them at Grade 9 level. All the user needs to do is select the subjects as shown in Figures 61 and 62.

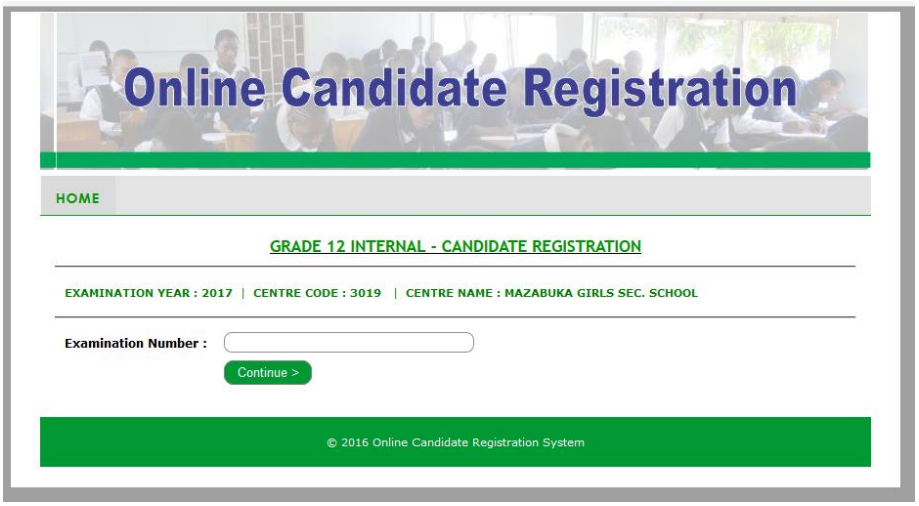


Figure 61: G12 Internal Registration – Candidate Registration

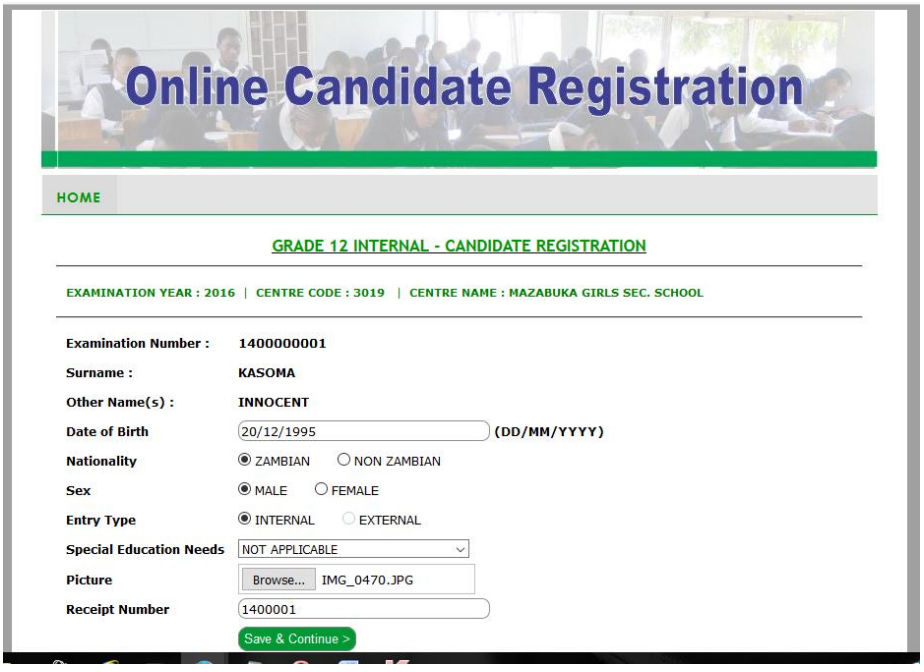


Figure 62: G12 Internal Registration – Candidate Details

Once the details have been retrieved as in the Figure 62 above, the selection of subjects can be done as shown in Figure 63.

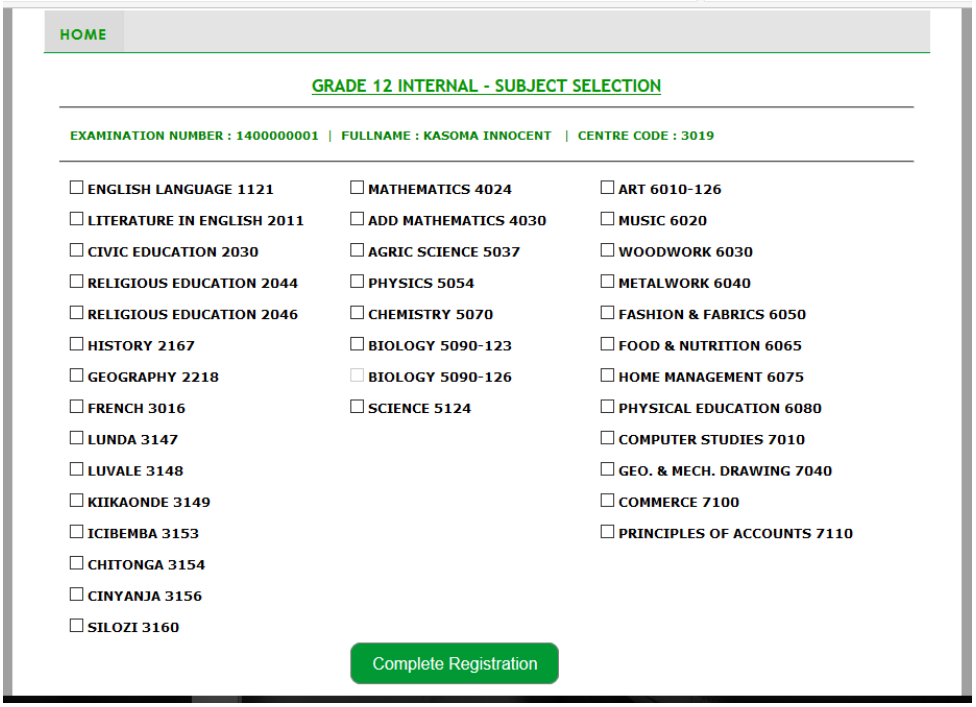


Figure 63: G12 Internal Registration - Subjects Selection

4.3.6 Updating Candidate Records

If the user wants to change some details on a particular candidate record, they can do so by entering the examination number to retrieve the record and change the details that they want as shown in Figure 64. After changing the record, click update and the record will be saved with the edited information.

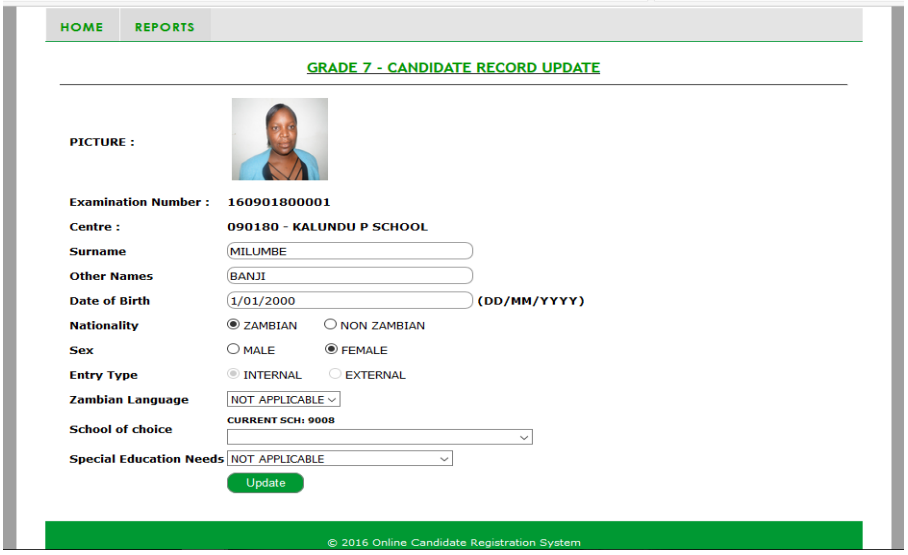


Figure 64: G7 Candidate Record Update

4.3.7 Generating a Report

The web based candidate registration system has several reports that can be generated by the user. Reports like the candidate provisional register, special education needs, centre subject totals and many others are available in the system. The Figure 65 below shows the page for selecting the required report.

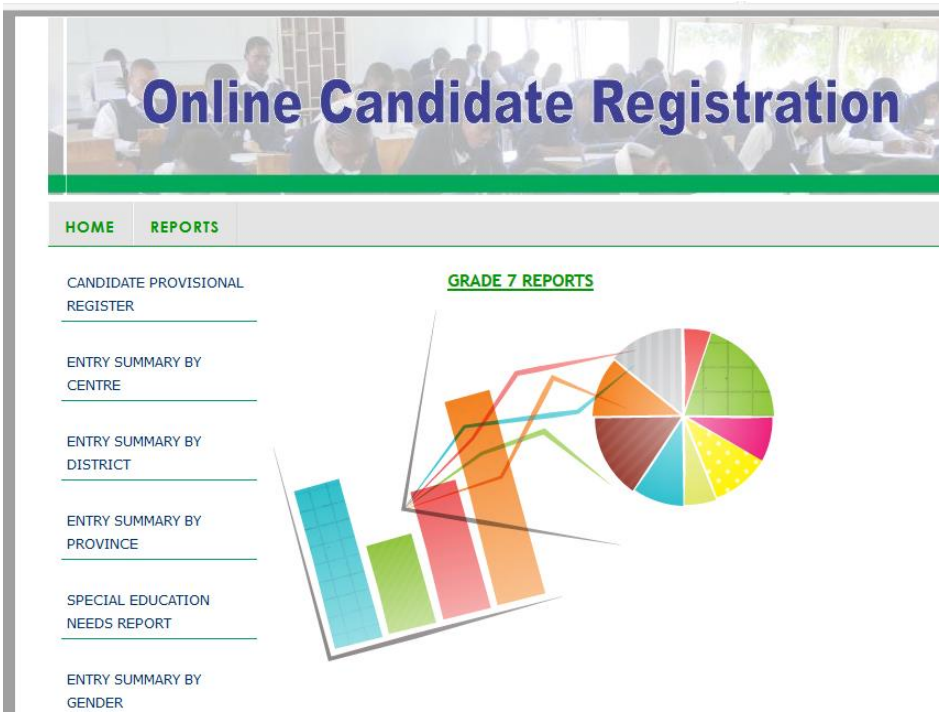


Figure 65: Types of Reports

Figures 66 and 67show an example of the Grade 7 and Grade 12 Candidate Provisional Register report respectively. The provision to delete a candidate from the system or edit a candidate record appears under this report.

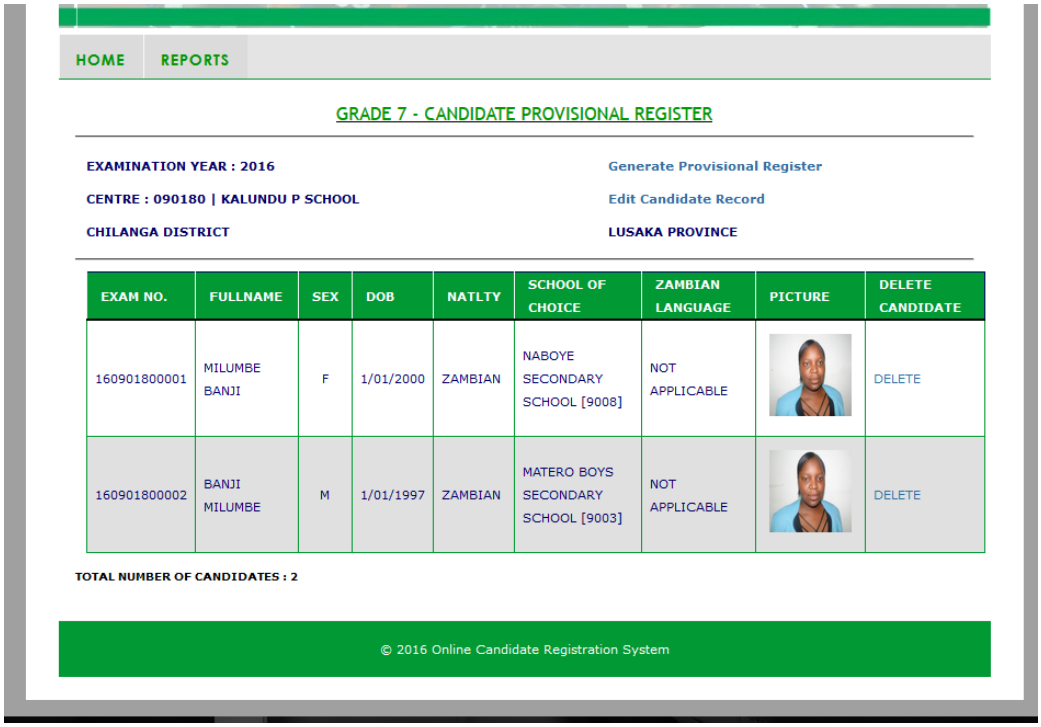


Figure 66: Grade 7 Candidate Provisional Register

Figure 67: Grade 12 Internal Candidate Provisional Register

4.2.8 Viewing candidate details

A candidate can view their details by entering their examination number. The screen shots in Figure 68 and 69 shows the candidate details of a Grade 7 and Grade 12 registered candidate respectively.

Figure 68: Candidate Entry Record

4.2.9 View Grade 12 Candidate Record

Figure 69: Grade 12 Internal Entry Record

4.4 Testing Results

The testing of the web based candidate registration system was done two phases. The first phase was done in all provinces in two selected districts and two centres. The testing of the system was done by ECZ staff that travelled to the various provinces to test the system with the provincial, district and school officials. The ECZ sponsored the testing exercise as an interested party in the application. Two districts and two schools were selected per province. The application was hosted on the ECZ server and 40 selected centres were used in the testing of the application.

The second test was done on the cloud domain hosted by A2 hosting services. This test was done by five users to check on the connectivity and stability on the public cloud environment.

4.4.1 Functionality Test

Table 23 Test Results of web application

	Number out of 39 schools	Percentage
Access to the Web application	39	100%
Entry of 50 Candidates	36	92%
Able to Update Candidates	39	100%
Reports Tested	39	100%

Source: Field Test

In the first phase of testing, all the 39 schools where the test was conducted schools could access the web application, able to update candidate details and tested the various reports. Thirty six out of thirty-nine (92%) schools successfully registered all the 50 candidates sampled while three centres could not register all the 50 due to the inadequate number of candidates selected as well as examination numbers of the sampled candidates supplied were not valid. Thus, the system could not retrieve candidate details to proceed with registration. This was part of testing the system for those conditions /rules as successfully applied to ensure that the data entered was accurate.

4.4.2 Tools used for testing

During the system testing, laptops and mobile wireless 3G Routers were used in the testing for the internet connection. The testing relied solely on the mobile phone service providers available in each area/school for internet connectivity. Even though the school had its own internet connection, it was not used because the testing wanted to establish availability of internet connectivity so that even schools that did not have internet of their own could easily purchase similar routers/modems and be able to access the web based registration system to register candidates.

4.4.3 Testing the Internet Connectivity

The internet connection speed was tested at each of the schools where the pilot was conducted using the online website speed tester, www.speed.io. The

download and upload speed was recorded as it showed under measured data of the online speed tester. The download speed ranged from 1.527 kb/s to 8972 kb/s while the upload speed ranged from 2kb/s to 506 kb/s. The time of testing the connection speed also had a bearing on the speed of the internet as certain times in certain places were congested while in other places there was little congestion and the internet speed was fast.

					Available Mobile Network			Preferred	Connection Speed (Kb/s)		Time tested
Province	**District**	**School**	**Type**	**Location**	**Airtel**	**MTN**	**Zamtel**	**Network**	**Download**	**Upload**	
Muchinga	Chinsali	Kenneth Kaunda	Secondary	Urban	Y	Y	N	Airtel	1.651	74	14 - 17 hrs
		Mulilansolo	Primary	Rural	Y	Y	N	MTN	34	0	08-12 hrs
	Chama	Chama Boarding	Secondary	Urban	Y	Y	Y	Airtel	0.75		
	Chama	Chama Primary	Primary	Urban	Y	Y	Y	Airtel	0.75		
Northern	Kasama	Ituna Secondary	Secondary	Urban	Y	Y	Y	Zamtel	2.733	197	14-17 hrs
	Kasama	Ngoli Middle Basic	Primary	Rural	Y	Y	Y	MTN	296	98	14-17 hrs
	Kaputa	Kaputa Secondary	Secondary	Rural	Y	Y	N	Airtel	153	2	08-12 hrs
	Kaputa	Kaputa Basic	Primary	Rural	Y	Y	N	Airtel	394	104	14-17 hrs
Southern	Choma	Shampande Primary	Primary	Urban	Y	Y	Y	MTN	3.729	73	08-12hrs
	Choma	Sikalongo	Secondary	Rural	Y	N	N	Airtel			
	Sinazongwe	Sinazongwe Primary	Primary	Rural	Y	Y	Y	MTN	1.836	69	08-12hrs
	Sinazongwe	Maamba Secondary	Secondary	Rural	Y	Y	Y	MTN			
Western	Sioma	Kalongola Primary	Primary	Rural	Y	Y	Y	Airtel	35	0	12-14 hrs
		Sioma Secondary	Secondary	Rural	Y	Y	N	MTN			
	Mongu	Kambule Secondary	Secondary	Urban	Y	Y	Y	MTN	1036	164	08-12 hrs
		Mawawa Primary	Primary	Urban	Y	Y	Y	Airtel	135	304	12-14hrs
Central	Kabwe	David Ramashu	Primary	Urban	Y	Y	Y	MTN	359	108	08-12 HRS
		Kabwe Secondary	Secondary	Urban	Y	Y	Y	MTN	567	144	14-17hrs
	Luano	Mkushi Copper mine	Secondary	Rural	Y	Y	N	MTN	7.14	339	08-12 hrs
		Chikupili	Primary	Rural	Y	N	N	Airtel	71	0	12-14 hrs
Copperbelt	Ndola	Masala	Secondary	Urban	Y	Y	Y	MTN	5960	1810	08-12 HRS
		Kansenshi	Primary	Urban	Y	Y	Y	MTN	845		
	Lufwanyama	St Joseph's Kalumbwa	Secondary	Rural	Y	Y	Y	MTN	558	222	08-12 hrs
		Nkana	Primary	Rural	Y	Y	Y	Airtel	616	60	12-14 HRS
Eastern	Chipata	Chipata Day	Secondary	Urban	Y	Y	N	Airtel	0.75		08-12hrs
		Hillside	Primary	Urban	Y	Y	N	Airtel	0.75		08-12hrs
	Vubwi	Mbande	Primary	Rural	Y	Y	Y	Airtel	0.75		14-17hrs
		Vubwi Day	Secondary	Rural	Y	Y	Y	Airtel	0.75		14-17hrs
North Western	Solwezi	Mutanda	Secondary	Rural	Y	Y	N	Airtel	297	138	12-14hrs
		Kikombe Upper Basic	Primary	Urban	Y	Y	N	MTN	8.972	411	08-12 hrs
	Chavuma	Chavuma	Secondary	Urban	Y	Y	N	MTN	518	506	12-14hrs
		Chiyeke	Primary	Rural	Y	Y	N	Airtel	455	207	08-12hrs
Luapula	Mansa	Mansa Secondary	Secondary	Urban	N	Y	N	MTN	4216	288	12-14 hrs
		Muwanguni	Primary	Rural	N	Y	N	MTN	108	8	14-17 hrs
	Chiengi	Chiengi	Primary	Rural	N	Y	N	MTN	77	8	
		Ponde	Secondary	Rural	Y	Y	N	MTN	1.527	392	
Lusaka	Kafue	Naboye	Secondary	Urban	Y	Y	Y	Airtel			
	Luangwa	Luangwa Boarding	Secondary	Rural	Y	Y	Y	Airtel	0.75		12-14hrs
		Luangwa Primary	Primary	Rural	N	Y	N	MTN	0.75		12-14hrs

Figure 70: Summary Results of Connectivity Test

Figure 70 shows that internet connectivity was available in all the schools that were used in the testing both rural and urban schools. In each of these schools there was at least one mobile network provider available and internet access was possible using the 3G wireless modems for internet service. It should be noted though that in one of the centres, internet could only be accessed at a particular point which was under a guava tree. Despite that however, registration of candidates using the web based application system was successful.

4.4.4 System Performance and responsive

The Figure 71 shows the system responsiveness during the testing. It can be noted that the system response was good in most of the schools used in the testing which accounted for 95 percent while 5 percent said it was fair. None of the schools in the test recorded poor system response which shows that the web based registration system generally performed very well.

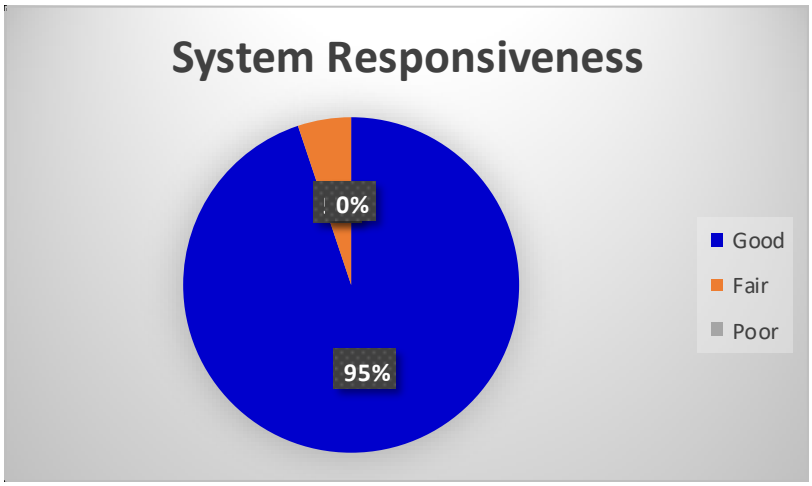


Figure 71: System Responsiveness

4.4.5 General Observations on the System

Outlined below are some of the observations made by the district and school representatives following phase one of the testing of the system.

(i) The application is easy and convenient to use, it is user friendly, easy to learn, simple to use, it is fast. Mistakes that come with registration will come to an end.

(ii) The system eliminates the use of CDs and consolidation of data, lessens the work and cuts down on movements and costs.

(iii) It is easy at G12 internal to detect repeaters, wrong examination numbers and avoids duplication of entries.

(iv) The system is efficient and effective, will save on time and reduce movements.

(v) The system should show a count of the subjects entered as the user is selecting subjects to be entered.

(vi) The 3G wireless modems would be ideal to use in remote locations and laptops as opposed to desktop computers due to intermittent power supply.

4.5 Summary

In this chapter, results of the baseline study, the system implementation and the system evaluation procedure conducted on the web based candidate registration system were explained. The baseline study established that ECZ was facing challenges in the registration of candidates for school examinations which had an effect on the other examination processes. In the study, participants recommended a web based registration system which was developed and tested. From the test results obtained, it can be concluded that the web based candidate registration system is more efficient and effective although there is still room for improvement to further enhance the features of the system. Generally, satisfaction of the system was observed in the participants' expression during the testing. Compared to the desktop application, the web based system has shown that it is more suitable for registering candidates for school examinations in Zambia.

Chapter Five

5.0 Discussion and Conclusion

5.1 Introduction

This chapter presents the discussion of the research findings as presented in chapter four. A discussion of the results of the baseline study, business process mapping, the system implementation, conclusion of the research and recommendations are presented.

5.2 Baseline Study

The registration of candidates for school examinations was achieved using a desktop application that was provided to the examination centres by ECZ. Several challenges were identified with this system of registering candidates which has impacted negatively on the operations of ECZ. A baseline study was conducted in order to establish the challenges that ECZ faced with registration of candidates as well as the examination centres. The findings helped to come up with a solution that was perceived to be much better so as to improve the efficiency in the candidate registration process.

Other than the challenges, the baseline study sought to establish the use and availability of internet services in the provinces, districts and schools. This was important to know as it helped to determine whether the proposed system would be usable or not in the various parts of the country. It was also necessary to ascertain whether the respondents were in favour of changing the desktop application to a web based application. Fortunately, the majority responded to the affirmative.

5.2.1 Demographic Information

The demographic information for the respondents was captured such as age, sex, location. The age of the respondents who participated in this study ranged from 27 to 54 years old with 31 percent female and 69 percent male. The highest levels of education for the participants ranged from Diploma to Master's degree with 35 percent being teachers, 2 percent examination officers, 53 percent education standard officers and 10 percent had other occupations. These participants were drawn from provincial education offices, district education board office, primary and secondary schools, within the Ministry of General Education.

The age of respondents showed that most of them were not a youthful audience which might have a big influence on their knowledge of computers as these facilities are quite recent in our country and mainly used by the younger generations. This may be a hindrance to the use of ICT as they may have not had the chance to train on how to use these facilities. Most of the respondents had a good education as above 75 percent of the respondents were degree holders if we add those with masters degree. This means that most of them had good analytical skills on the issues at hand.

On occupation, it can also be deduced that majority of the respondents are education officers and these officers are mostly in charge of examinations at district or the provincial level. These people gave us vital information for this research as they are the people on the ground supervising schools in their respective districts and provinces. The teachers were the second majority followed by other occupations and lastly examination officers.

The respondent's views on the challenges faced during the registration of candidates was very critical and the proposed solution. Therefore, knowing which province the respondents come from is important as a representation of all the ten (10) provinces of Zambia would help in understanding whether the proposed solution could be implemented across the country.

5.2.2 Challenges using the desktop application for candidate registration

The research findings show that there were challenges with the desktop application used for registering candidates for national examinations in Zambia. Most of the challenges mentioned were in tandem with the challenges faced by other examination bodies, colleges and universities in the registration and management of student's records as revealed in the literature in chapter 2. The knowledge of the challenges was important as it can help in designing a suitable system that would help to resolve these challenges. As noted in the study, findings on the challenges were used to come up with a web based candidate registration system which was overwhelmingly supported by the participants in the study.

The beauty about first understanding the problems was that it helped the researcher to also probe for a solution which when implemented would increase users' understanding and acceptance of the system. Concerning user involvement in the system development process [1] recognised that 'users must have sufficient control over the design process to ensure that the system reflects their business priorities and information needs, not the biases of the technical staff'. A common feature of the environment in which all types of organisations operate is the presence of an apparently ever-accelerating rate of change [12]. Therefore, it is necessary that the systems that are being used are also changed in order to keep pace with the new environment and technologies.

As indicated in Figure 47 of chapter four, the challenges respondents mentioned can be categorised as being system related at 82 percent (omission of candidates 18 percent, ECZ system failure to capture all the entries 27 percent, easy for data to be lost when CD is broken or dropped 7 percent, system is slow 17 percent duplication of entries 13 percent), while 18 percent were administrative and logistical (8 percent lack of computers for data capturing, 2 percent lack of easy access in rural areas , 2 percent teachers finding it difficult to sign in for pupils, while 6 percent accounted for few trained personnel). From the findings, it is evident that challenges were there with the candidate registration system and that measures needed to be put in place so that those challenges could be reduced or

eradicated. With such a huge percentage indicating that they were having challenges, it justifies that a change in the system of registration was eminent.

5.2.3 Suggested Solution

The respondents also suggested some possible solutions to mitigate the challenges faced when registering candidates for national examinations such as replacing the current registration system with an online system 46.7 percent, updating the system regularly by ECZ 19 percent and said resolving the issues of shared numbers 11 percent. The other suggested solutions were more of an administrative nature than system related. This seem to suggest that the majority of the respondents subscribe to having a web based system for registering candidates as a way of improving the registration process and resolving the challenges identified.

5.2.4 Internet Accessibility

Almost all respondents 91 percent use internet either for work or personal purposes while 9 percent do not use internet. According to the findings in figure 52 in chapter 4, 80 percent of the respondents access internet through their personal mobile devices, like phones, tablets or dongles, 17 percent access internet from their work place and that the internet is provided by their employers, while 1 percent access internet through public Wi-Fi and 2 percent accessed it through internet cafes. This means that people are able to access internet on their own in one way or another as indicated by most of them.

Having established that the majority of the respondents access internet using personal mobile devices, it was important to also find out whether there was any mobile phone service provider available in the areas where the respondents are. This is because most of these mobile devices depend on mobile phone providers for internet services. The findings show that in all the respondents locations, there was at least one mobile phone service provider. Knowing that there is a mobile network in the area helps to establish that it would be possible to access and use a web based system for registering candidates once implemented.

5.2.4 Developing a web-based candidate registration system

The teachers and standards officers said that they think registering candidates using a web based registration system will improve efficiency. 92 percent of them said yes to an online system. Furthermore, 93 percent of the respondents recommended using a web based candidate registration system. Some of the reasons cited why it is necessary to use a web based registration system are that; it was cheaper, it would resolve the problems of omissions and duplication, would make monitoring schools easier, reduce on the delays to meet deadlines, it would be very convenient, become more efficient and effective to register candidates for national examinations.

From these findings, we can deduce that it is actually necessary to migrate to a web based candidate registration system as most of the people think that it will improve the effectiveness and efficiency of registering candidates for national examinations.

In view of a web based candidate registration system being highly recommended, it is imperative that systems be changed and efficiency of registering candidates for national examinations. Merits of a web based application system were also alluded to by [56].

On the other hand, the minority accounting for 4 percent who did not recommend a web based registration system indicated their fears of having such a system such as the anticipated unavailability of internet, the system becoming slow due to congestion as well as the cost of internet connectivity.

All in all, with the majority of the respondents giving their positive view on a web based system, it is indeed necessary to change the desktop system and replace it with a web based registration system.

The participants in the study opined that registering candidates using a web based registration system would improve efficiency. This assertion ties well with the literature reviewed which shows that using web based applications offers greater advantage over desktop applications. With the participants supporting the

development and use of a web based candidate registration system it gives confidence that this kind of system would be successfully implemented in Zambia, a developing country.

5.3 Business Process Mapping

The business processes that were mapped and the models that were designed in chapter 3 are discussed in this section. The candidate registration methods previously used by ECZ were reviewed in order to have a full understanding of how the registration of candidates has evolved over the years.

The first method used when the ECZ became operation was the manual method of candidate registration. The manual registration process was reviewed and challenges associated with the manual processes were identified. Secondly, the OMR registration method was reviewed to give an understanding of the processes involved, the challenges experienced. The change from the OMR registration method to the desktop application and the processes involved were also reviewed. It was established through the baseline study that although the registration process was automated, there were a number of manual processes that were involved and a number of challenges with the desktop application.

Having reviewed the whole candidate registration process, the business process was mapped and a web based registration application was seen to be a better solution. The architecture of the web based registration system utilises the cloud model with integrated bulk SMS. Bulk SMS offers advantage in that it is easier to reach many clients at low cost. Also using the cloud model entails that some of the huge ICT infrastructure costs are done away with as it becomes the responsibility of the cloud service provider.

5.4 System Implementation

In chapter 4 section 4.3 the implementation of the system that was presented will be discussed in this section.

The challenges that were faced with the desktop application such as cost, transportation of CDs, omission of candidates, duplication of entries, loss of data and the time it took to get the candidate registration data to ECZ can be reduced by automating the whole registration process which would cut off a number of intermediary processes. The web based candidate registration system implemented functionalities such as creating users, updating and deleting a user account, registering a candidate, updating a candidate record, deleting a candidate record, generation of reports and viewing candidate's records, generation of barcodes and printing of student identity cards with barcode.

The integration of the SMS facility was not fully implemented due to limitations and required more time to further investigate to ensure that all mobile service providers are integrated and users are able to send messages from their phones as well.

In this study, the development tools used were all open source as these were readily available at no cost. The tools used as discussed in chapter 4 were XHTML, PHP, CSS, Java Script, SQL, Apache webserver and MySQL as a relational database management system. The prototype shows how data can be centrally managed and received in real time as it is entered from the source.

The system requirements were derived from the previous and current candidate registration processes. The baseline study and the interviews with the key informants gave some insight of some of the changes envisaged in the registration process.

The web based system was tested firstly using the ECZ web server as a host while the second test was done using the purchased domain by the researcher for the purpose of the research study. The first test used real data so as to test the use of the system and the validations that had been put in place. The ECZ sponsored

the testing as an interested party in the web based system. The second testing used dummy test data to ensure anonymity of the candidates especially those for Grade 12 who use their Grade 9 numbers.

It can therefore be concluded that the web based candidate registration system is indeed a viable solution which would greatly improve the efficiency in the candidate registration process. Web based systems as we have seen offer a lot of efficiency and flexibility when it comes to management of the system as well as accessibility.

5.5 Conclusions

This study brought out a lot of important points concerning the challenges faced in the registration of candidates for school examinations in Zambia. The literature reviewed also gave a clear understanding of the challenges with desktop applications and some of the advantages web based applications offer which the ECZ could take advantage of, the cloud technology was also reviewed to have a clear understanding so that as the decision is made on the type of service to adopt. The whole candidate registration process was reviewed which helped to come up with the web based system to mitigate the challenges that were faced with the desktop application.

A baseline study was conducted to answer to research objective 1 which sought to establish the challenges faced with the registration of candidates in Zambia. The study confirmed that there were indeed challenges and that systems needed to be changed to ensure that there was efficiency in the whole registration process.

Various studies were reviewed to find out what challenges other examination bodies were facing in the registration of candidates or management of students records. It was discovered that in section 2.4 the challenges were similar in all the literature reviewed which made it easier to implement a similar solution that other examining bodies had or were in the process of implementing. In most of the examining bodies, a web based system was recommended or implemented.

The second objective was to map the business process and come with a model that would address the challenges established by the baseline study. In the mapping of the business process, the model that was designed encompasses the cloud model which integrates the bulk SMS system. These models are detailed in chapter 3.

The third and final objective was to develop a web based system for registering candidates for school examinations. This system was developed and implemented with the results of the testing clearly outlined in chapter 4.

From the results and discussions, it has revealed that a web based system for registering candidates is indeed a needed application in order to make the process more efficient and time-saving where more than 90 percent of the sample group agreed to that matter. This system will provide users with rapid access to information regarding the candidate and the system can be easily accessed via the Internet where it provides full support for simultaneous access of multiusers from dispersed locations. Other than that, the use of the database will also provide secured and controlled data management system, thus increasing the reliability of the entry data.

Suffice to mention that the system is being scaled up and will be implemented by the ECZ. Therefore, the advancement of this system will be kept in view for future implementation and improvement. Although as earlier alluded the integration of bulk SMS was not implemented, this will be implemented in the bigger picture of the application.

5.6 Recommendations

The study has revealed that the web based registration system is desirable and therefore this system should be fully implemented at all levels of school examinations as well as tertiary examinations.

The Ministry of General Education should engage ZICTA to encourage mobile service providers to cover areas that currently do not have network services so that centres in such areas could register candidates online in future.

It is recognised that Examination Centres which are in the far flung areas may face difficulties of access the system, therefore the Ministry of General Education should make arrangements so that nearby centres that have network and internet availability are used as registration centres. Alternatively, the DEBS office should be used as a registration centre for such schools.

The use of cloud computing services should be explored further by the Examinations Council of Zambia so that web based systems should utilise the cloud model proposed in this research.

5.7 Future Works

As a proposed future work on this system, the following points should be taken into consideration:

Short Messaging Service (SMS): this is a very important service the system must be included. Candidates or their Guardian’s cell-phone numbers must be stored into the system's database so as to come out with a subsystem that enables the system to send news to students, such as their examination dates, new regulations and their results.

Security: The second level user authentication for using biometrics should be included. In addition the use of CCTV in the registration rooms and GPS/GIS Location should be pursued further to enhance the security of the system in the cloud.

The system can further have an alternative fully fledged mobile application for popular and affordable mobile devices such as those that use the Android operating system

5.8 Summary

The study brought out important points on the fact that there were challenges in the mass registration of candidates or capture of data. These challenges were common even in other institutions that handle massive data. The participants all agreed to the fact that the many challenges that 'haunt' the registration of candidates for school examinations in Zambia could probably be resolved by developing an online / web based system which would eliminate the handling of data at the district level through consolidation. Since the web-based system would enable registering and storing candidate records centrally.

The proposed web system would cut down on some unnecessary processes thereby reducing cycle time. Turban et al., 2004 defines cycle time as the time it takes to complete a process from the beginning to the end [119]. Time is recognised as a major element that provides competitive advantage, and therefore cycle time reduction is a major business objective. A major contribution of this paper is in explaining the challenges of registration or capture of data which helped to come up with a solution that uses the current technologies to ensure efficiency in the whole candidate registration process. Many other sectors of education can also take advantage of the emerging technologies to ensure improved services even at an individual learner level. The results obtained show that in Zambia, there is also wide use of these ICTs which means that many other learners even in far flung areas can be reached.

As technology keeps on changing, it is important that systems are regularly updated. In this study, use of cloud computing has been proposed as it offers organisations flexibility to choose the type of cloud service that they want to implement at a low cost. Adoption of a hybrid cloud is proposed for this system so that confidential data are kept in the private cloud while non confidential data can be kept in the public cloud.

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Appendices

Appendix 1: Code Listing

Grade 7 Registration

```
include "conn.php";
conn();
session_start();
if (isset($_SESSION['username'])) {

    $centre_code_reg = $_SESSION['centre_code'];
    $short_exam_year = $_SESSION['short_exam_year'];
    $school = $_SESSION['school'];
      $short_centre_code = substr($school, 1, 1);
    $full_exam_year = '20'.$short_exam_year;

  //get details to display on header
  $sql = "SELECT TRIM(centre_code), centre_name, entry_type FROM
g7centre WHERE centre_code = '$centre_code_reg'";
  $result = mysql_query($sql);

   while ($row = mysql_fetch_row($result)){
          $centre_code_reg=$row[0];
          $centre_name=$row[1];
          $entry_type=$row[2];
          //disable entry type radio button
          if ($entry_type == 'I'){
            $disabled = "disable_i";
            }
          if($entry_type == 'E'){
            $disabled = "disable_e";
            }
     }

  //generate exam number
  $sql = "SELECT MAX(SUBSTRING(exam_no,9,4)) AS Serial,
COUNT(centre_code) FROM g7candidates WHERE centre_code =
'$centre_code_reg'";
   $result = mysql_query($sql);
   $count = mysql_num_rows($result);
   while ($row = mysql_fetch_row($result)){
   $serial1 = $row[0];
   $counted_centre_code = $row[1];
   //$short_exam_year = $_SESSION['exam_year'];

      if ($counted_centre_code < 1){
          $serial2 = '0001';
          $full_examno =
$short_exam_year.$centre_code_reg.$serial2;
        }
          else{
           $full_examno =
$short_exam_year.$centre_code_reg.$serial1 + 1;
          }
      }
```

```
   }
else
{
 echo "<script>document.location.href='index.php'</script>" ;
}
?>

<?php
if (isset($_POST['examno'])) {
    $exam_no  = $_POST["examno"];
    $count = "";


   //check if exam no is available
  $sql = "SELECT surname, other_names, centre_code,
COUNT(exam_no) AS count FROM g7candidates WHERE
exam_no='$exam_no' GROUP BY surname, other_names, centre_code";
   $result = mysql_query($sql);
   //$count = mysql_num_rows($result);
   while ($row = mysql_fetch_row($result)) {
         $surname=$row[0];
         $onames=$row[1];
         $centre_code_reg=$row[2];
         $count=$row[3];

         if ($count != 0){
              echo "<SCRIPT LANGUAGE=javascript>alert('THE EXAM
NUMBER ($exam_no) ENTERED IS ALREADY IN USE BY $surname $onames
OF CENTRE $centre_code'); location =
'g7registration.php';</script>" ;
        }
     }
  }
?>

<?php
 if (isset($_POST["register"])){

  //validate gender
 if (!isset($_POST['sex'])){
         echo "<SCRIPT LANGUAGE=javascript>alert('Please Select
Candidates Gender'); location = 'g7registration';</script>" ;
         exit;
}

       //populate variables
       $dobDay=$_POST["dobDay"];
       $dobMonth=$_POST["dobMonth"];
       $dobYear=$_POST["dobYear"];

       $centre_code_reg = $_SESSION['centre_code'];
       $username = $_SESSION['username'];
       $examno = $full_examno;
       $sname = mysql_real_escape_string(trim($_POST['sname']));
       $oname = mysql_real_escape_string(trim($_POST['oname']));
       $dob=$dobDay."/".$dobMonth."/".$dobYear;
       $nationality = $_POST["nationality"];
       $sex = $_POST["sex"];
         $phone = $_POST["phone"];
       $entry_type = $_POST["entry_type"];
```

```
        $sch = substr($_POST["sch"], 0, 4);
          $date_entered = date("d M Y h:i A");

        //get sen code
        if ($_POST["sen"]=='NOT APPLICABLE'){
            $sen = '-';
          }
          else if ($_POST["sen"]=='HARD OF HEARING'){
            $sen = '1';
          }
          else if ($_POST["sen"]=='HEARING IMPAIRED'){
            $sen = '2';
          }
          else if ($_POST["sen"]=='PHYSICALLY IMPAIRED'){
            $sen = '3';
          }
          else if ($_POST["sen"]=='VISUALLY IMPAIRED BRAILLE'){
            $sen = '4';
          }
          else if ($_POST["sen"]=='VISUALLY IMPAIRED ENLARGED
PRINT'){
            $sen = '5';
          }

        //get zambian language code
        if ($_POST["zamlang"]=='NOT APPLICABLE'){
            $zamlang = '-';
          }
          else if ($_POST["zamlang"]=='CINYANJA'){
            $zamlang = '1';
          }
          else if ($_POST["zamlang"]=='ICIBEMBA'){
            $zamlang = '2';
          }
          else if ($_POST["zamlang"]=='SILOZI'){
            $zamlang = '3';
          }
          else if ($_POST["zamlang"]=='CHITONGA'){
            $zamlang = '4';
          }
          else if ($_POST["zamlang"]=='LUVALE'){
            $zamlang = '5';
          }
          else if ($_POST["zamlang"]=='LUNDA'){
            $zamlang = '6';
          }
          else if ($_POST["zamlang"]=='KIIKAONDE'){
            $zamlang = '7';
          }

//upload image
if (!empty($_FILES['picfile']) &&
($_FILES['picfile']['error']==0)) {
  //$filename = basename($_FILES['picfile']['name']);

  $filename = $exam_no.'.jpg';

  $ent = substr($filename,strrpos($filename,'.')+1);
```

```
  if ( ($ent == 'jpg') && ($_FILES['picfile']['size']<=5000000)
){

          $newname = dirname('_FILE_').'/portraits/'.$filename;

          if (!file_exists($newname)){

move_uploaded_file($_FILES['picfile']['tmp_name'],$newname);
               }
           else {
                echo "<SCRIPT LANGUAGE=javascript>alert('Picture
already exists'); location = 'g7registration.php';</script>";
                exit();
            }

}
  else {

                  echo "<SCRIPT
LANGUAGE=javascript>alert('Invalid Picture: Either too big or not
in JPG format'); location = 'g7registration.php';</script>";
            exit();
   }
}

            // insert new record into database
        $sql = "INSERT INTO g7candidates(exam_no, surname,
other_names, dob, nationality, sex, entry_type, zam_lang, sch,
sen, centre_code, session, signature, username, date_entered,
phone)"
                                ."values ('$examno', '$sname',
'$oname', '$dob', '$nationality', '$sex',
'$entry_type','$zamlang', '$sch', '$sen', '$centre_code_reg',
'$short_exam_year', '', '$username', '$date_entered', '$phone')";

        $result = mysql_query($sql);

        if ($result){

                echo "<SCRIPT
LANGUAGE=javascript>alert('Candidate successfully registered');
location = 'g7registration.php';</script>";
              }
      else {
            die(mysql_error());
           }
    }
 mysql_close();
?>
```

UPDATE RECORD

```
<?php
session_start();

if (isset($_SESSION['username'])) {
    $username = $_SESSION['username'];
    $short_dcode2 = $_SESSION['short_dcode2'];
    $school = $_SESSION['school'];
```

```
        $short_centre_code = substr($school, 1, 1);
        //echo $short_centre_code;
}
 else
    {
       echo "<script>document.location.href='index.php'</script>"
;
    }
?>

<?php
include "conn.php";
conn();

if (isset($_SESSION['username'])) {
   $examno = $_POST['examno'];

       $surname = " ";
       $othernames = " ";
       $sex =" ";
       $dob = " ";
       $sen = " ";
       $sch = " ";
       $zamlang = " ";

   //retrieve item record for updating
   $sql = "SELECT ca.exam_no, ca.surname, ca.other_names, ca.sex,
ca.dob, ca.sen, ca.zam_lang, ca.entry_type, ca.sch,
ca.nationality, c.centre_name, ca.centre_code, ca.phone
   FROM  g7candidates AS ca, g7centre AS c
   WHERE ca.centre_code = c.centre_code
   AND ca.exam_no = '$examno'
   AND ca.username = '$username'";
   $result = mysql_query($sql);

   $count = mysql_num_rows($result);
   if ($count > 0) {
   while ($row = mysql_fetch_row($result)) {

             $exam_no= $row[0];
             $surname = $row[1];
             $othernames= $row[2];
             $sex= $row[3];
             $dob = $row[4];
             $sen1= $row[5];
             $zamlang= $row[6];
             $entry_type = $row[7];
             $sch =  $row[8];
             $centre_name =  $row[10];
             $centre_code =  $row[11];
                   $phone =  $row[12];
             $pic = $exam_no.'.jpg';
                   $real_pic = "<img height='100' width='100'
src='./portraits/$pic'>";

     //get sen description
     if ($sen1=='-'){
          $sen = 'NOT APPLICABLE';
      }
        else if ($sen1=='1'){
```

```
            $sen = 'HARD OF HEARING';
          }
          else if ($sen1=='2'){
            $sen = 'HEARING IMPAIRED';
          }
          else if ($sen1=='3'){
            $sen = 'PHYSICALLY IMPAIRED';
          }
          else if ($sen1=='4'){
            $sen = 'VISUALLY IMPAIRED BRAILLE';
          }
          else if ($sen1=='5'){
            $sen = 'VISUALLY IMPAIRED ENLARGED PRINT';
          }

    //get zam lang description
         if ($zamlang=='-'){
          $zamlang = 'NOT APPLICABLE';
      }
          else if ($zamlang=='1'){
            $zamlang = 'CINYANJA';
          }
          else if ($zamlang=='2'){
            $zamlang = 'ICIBEMBA';
          }
          else if ($zamlang=='3'){
            $zamlang = 'SILOZI';
          }
          else if ($zamlang=='4'){
            $zamlang = 'CHITONGA';
          }
          else if ($zamlang=='5'){
            $zamlang = 'LUVALE';
          }
          else if ($zamlang=='6'){
            $zamlang = 'LUNDA';
          }
          else if ($zamlang=='7'){
            $zamlang = 'KIIKAONDE';
          }

           $nationality = $row[9];
          }
    }
 else
   {
    echo "<SCRIPT LANGUAGE=javascript>alert('Candidate record not
found, please enter a valid Examination Number'); location =
'g7search.php';</script>" ;
    exit;
   }
}
?>

<?php
 if (isset($_POST["update"])){
     //populate variables
      $centre_code = $_SESSION['centre_code'];
      $examno = $_POST["examno"];
      $sname  = $_POST["sname"];
```

```
        $oname = $_POST["oname"];
        $dob = $_POST["dob"];
        $nationality = $_POST["nationality"];
        $sex = $_POST["sex"];
          $phone = $_POST["phone"];
        //$entry_type = $_POST["entry_type"];
        $sch = substr($_POST["sch"], 0, 6);
        $year = date('y');

        //get sen code
        if ($_POST["sen"]=='NOT APPLICABLE'){
            $sen = '-';
          }
          else if ($_POST["sen"]=='HARD OF HEARING'){
            $sen = '1';
          }
          else if ($_POST["sen"]=='HEARING IMPAIRED'){
            $sen = '2';
          }
          else if ($_POST["sen"]=='PHYSICALLY IMPAIRED'){
            $sen = '3';
          }
          else if ($_POST["sen"]=='VISUALLY IMPAIRED BRAILLE'){
            $sen = '4';
          }
          else if ($_POST["sen"]=='VISUALLY IMPAIRED ENLARGED
PRINT'){
            $sen = '5';
          }

        //get zambian language code
        if ($_POST["zamlang"]=='NOT APPLICABLE'){
            $zamlang = '-';
          }
          else if ($_POST["zamlang"]=='CINYANJA'){
            $zamlang = '1';
          }
          else if ($_POST["zamlang"]=='ICIBEMBA'){
            $zamlang = '2';
          }
          else if ($_POST["zamlang"]=='SILOZI'){
            $zamlang = '3';
          }
          else if ($_POST["zamlang"]=='CHITONGA'){
            $zamlang = '4';
          }
          else if ($_POST["zamlang"]=='LUVALE'){
            $zamlang = '5';
          }
          else if ($_POST["zamlang"]=='LUNDA'){
            $zamlang = '6';
          }
          else if ($_POST["zamlang"]=='KIIKAONDE'){
            $zamlang = '7';
          }

          // Update record
          $sql = ("UPDATE g7candidates SET surname = '$sname',
other_names = '$oname', dob = '$dob', sex = '$sex', nationality =
```

```
'$nationality', zam_lang = '$zamlang', sch = '$sch', sen =
'$sen', phone = '$phone' WHERE exam_no = '$examno'");
        $result = mysql_query($sql);

           if ($result){

                 echo "<SCRIPT LANGUAGE=javascript>alert('Record
Successfully Updated'); location = 'districtmenu.php';</script>"
;

               }
         }
 mysql_close();
?>
```

Generate Provisional Register

```
<?php
  session_start();

if (isset($_SESSION['username'])) {
  $username = $_SESSION['username'];
  $centre_code = $_SESSION['centre_code'];
  $d=$centre_code.'_'.'G7 PROVISIONAL
REGISTER'.'_'.date('d_m_Y');
  }
else
    {
       echo "<script>document.location.href='index.php'</script>"
;
    }
?>
<html>
<head>
</script>
<link rel="stylesheet" href="images/ecz.css" type="text/css" />
<link rel="shortcut icon" href="images/icon.ico" />
<title>ECZ OCRS</title>
</head>
<body>

<!-- wrap starts here -->
<div id="wrap">

      <div id="header-photo">

      </div>

      <!-- navigation starts-->
      <div  id="nav">
            <ul>
                  <li id="current"><a
href="districtmenu.php">Home</a></li>
                  <li id="current"><a
href="g7reports.php">Reports</a></li>
            </ul>
      <!-- navigation ends-->
      </div>
```

```
      <!-- content-wrap starts -->
      <div id="content-wrap" class="three-cojl"  >

            <div id="main">

     <?php
require('fpdf.php');
//$d=date('d_m_Y');

class PDF extends FPDF
{

function Header()
{
  $centre_name = $_SESSION['centre_name'];
  $centre_code = $_SESSION['centre_code'];
  $district_name = $_SESSION['district_name'];
  $province = $_SESSION['province'];
  $exam_year = $_SESSION['exam_year'];

if($this->PageNo()==1)
   {
    //Logo
    $this->Image('mylogo.jpg',10,6,30);
    $name="Grade 7 Provisional Register";
    $this->SetFont('Arial','B',12);
    //Move to the right
     $this->Cell(75);
    //Title
    $this->Cell(140,10,"ONLINE CANDIDATE REGISTRATION",0,0,'C');
    $this->Cell(-140,20,$exam_year . " GRADE 7 CANDIDATE
PROVISIONAL REGISTER",0,0,'C');
    $this->Cell(140,30,$centre_code.' - '.$centre_name,0,0,'C');
    $this->Cell(-140,40,$district_name . " DISTRICT " . ", " .
$province ." PROVINCE",0,0,'C');
    //Line break
    $this->Ln(0);
  }
}

//Page footer
function Footer()
{
 $count = $_SESSION['count'];
 $this->Cell(37,10, "TOTAL NUMBER OF CANDIDATES : " .
$count,0,0,'C');
 $this->Cell(-18, 30,"DATE VERIFIED :
_________/_________/_____________",0,0,'C');
 $this->Cell(200,30,"HEAD TEACHER'S FULLNAME / SIGNATURE
:_____________________________________________________",0,0,
'C');
 $this->Cell(15,30,"SCHOOL DATE STAMP
:_____________________________",0,0,'C');
 //}
 $this->Cell(0,50,'Page '.$this->PageNo(),0,0,'C');
}

//Load data
function LoadData($file)
{
```

```
//Read file lines
$lines=file($file);
$data=array();
foreach($lines as $line)
$data[]=explode(';',chop($line));
return $data;
}

//Simple table
function BasicTable($header,$data)
{

$this->SetFillColor(255,255,255);
$this->SetDrawColor(0,0,0);
$w=array(20,30,30,10,15,20,50,45,25,35);

//Header
for($i=0;$i<count($header);$i++)
$this->Cell($w[$i],10,$header[$i],1,0,'C',true);
$this->Ln();
//Data
foreach ($data as $eachResult)
{ //width
$this->Cell(20,15,$eachResult["exam_no"],1);
$this->Cell(30,15,$eachResult["surname"],1);
$this->Cell(30,15,$eachResult["other_names"],1);
$this->Cell(10,15,$eachResult["sex"],1);
$this->Cell(15,15,$eachResult["dob"],1);
$this->Cell(20,15,$eachResult["nationality_desc"],1);
$this->Cell(50,15,$eachResult["centre_name"],1);
$this->Cell(45,15,$eachResult["sen_desc"],1);
$this->Cell(25,15,$eachResult["option_desc"],1);
$this->Cell(35,15,$eachResult["signature"],1);
$this->Ln();
        }
    }
}

$pdf=new PDF();
$header=array('EXAM NO.','SURNAME','OTHER NAME(S)','SEX','DOB',
'NATIONALITY', 'SCHOOL OF CHOICE', 'SPECIAL EDUCATION NEEDS','ZAM
LANGUAGE', 'SIGNATURE');

$centre_code = $_SESSION['centre_code'];
$short_exam_year = substr($_SESSION['exam_year'], 2,4);

//connect to db
$objConnect =
mysql_connect("Chambeshi","sys_user","rWudPy4Dnr3UaQ4f") or
die("Connection to database failed");
$objDB = mysql_select_db("o_c_r_s14");

$strSQL = "SELECT DISTINCT ca.exam_no, ca.surname,
ca.other_names, ca.sex, ca.dob, na.nationality_desc,
CONCAT(g9.centre_name, ' [ ', g9.centre_code, ' ]') AS
centre_name, sen.sen_desc, opt.option_desc, signature
FROM g7candidates AS ca, sen, g7subject_option AS opt,
nationality as na, g9centre as g9
WHERE sen.sen_code = ca.sen
AND ca.zam_lang = opt.option_code
```

```
AND ca.sch = g9.centre_code
AND na.nationality_code = ca.nationality
AND ca.centre_code = '$centre_code'
AND ca.session = '$short_exam_year'
ORDER BY ca.exam_no";

$objQuery = mysql_query($strSQL);
$resultData = array();
for ($i=0;$i<mysql_num_rows($objQuery);$i++) {
$result = mysql_fetch_array($objQuery);
array_push($resultData,$result);
}
//************************//

function forme()
{
echo '<br/>';
echo "The Grade 7 candidate provisional register has been
successfully generated.";
  $ext = '.pdf';
  $url = '_____';
  $centre_code = $_SESSION['centre_code'];
  $d=$url.$centre_code.'_'.'G7 PROVISIONAL
REGISTER'.'_'.date('d_m_Y').$ext;
  echo "<SCRIPT LANGUAGE=javascript>window.open('$d',
target='_blank');</SCRIPT>";
}

$pdf->SetFont('Arial','',6);

//*** Table 1 ***//
$pdf->AddPage('L');
//$pdf->Image('mylogo.jpg',80,8,33);
$pdf->Ln(35);
$pdf->BasicTable($header,$resultData);
forme();
$pdf->Output("$d.pdf","F");

?>

            </div>

      <!-- content-wrap ends-->
      </div>

      <!-- footer starts -->
      <div id="footer-wrap"><div id="footer">


                  <p>
                        &copy; 2016 Online Candidate Registration
                  </p>

      </div></div>
      <!-- footer ends-->
<!-- wrap ends here -->
</div>
</body>
</html>
```

Appendix 2: Field Questionnaire

The University of Zambia

Questionnaire

Dear Respondent,

I am a student at the University of Zambia pursuing a Master of Science in Computer Science. As partial fulfilment for the award of a Master of Science degree, I am carrying out a study on**: Automation of the Candidate Registration for School Examinations in Zambia using the Cloud Model.** You are one of those who have been selected to participate in this study. This study is strictly for academic purposes and your responses will be treated with strictest confidentiality.

Instructions

Please **Tick** or **Write** your appropriate answer.

Thank you in advance for your time and cooperation

Section A: Personal Demographic Data

1 What is your Sex?

(a) Male ☐

(b) Female ☐

2 How old were you on your last birthday? ☐

3 What is your highest level of education?

(a) Certificate ☐

(b) Diploma ☐

(c) Degree ☐

(d) Master Degree ☐

(e) Doctorate ☐

(f) Others Specify…….

4 What is your occupation?

(a) Teacher ☐

(b) Examination Officer ☐

(c) Education Standards Officer ☐

(f) Others Specify…….

5 What is your occupation?

(a) Teacher ☐

(b) Examination Officer ☐

(c) Education Standards Officer ☐

(f) Others Specify…….

6 What is the Category of your institution?

(a) Primary School ☐

(b) Secondary School ☐

(c) District Education Officer ☐

(d) Provincial Education Officer ☐

(e) Others Specify…….

7 Province Name:……

Section B: Challenges with the Electronic Candidate Registration System (ECRS)

Section A: Personal Demographic Data

1 Give a brief description of the activities /registration process at your school/District/Province

……..

……..

……..

2 What challenges are you having with registration of candidates using the ECRS?

……..

……..

……..

3 What solutions would you recommend to help reduce the challenges the ECRS candidate registration system is facing?

……..

……..

……..

4 What solutions would you recommend to help reduce the challenges the ECRS candidate registration system is facing?

……..

……..

……..

Section C: Access to Internet services

1 Do you use internet?

Yes ☐ No ☐

2 How do you access internet?

Personal Mobile Devices (e.g. Phones, Tablets, Dongles) ☐

Through place of work (internet for employer) ☐

Public Wi-Fi (e.g. iConnect, I-Zone, Wifi at Shopping Mall) ☐

Internet Café ☐

3 Which Mobile phone provider is available in your area??

Airtel ☐ MTN ☐ Zamtel ☐

Section D: Developing Web based Candidate Registration System

1 Do you think that registering candidates using a web based candidate registration system would improve efficiency in the candidate registration process?

Yes ☐ No ☐ Not sure ☐

2 Would you recommend using a web based candidate registration system for registering candidates for school examinations?

If yes, why would you recommend the use of a web based candidate registration system?

……...

……...

If no, why would you not recommend the use of an online candidate registration system?

……...

……...

Thank you for your time and cooperation.

Appendix 3:

Interview Guide

1 Briefly describe the current registration process and the methods previously used by ECZ for registering candidates for school examinations.

2 What do you think are some of the challenges of using Electronic Candidate Registration System (ECRS)?

3 What do you think are some of the possible solutions to the challenges you have highlighted above?

4 What are some of the broader challenges in registering candidates for national examinations apart from the one you have mentioned above?

5 Do you think that it would be necessary for ECZ to develop a web based registration system so that candidate registration is online?

6 If Yes, why do you think that it is necessary to ECZ to do that?

7 If No, why do you think that it is necessary to ECZ to do that?

8 What are some of the features you would want to see in the web based candidate registration system?

9 Do you think it can help reduce the challenges the current system is facing?

10 Lastly what would be your recommendation in general on how to improve efficiency and effectiveness in registering candidates for national examinations?

Many Thanks for Your Time and Support

Appendix 4:

System Testing Form

Web Based Candidate Registration Pilot Data Collection Form

Date:	___/___ /_____

Province:	
District:	
School/Centre:	
Centre Code:	
Level:	
Team Members:	**1.** **2.** **3.** **4.** **5.**

Task	Response			Comment
1. Network available *(tick applicable)*	MTN ☐ Zamtel ☐ Airtel ☐			
2. Access to the web Application?	Yes ☐ No ☐			
3. Online website speed tester www.speed.io *Note: Press "Start Speedtest"* *Take note of "**Download**" and "**Upload**" speeds under "**Measured Data**:"*	Time (hrs.)	Download Speed	Upload Speed	
	08:00 -12:00			
	12:00 - 14:00			
	14:00 - 17:00			
4. Preferred network based on performance.	MTN ☐ Zamtel ☐ Airtel ☐			
5. Entry of 50 candidate's	All 50 Registered: ☐			

6. System responsiveness	Good ☐ Fair Poor ☐ ☐	
7. Able to update candidate records?	Yes ☐ No ☐	
8. Reports tested *(tick tested reports)*	Candidate Provisional Regi ☐ Entry Summary By Centre ☐ Entry Summary By District ☐ Entry Summary By Provinc ☐ Special Education Needs ☐ Entry Summary By Gender ☐ Centre Subject Totals ☐ Payments Report ☐	
9. General feel of Candidate Registration Web application (i.e. error handling messages, ease of use, navigation etc.)	**Comments:**	
10. Other observations and comments.	**Comment:**	

Centre Representative: .....

Signature: .....