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# A Secure end to end verifiable e-voting system using cryptography: a case of Independent Electoral and Boundaries Commission of Kenya

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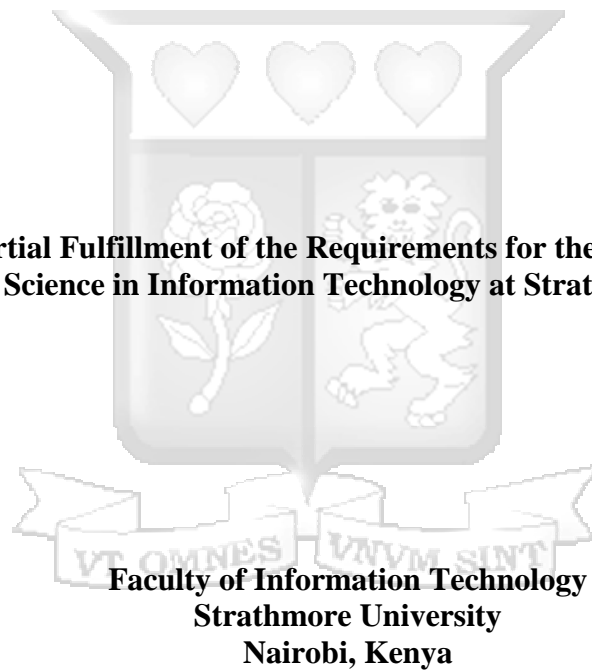
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**A secure end to end Verifiable E-Voting System Using Cryptography: A Case of  
Independent Electoral and Boundaries Commission of Kenya**

**William Magonga**

**Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of  
Master of Science in Information Technology at Strathmore University**



**Faculty of Information Technology  
Strathmore University  
Nairobi, Kenya**

**JUNE, 2019**

## Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

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William Magonga

Adm No. 094965

Signature ..... Date .....

## Approval

The thesis of William Magonga was reviewed and approved for examination by the following:

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## DEDICATION

This work is dedicated to my dear family without whose love and support I would not have been able to complete this work.



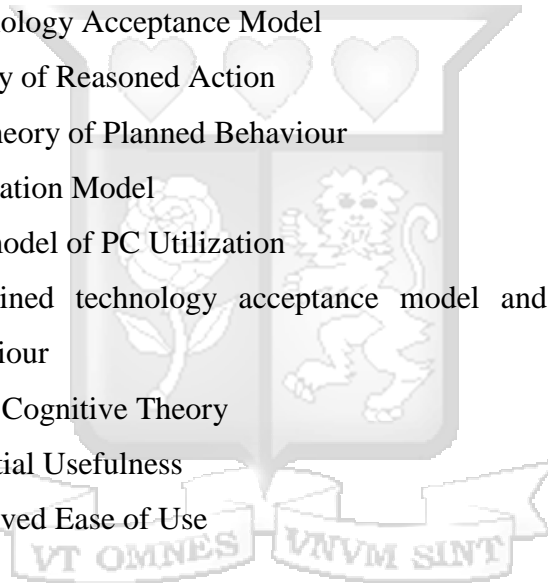
## **ACKNOWLEDGEMENT**

This study wishes to appreciate the great sacrifice, commitment and support of my supervisor Dr. Vitalis Ozianyi. I further appreciate the good work and support of the management of IEBC for allowing the research project to be conducted in their organization. I significantly wish to acknowledge my advisor DR. James Muya (Director Kisii University – Nairobi Campus) for taking their time to correct, advice and guide me in this study.



## LIST OF ABBREVIATIONS

<b>EVS</b>	Electronic Voter Security
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>VVPB</b>	Voter verified paper ballot
<b>AFT</b>	Advanced File Transfer
<b>IDC</b>	Interdisciplinary Center
<b>EVM</b>	Electronic Voting Machine
<b>RFID</b>	Radio-frequency identification
<b>UTUAT</b>	Unified Theory of Acceptance and Use of Technology
<b>IDT</b>	Innovation of Diffusion Theory
<b>TAM</b>	Technology Acceptance Model
<b>TRA</b>	Theory of Reasoned Action
<b>TPB</b>	The theory of Planned Behaviour
<b>MM</b>	Motivation Model
<b>MPCU</b>	The model of PC Utilization
<b>C-TAM-TPB</b>	Combined technology acceptance model and the theory of planned behaviour
<b>SCT</b>	Socio Cognitive Theory
<b>PU</b>	Potential Usefulness
<b>PEOU</b>	Perceived Ease of Use

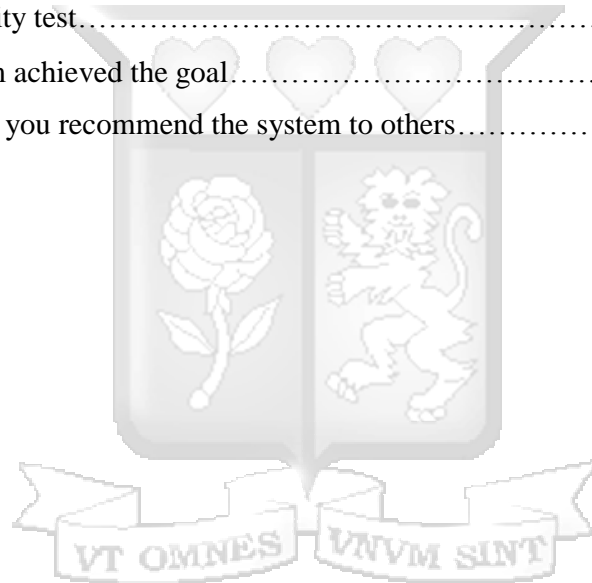


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## ABSTRACT

Elections that are run purely on manual voting system have presented a plethora of challenges that have often affected the credibility of elections done entirely using the traditional manual voting system. Countries round the world are quickly shifting to the use of e-voting systems with such nations already reaping the benefits of running their elections using e-voting systems. However, a number of countries especially in the developing world are yet to embrace a full e-voting platform and this has often affected the election outcomes in such countries. This study sought to evaluate the use of electronic voting systems to address the electoral malpractices in elections. The study proposes an e-voting system that employs a java enterprise application standard which makes use of the tiered design pattern allowing for scalability using distributed approach. All components are an extension of the server to the client machine, allowing for dynamic content delivery. Voters are only allowed to vote once. After voting, the user identity is flagged to prevent another attempt. Any further attempted logins will be denied access. Communication between the client machines and the servers are secured preventing eavesdropping or snooping on the user's identity in transit. Further once the data is delivered to the server, the application environment also provides added layer of security ensuring that only authorized personnel have permission to view data. To further enhance security all user actions on the client terminals are relayed to the server based on event response model. Security logs can be generated based on user activity which can only be viewed by users with administrative rights. The system uses two different databases. The electoral process that involves capturing data is managed using election database. The security aspect that involves starting/stopping the election, managing and viewing of security logs is managed using a security database. Both of them run on MySQL platform. This platform was used because of its compatibility with PHP and other platforms as well as the ability to encrypt passwords before storage. This ensures that confidentiality and integrity aspects are enforced.

## **CHAPTER ONE: INTRODUCTION**

### **1.1 Background of the study**

Traditional manual voting systems are becoming too unsustainable in the current world where processes are now being automated as a result of advancements in the technology arena. Voting is shifting into an electronic form with nations that embrace e-voting already enjoying the numerous benefits that are associated with developed e-voting systems (Aamaral, et.al, 2016). Across the world, several E-voting models have been developed as alternatives to traditional manual voting systems. The urgency to make significant changes in how elections are conducted across different countries has been necessitated by a plethora of the numerous challenges manual voting systems have presented which includes time consuming procedures, tedious processes and cumbersome vote tallying phases (Aboelnaga &Hussein, 2013).

In a majority of countries that are still developing, elections are still conducted entirely by traditional methods of voting often paper ballots in contrast to developed countries that have embraced E-voting systems (Yatin,Sameer, Vinaye, & Sheeba, 2012). A burgeoning body of current literature suggests that in societies where manual voting is the norm, election malpractices such as vote rigging, ballot stuffing and blatant theft are highly evidenced (Kiayias, Zacharias, & Zhang,2017). Countries that still use manual voting systems have therefore being urged to make a shift into e-voting systems to address the numerous challenges presented by traditional manual voting systems. Manual voting systems are also well known for the common counting errors and in certain instances voters have been able to vote more than once thus causing irregularities in the final process of counting votes (Ebaid,Hayajneh, Al-Jarrah, Malkawi,&Khasawneh, 2008).

Existing studies show that when electronic voting is carefully designed and implemented, the process of polling and voting becomes more secure, confidential, sincere with significant reduction in costs, materials, logistics and an availability of instantaneous vote analysis and reporting (Jegade et al., 2012). E-voting systems aim at improving participation in elections and increasing outcomes of elections by providing solutions to impediments and challenges encountered in traditional voting practices. Electronic voting

suppresses unwanted human errors and results in significant cost reductions in the vote tallying process (Ojo & Adeshina, 2014).

Evidence exists of the use of E-voting systems around the world. In Europe, e-voting systems in countries such as Norway, Spain and Belgium have brought huge efficiencies in the election processes (Stenbro, 2010). In the United States, e-voting has become the standard procedure for conducting and reporting election outcomes. The developing countries of South America and Asia are also witnessing a growth in popularity of the use of e-voting systems in conducting elections (Ebaid, 2014). On the African continent, a majority of the countries still use manual voting systems and as a result, disputes in election outcomes are common often leading to unrests, mass protests and wars due to bungled elections. In Kenya in particular, bungled elections such as the 2007 general election did unwarranted damages to this promising country (Mozibuko & Nyuykonge, 2017). Elections up to then had been purely manual and needless to say, the country had witnessed an elongated list of challenges top among them electoral malpractices and rigging that for a long time haunted the electoral process in the country. In 2013 and 2017 however, the country begun making baby steps towards use of e-voting systems although the country is yet to witness a fully automated electoral process that is wholly run using an E-voting system (Mutiga, 2017).

## **1.2 Statement of the Problem**

Elections in Kenya have up to now used traditional manual voting systems to conduct most or all the processes of elections. The recent advancements in the elections of 2013 and 2017 (Carter Center Report, 2017) made advances of using technology in the election but such technologies used were merely in the identification of voters and transmission of results. Everything else was done manually leaving the country to the wide array of challenges that are encountered whenever manual voting systems are used. It comes as no surprise then that most of the election outcomes in Kenya have always been greatly contested and often on valid grounds. Election malpractices due to manual voting in Kenya have been witnessed such as stuffing of ballot, rigging, and a lack of transparency which has often led to the electoral process being shrewd in mystery (Carter Center Report, 2017). The elections body has frequently been accused of doing a shady job, often leading to a high

number of court petitions seeking the nullification of electoral outcomes. This is just an opening of the lid of what ails elections in Kenya.

The process of tallying and tabulation of final voting results in Kenya suffers from a lack of transparency and delays which is further exacerbated by political tensions and open confrontations by political leaders. The electoral process has frequently been accused, often with enough evidence, of having massive fraud and a hacking of election results (Carter, 2017). There is biasness, often openly, in the election process with powerful elites often manipulating the electoral process to have their preferred candidates win elections. This has resulted in elections in Kenya becoming hotly contested affairs that are either a do or die affair. Sadly, those who have refused to tow the line have either lost their lives or been bungled out of office for lack of cooperating.

The challenge to the Kenyan elections is majorly ascribed to the heavily manual system of voting. Voters still have to manually use and cast their ballots and the process of counting is entirely manual. This has made the system easy to manipulate due to a number of available loopholes in manual voting systems. There is enough existing literature that Kenya has borne a great price both financially and humanly as a result of having an electoral process that is highly manual and the electoral malpractices have threatened to steer the country on a path of self-destruction. As a remedy to this situation, this study seeks to evaluate the use of an E-voting system to address the plethora of problems that have bedeviled a heavily manual voting system in Kenyan elections.

### **1.3 Research Objectives**

- i) To establish the challenges encountered in manual voting systems in elections in Kenya.
- ii) To design an e-voting that can be used in general elections in Kenya.
- iii) To test the proposed new electronic voting system and assess its effectiveness in conducting elections.

#### **1.3.2 Research Questions**

- i) What are the challenges encountered in manual voting systems in elections in Kenya?
- ii) Which e-voting system design can be used to manage general elections in Kenya?

- iii) How does the proposed new electronic voting system work and how effective is it in conducting elections?

#### **1.4 Justification of the Study**

This study offers a system that can be used to conduct elections in Kenya as a way of curbing inefficiencies in elections and ensuring sustainable elections outcomes. The system offers a reference to other nations that are yet to transit into e-voting of a working system that can be used to conduct elections. The study informs policy makers and the government of policy factors to consider that promote the adoption of an e-voting system to curb election fraud. This study also adds to the existing body of knowledge on the same topic and offer a point of reference for scholars and researchers on the same field.

#### **1.5 Scope of the Study**

This study focuses on establishing the challenges of manual voting in Kenya and identifying the potential benefits of adopting the use of e-voting systems to run elections in Kenya. The study focuses on designing an e-voting system that can be used to curb inefficiencies in elections and ensure sustainable election outcomes in Kenya.

#### **1.6 Limitations of the Study**

A lack of sufficient body of knowledge on similar studies done in Kenya may limit the available literature and material for the study. The researcher however referred wide and used more studies done outside Kenya to curb this shortcoming. It is imperative for the researcher to beware that resistance to change may be an obstacle to use of a designed e-voting system in elections in Kenya.

## CHAPTER TWO: LITERATURE REVIEW

### 2.1 Introduction

This section presents literature related to electronic voting. A theoretical review with relevant theories presented followed by empirical literature. The chapter concludes with a conceptual model for the study.

### 2.2 Concept of E-Voting

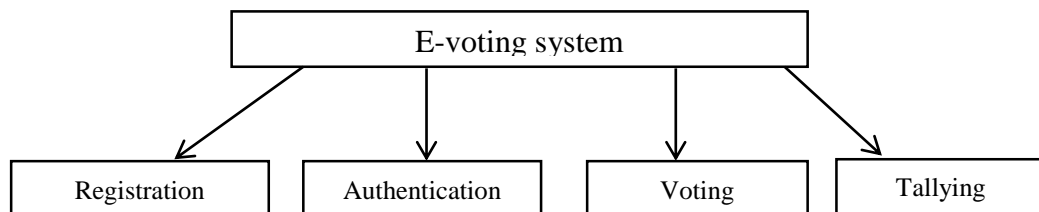
According to Qadah and Taha (2007), electronic voting refers to the use of modern technologies such as computers for the identification, verifiability, casting, transmission and presentation of votes in an election.

Sæbøet et al., (2008) define electronic voting to be a process in which citizens, politicians and public institutions carry out such an activity within the boundaries of certain factors such as availability of information, infrastructure and accessibility to technologies, which result some effects such as civic engagement, deliberations and democracy.

Everett et al., (2008) define electronic voting as any kind of system in which voters cast their ballots using an electronic system as opposed to a ballot paper. E-voting encompasses presence of voting machines at polling stations. Upon recording, electronic votes are then digitally stored and moved from all electronic machines used for voting to a tallying system that is centrally placed.

#### 2.2.1 E-Voting Basic Requirements

The basic E-voting system is generally standardized although different types of protocols and e-voting systems have been developed. According to Talab and Ameen (2005), any system for e-voting should include the key actors who are voters, registration authority, tallying authority, registration, authentication and authorization, voting and tallying. Figure 2.0 below illustrates the phases of an e-voting system.



**Figure 2.1 Phases of an e-voting system**

According to Gritzalis (2002) e-voting can be classified into three major categories which are software, hardware and human attributes. Security relevant factors for hardware entail

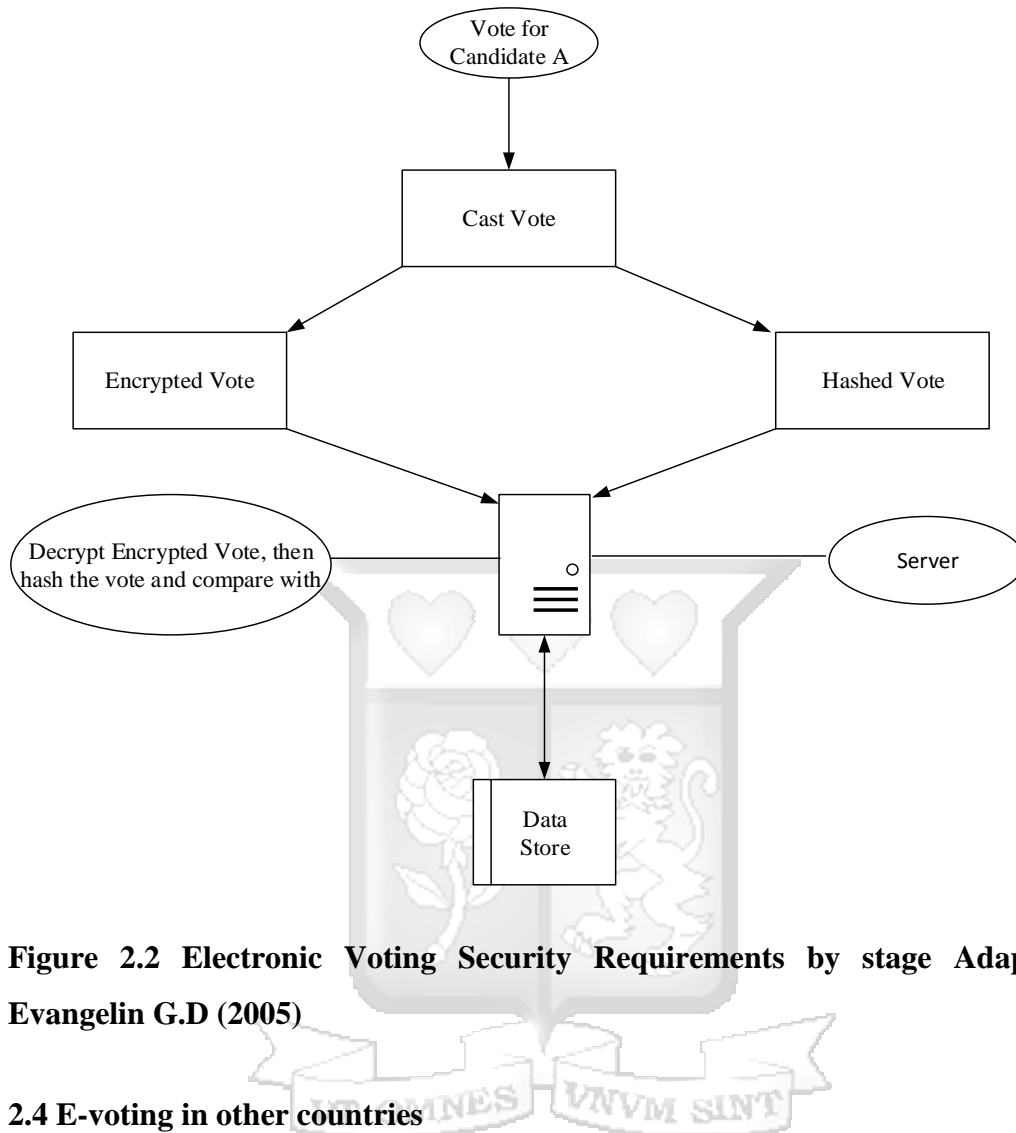
the electrical and mechanical parts; software security elements include programs, databases, compilers, drivers, procedures and sequences and the human factors includes usability, politics, transparency, acceptance and trust.

The pre-voting essential requirements have to ensure proper authentication to ensure that a chosen voter is the one doing the actual vote casting. The system needs to also ensure that voters are able to select the person of their choice in the election. The system must also allow only eligible voters to vote and there should be no requirements to possess special skills and knowledge prior to voting (Karro & Wang, 2009).

### **2.3 Electronic Voting Security Requirements**

Any voting systems have security and accuracy at the most crucial factors that have to be incorporated into the system. According to Gina et al., (2010), EVS should satisfy certain security requirements. Eligibility makes sure that voters that are authorized are the ones who actually vote. Uniqueness prevents voters from voting more than once, and privacy protects the secrecy of the person who is voting. Integrity of the e-voting systems protects the security of the whole voting process and protects the system from being manipulated by outside parties. Additionally, the votes should not be duplicated by anyone in a good e-voting system. Accuracy guarantees the voter that their cast ballot matters and will be taken into consideration in the final tabulation of votes.

According to Moayed et al., (2008), to achieve the security features required in an e-voting system many security schemes are provided. The use of blind signatures and cryptography is a popular method that is used to encrypt votes and voting receipts. Receipts that are part of the ballot can also be encrypted using mix-net based scheme and a hemimorphic method can be used to protect the information of the voter and the content in the ballot.



**Figure 2.2 Electronic Voting Security Requirements by stage Adapted from Evangelin G.D (2005)**

#### **2.4 E-voting in other countries**

Globally, manual and paper based voting processes are gradually being replaced by e-voting systems. India and Brazil which are the two most populous world democracies were among the first to use voting systems that are automated (Kumar, 2008). Thompson (2009) notes that the major motivator for the use of e-voting systems is due to the potential they have in boosting the level of confidence in an election process. Many countries in the world are currently adopting the use of e-voting systems and this includes Belgium, the Philippines, Norway, Pakistan, United States of America and Estonia.

However, some countries are actually moving away from the use of e-voting systems. For instance, the Netherlands went back into manual voting systems in 2008 despite having used e-voting systems for a number of years. German also banned e-voting systems it was

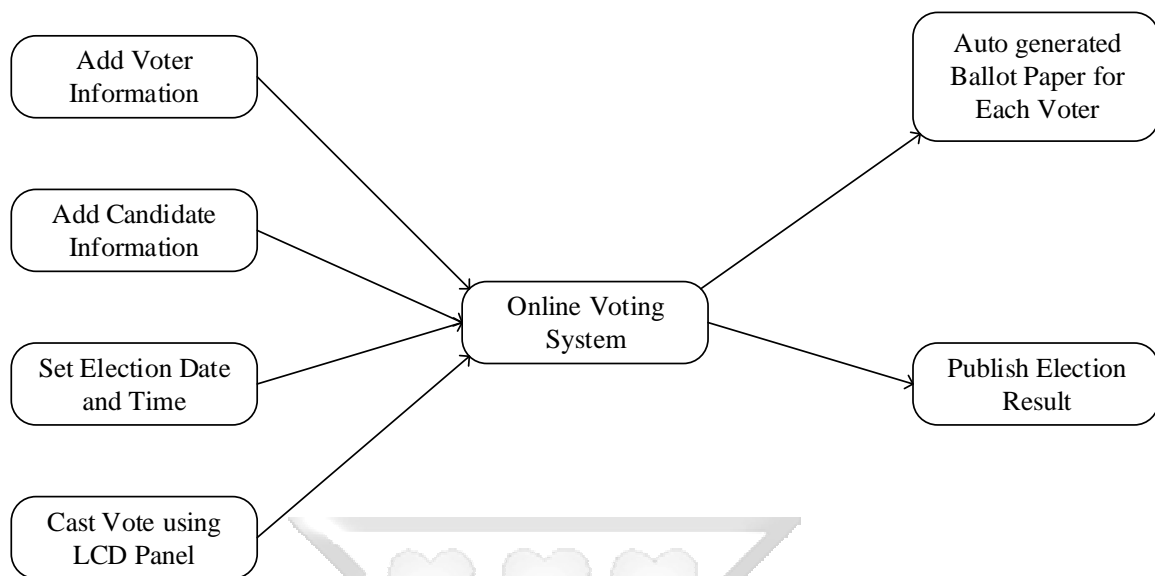
using in previous elections. Ireland spent hugely on e-voting systems that ended up just as pilot tests. The worldwide experience in the use of e-voting is therefore mixed when considering the adoption, non-adoption or adoption is preceded with abandonment (Goldsmith, 2011).

### **2.4.1 E-Voting Models**

Various types of E-voting models that have different security features have been used around the world.

#### **2.4.1.1 ElGamal Cryptosystem**

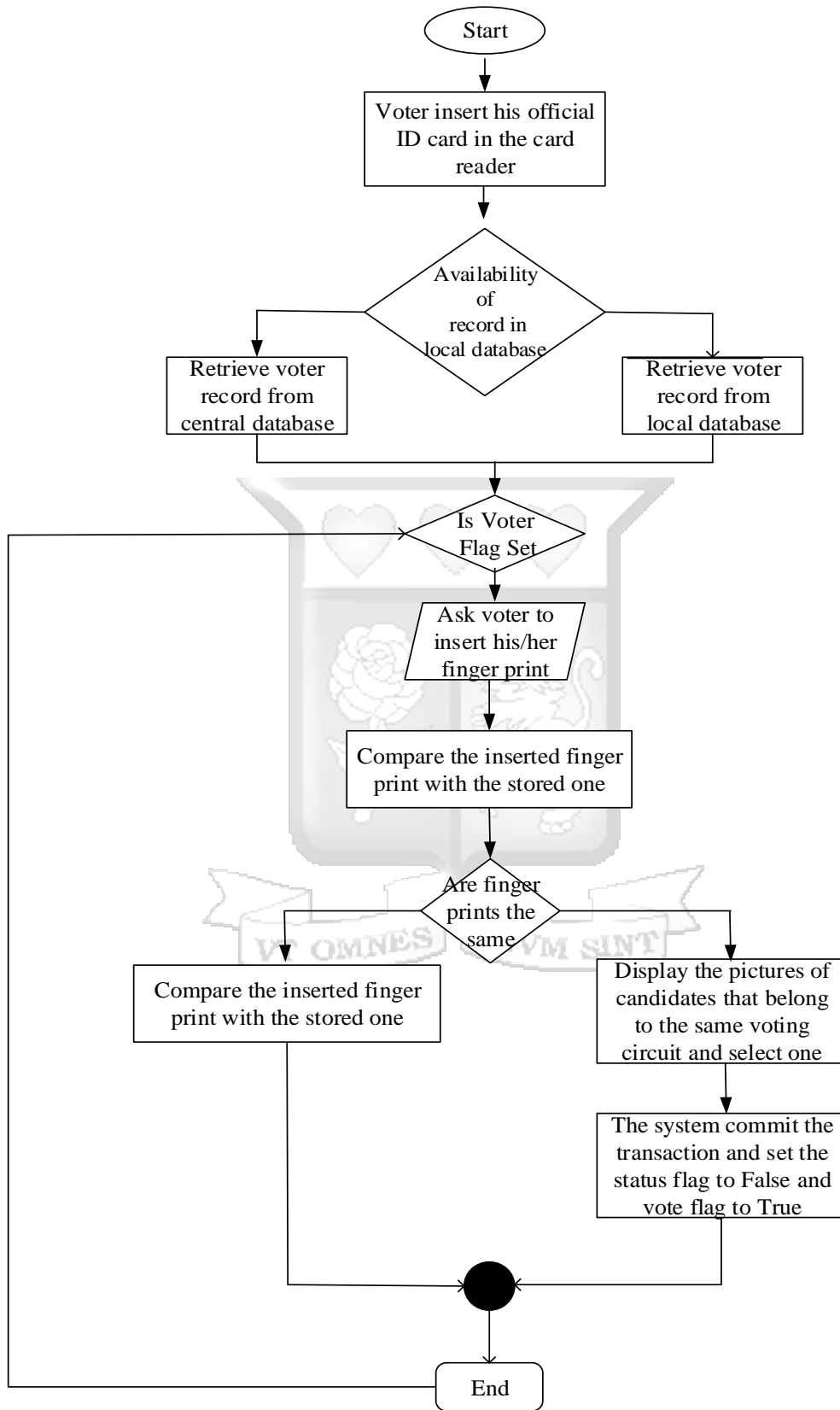
Thammawaj and Lertwatechakul (2008) developed an e-voting system that used ElGamal cryptosystem coupled with printing that is secure as a way of enhancing the verifiability property for users. The e-voting model aimed at providing voters their privacy, safety, verifiability and correctness in the voting process. Qiu and Zhu (2009) presented electronic voting systems that were based on distributed Pailler's encryptions. Standard cut-of-the-choose techniques were used by the system to prevent computational zero knowledge proofs and showed that the system was more secure when a simulation of the model was done. Nishino et al., (2010), employed the use of touch panel haptic display in designing and developing an e-voting model that had straight forward touch sensations. The e-voting model easily confirmed, selected and allows the voter to vote for their preferred candidate easily with little assistance.



**Figure 2.3 ElGamal Cryptosystem Model (Adapted from Cranor, L., 2011)**

#### **2.4.1.2 Electronic Voting and counting system (eVACS)**

The Electronic Voting and Counting system (eVACS) was implemented by an Australian company in 2003 in a pilot group of eight polls. The eVACS voting system essentially had two major parts namely, voting electronically and counting of votes electronically. Individual steps in the development of the model went through verification by officials from the independent electoral body. Computers were used as voting terminals which connected to a network that acted as servers for polling centers, vote recording and provision of information were used. Bar code readers were used by the system to cast each vote and reset the PC. As a security measure, no connection to external network was done and after conclusion of polling, physical transportation of the votes to the counting (back-end system) using duplicate zip disks (ACTEC, 2004). Mercuri (2002) developed the Mercury method of E-voting under the IEEE Project 1583. In the model, there was intensive use of voter verified paper ballot (VVPB) in the actual process of counting of votes but machines were used to cast the vote.



**Figure 2.4 Electronic Voting and counting system (eVACS)**

### **2.4.1.3 Biometric-Secure E-voting system**

Ebaid et al., (2008) proposed a system of e-voting that had the capability of handling electronic ballots with different scopes such as presidential, parliamentary municipal among others simultaneously. The biometric e-voting system addressed both functional and non-functional needs. Functional needs addressed by the e-voting platform include embedded in the system a system ensuring the identification and security of voters by combining simple biometrics. This systems ensures that no votes are in favor of a particular candidate are mishandled as a result of errors in the tallying of votes through the use systems FLAG's. The system allowed voting to take place through a transparency manner to ensure voters were able to vote for candidates of their choice.

The proposed system works very similar to the biometric-secure E-voting system. However there are some differences. The proposed system checks to verify that each vote casted is not altered while in transit. This is mainly because transmission of votes is encrypted. The process involves comparing the result of each unique identity by comparing the encrypted vote to the hashed vote. The encrypted vote is decrypted and then hashed. If the hashed result matches with the hashed function sent during voting, the system would automatically update the user's vote by incrementing one, else, the vote would be regarded as to have been hacked while in transit, hence, vote would not be counted for the voter.

### **2.4.1.4 Mosaic Component of E-voting**

Takoua (2012) propose a Mosaic based system for e-voting that works by using AFT security protocol. The system integrates a system for managing elections with external events that are likely to arise as a way of both detecting and making recoveries from system failures and security attacks during run-time. The system allows for parallelization of tasks that minimizes processing times and ensures its scalability. The Mosaic system encompasses two different layers: the functional layer that has the Mosaic servers and a management layer that encompasses an administrator component. Both layers in the system are designed as composites that contain sub-components that have been constructed through the use of the same component model (Bruneton, Coupaye, Leclercq, Qu'ema,& Stefani,2004).

#### **2.4.1.5 Wombat Voting System**

The Wombat system of voting was designed by Alon Rosen, Jonathan Ben-Nun and Amnon Ta-shma among others and used for elections in Israel at the Interdisciplinary Center (IDC). The system is a variant of the Helios system in which the ballots are encrypted and published in a bulletin board adjacent to the name of the voter that used the system to cast a ballot. In the system, a voter presents the identification card, enters the voting booth, voter casts an encrypted ballot, the encrypted ballot and original serial number then becomes the receipt that the voter receives as proof that he/she voted. After the voting process has been completed, data from the bulletin board is relayed to a mix net and decryption is done by a group of trusted people (Vogt, Truderung, & Kusters, 2012).

#### **2.4.1.6 Smartmatic E-Voting System**

The Smartmatic electronic voting system is currently in use in Venezuela and the Philippines. The system comprises of hardware such as printer, touch screen and voting machines and software (electronic management software) together with software for canvassing for central location servers. The Smartmatic system has been found to ensure that the phase of election is conducted with maximum security and accuracy that includes use of public key infrastructure to do encryption. Additionally, the method uses biometric voter identification using fingerprints to authenticate voters before they are allowed to vote. This system of voting also has number of capabilities such as multiple auditing at different stages, receipts of the vote transmission that is secure, redundant storage capacity and advanced mechanism of recovering data (Yatin et al., 2012).

#### **2.4.1.7 U-Vote E-voting System**

The system was designed by Youssef and Abdelkader (2012), and the system is an incoercible, verifiable and ubiquitous system and works as a front end which is different from the existing e-voting systems by offering the voter a solution that is convenient for voting and safeguarding the cast votes. The system allows voting to be done from different gadgets and communication technologies such as cell phones. The system protects users from malware on the devices of users, use of coercion and selling of votes.

## 2.5 E-voting Challenges

According to Benaloh and Tuinstra (2004), e-voting systems present various kinds of challenges. A failure to carefully plan and design an E-voting system will undermine the confidence in the entire electoral process. Any process in which there exists a probability of threats to the integrity of a system must be met with a lot of caution and suspicion. A major reason why any security threats to an e-voting system possess great challenge is because in the event of a successful attack, the situation will be extremely high profile (Talab & Ameen, 2005).

Hari et al., (2009) did a study on electronic voting systems in India and focused on the Indian Electronic Voting Machine (EVM). The study established that in spite of the simplicity of e-voting machines; they are still open to attacks that may change the results of an election. The study further established that inside officials who are attackers can use hardware that is portable to illegally access and change votes that are stored in the memory of the machine. Such attacks would be successful because of lack of cryptography to safeguard the data of cast votes internally in Electronic Voting Machine (EVM).

A study by Thakur (2013) found that the use of e-voting systems does not take place in a sudden way or go through an immediate switchover. Instead, the process occurs in various phases that give voters a chance to register their votes in e-voting systems. The study further established that countries that have recorded successful e-voting use did so in a phased manner that had transparent trials, pilots and then the actual full system implementation. A study by Goldsmith (2011) identified variables that influence a nation to use e-voting systems. The study established that challenges of paper ballot movement in large countries use e-voting because of logistical benefit it offers.

Gupta (2011) identified technology challenge as the biggest impediment to the deployment and successful use of e-voting technologies. Change management was identified to be important both in terms of cultural change, operations and process offered by e-voting. Gupta (2011) further identified transparency a key factor in trust building and maintaining the integrity of the voting process.

A study by Kumar et al., (2011) established that e-voting saves costs, even though implementation of the e-voting system is costly at the beginning. The study established

that subsequent use of the e-voting system in subsequent elections turns out to be cheaper than voting systems that are entirely manual.

## **2.6 Securing E-voting Process and Data**

According to Essths (2012), secure e-voting systems have to meet certain security features which include; voter privacy, resistance to coercion and universal verifiability. Privacy protects the secrecy of who cast the vote and for whom, resistance to coercion ensures that no one manipulates the system and universal verifiability ensures that the whole process can be audited at whatever stage.

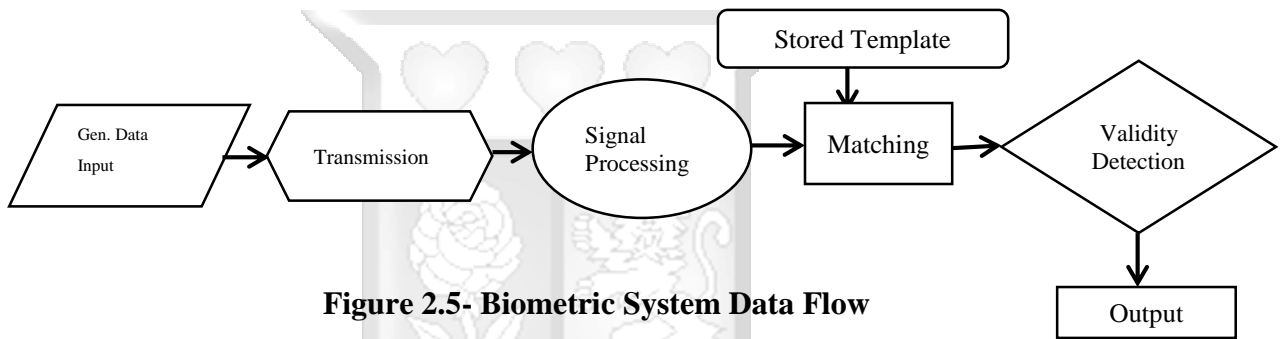
Takoua (2012) did a study on Building reliable security systems focusing on an e-voting system in Tunisia. The study found out that e-voting systems are prone to complex severity challenges because of issues of scalability especially when those who are using the system are key when there is failure in the system. The study further established that using component based security architecture provided better security features for e-voting systems and improved performance of the system.

Vogt et al., (2012) did a study on Clash Attacks on the Verifiability of E-Voting Systems in Germany. The study raised awareness of simple attacks on e-voting systems that they referred to as clash attacks and established that even though clash attacks are quite simple, under reasonable trust assumptions it applies to various e-voting systems. The study provided counter measures for each of the systems in the study that were based on Helios. Yatin et al., (2012) in their study on Electronic Voting models developed a better security framework for use in Mauritius. The study proposed an e-voting system model that aimed at availing a secure architecture for use in Mauritius. The study discussed different e-voting models and further analyzed two models. The study concluded by enhancing existing models for it to be successfully integrated into the Mauritian context successfully.

Aboelnaga and Hussein (2013) did a study on designing a secured E-voting System. The study established that e-voting systems were becoming popular as a result of the wide spread use of developments in computers and other technologies. The study established that security is essential part of the e-voting system and concluded by proposing a system that employed RFID for storage of all conditions that comply with government regulations to check the eligibility of voters.

### 2.6.1 Voting Process Authenticity

Authenticity of the voting process is important to mitigate numerous factors that may hamper a credible election process. However, total reliance on technologies warrants authentication and validation of voter identities. Incorporation of biometrics into e-voting systems assists in attaining required levels of integrity of an election (Ebaid et al., 2008). Biometrics allows voter identification and verifiability. The identification process entails ascertaining a person from biometric measurements contained in a database; verification then authenticates the identity of a person in a one-to-one match (Smith, 2005). The verification of a person's identity against established biometric measures involves five stages that an e-voting system must do. This is illustrated in figure 2.1 below:



**Figure 2.5- Biometric System Data Flow**

According to Ebaid et al., (2008), the use of biometric technologies may be as basic as using one biometric. However, single biometric authentication is subject to security breaches when they are not properly administered and attended to. Security password, signatures and finger prints can be spoofed when used enough security layers are not in place. A proper combination of biometrics leads to enhanced security layers an e-voting system.

## 2.7 Conceptual Model

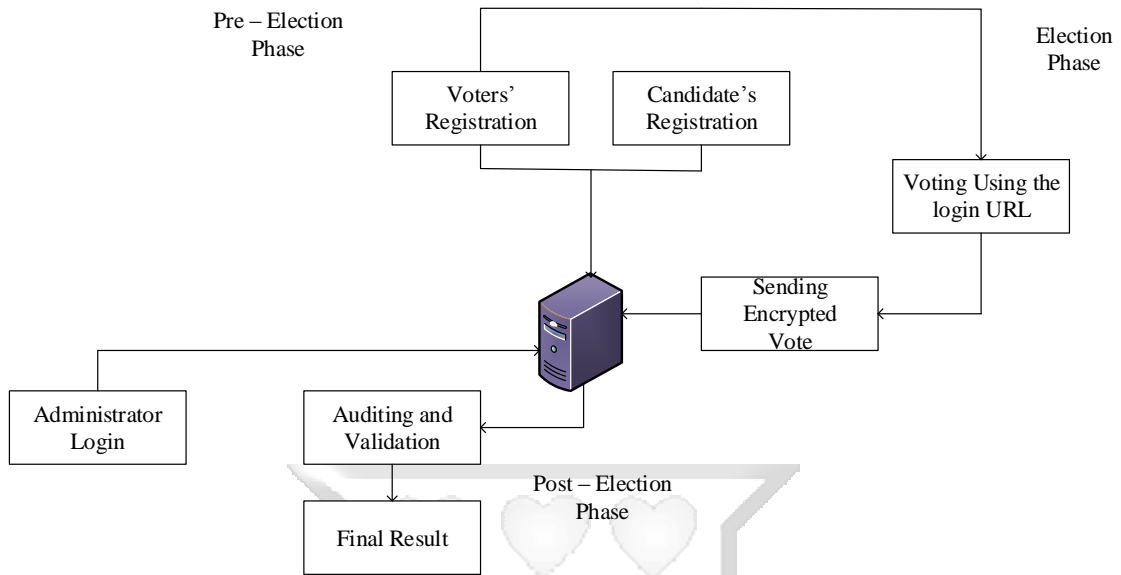
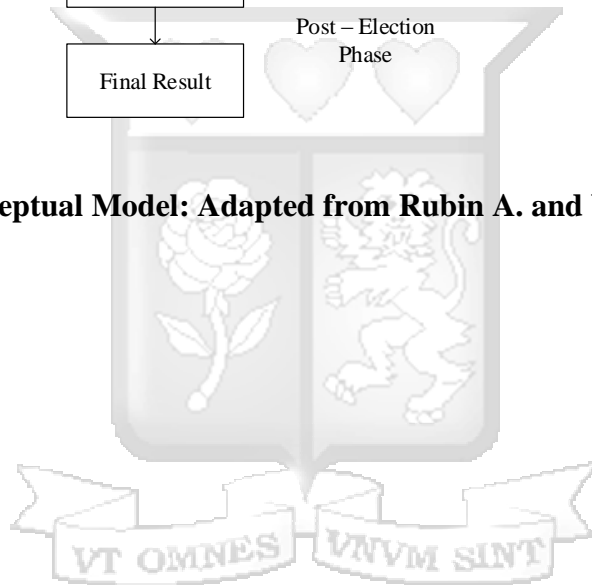


Figure 2.6: Conceptual Model: Adapted from Rubin A. and Wallach D. S, (2004)



## **CHAPTER THREE: RESEARCH METHODOLOGY**

### **Introduction**

This chapter presents the methodology that was to be used to carry out the study. It outlines the research strategy, quantitative and qualitative procedures and techniques for the research, sample size and sampling strategy. The chapter also discusses different tools that were used in data collection and analysis and concludes with ethical considerations for the research.

### **3.1 Research Design**

The study adopted a descriptive and exploratory research designs. The descriptive research method was used because it gave a clear picture of the study phenomena on which collection of data was to be done. The exploratory design allowed the researcher to review different literatures that were related to the subject area and conduct interviews to give a clearer picture of the e-voting adoption requirements. The project mainly focused on how an effective electronic voting system can be developed and adopted to curb inefficiencies in the electoral process.

### **3.2 Target Population**

Population refers to the entire group of units, elements or people from which a sample can be derived for the purpose of doing a statistical measurement. Population for a research usually has common characteristics such as age, gender and education. The population for this study included eligible voters within Kenya and top management and technical staff from the Kenyan electoral commission.

### **3.3 Sampling Methods and Size of Sample**

The study adopted simple random sampling and purposive sampling methods. In simple random sampling, each member has an equal opportunity of being chosen (Mugenda & Mugenda, 2009). Purposive sampling allows a researcher to choose a sample participant

for specific required information. Purposive sampling was used to select electoral commission top staff officials and other relevant staff that have direct relationship with the electoral commission body and respondents were selected using simple random sampling.

**Table 3.1 Sample size**

<b>Category</b>	<b>N</b>	<b>n</b>
IEBC Staff	350	30
Registered voters (Nairobi County, Nairobi Central Ward,)	140,800	256
Total	141, 150	386

**Source (IEBC HR Resources & Voter Register, 2018)**

### **3.4 Data Collection Methods**

Primary data for the research was obtained using questionnaire and interviews and the secondary data was obtained through the use of existing literatures and relevant case studies on e-voting systems. Structured questionnaires were used to carry out a survey to analyze and ascertain the perceptions of the people on the current paper based voting and the introduction of E-voting systems, in addition to interviewing electoral staff to get their views.

### **3.5 Data Analysis and Presentation**

The data collected was analyzed using both qualitative and quantitative procedures. The collected information was checked for completeness and correctness and serialized for coding, passage and examination. The Statistical Package for Social Sciences (SPSS) v24 was utilized in the analysis of quantitative data and the results presented in tables and figures accompanied by explanations.

### **3.6 System Analysis and Design**

#### **3.6.1 System Analysis**

An in depth analysis of the existing system was carried out. The main areas of concentration included the flaws that exist in the current system and the massive expenses that the government incurs which can be eliminated by automating the processes.

#### **3.6.2 System Design**

Based on the findings of the current system, a physical design of the proposed system was developed. This stage was categorized into two broad sections:

##### **3.6.3 General design and structured design**

In the general design, tools such as flow charts and data flow diagrams were used to give the general overview of the proposed system.

In the structured design, the coding language was defined, the type of database to be used and the security measures that were put in place to safeguard the system from security breaches.

### **3.7 Research Quality**

#### **3.7.1 Reliability**

According to Mugenda and Mugenda (2009) reliability refers to the capability of a research instruments to provide similar results in similar conditions using the same methodology.

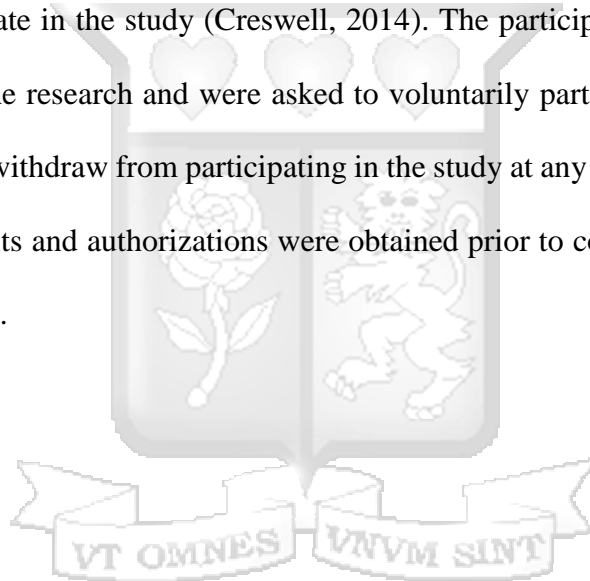
Reliability involves consistency, consistency, and soundness of the findings of research study. When the results are consistent, then the research instrument is regarded as being strong as indicated by (Kerlinger & Lee (2000)). One of the popular ways of ensuring reliability is the use of Cronbach's Alpha. The model measures the internal consistency of the research. An alpha value of 0.70 and above is regarded as being worthy and indicates the strength of the research instrument.

### **3.7.2 Validity**

Validity refers to the degree to which the data validates the concept that is being measured in a study. Pre-testing is a popular method used to measure validity of the research instrument. The study pre-tested the questionnaires to ensure they give consistency in responses. A pilot study was done where the responses were checked to ensure that they were consistent.

### **3.8 Ethical Considerations**

Research ethics ensures that the privacy of the respondents is secured and that no one is forced to participate in the study (Creswell, 2014). The participants were made aware of the purpose for the research and were asked to voluntarily participate in the study. They were also free to withdraw from participating in the study at any given time. Additionally, all required permits and authorizations were obtained prior to commencement of the data collection process.



## CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATIONS

### Introduction

This chapter presents the results of findings and analysis of the field data in line with the research questions and objectives set out in chapter one. The findings have been analyzed in frequency tables and charts. The findings have been presented in three parts; first part representing data gathered from Top management and staff of EC and second depicting responses from voters across the selected regions. The analysis of this research was mainly conducted using statistical package for social sciences (SPSS) tool and Microsoft excels 2013.

### 4.1 Questionnaire Design

To ensure that the questions to be used in the survey are simple with no Ambiguity, and considering the fact that not all the respondents are computer or IT expert, the researcher make sure the final questionnaires are simple and very easy to understand and can be answered by all. In order to achieve this, a pilot survey was done. Sample questionnaires were sent to few selected people from different social and educational background. The questions were reviewed to include the concerns and suggestions of these respondents.

### 4.2 Findings from Electoral Commission (EC)

#### 4.2.1 Demographic Information

This section shows the survey response base on demographic details of respondents, which includes their gender, age, and educational background.

**Table 4.1 – Gender**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	16	72.7	72.7
	Female	6	27.3	100.0
	Total	22	100.0	100.0

**Source: Fieldwork, 2019**

Table 4.1 shows that out of the 22 respondents 16 (72.7%) were male while 6 (27.3%) were female.

**Table 4.2 - Age**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 18-30	13	59.1	59.1	59.1
31-40	7	31.8	31.8	90.9
41-50	2	9.1	9.1	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

Table 4.2 shows that 13 respondents (59.1%) were between the age of 18-30, 7(31.8%) were between 31-40 years, and 2 (9.1%) were between 41-50 years.

**Table 4.3 - Education**

	Frequency	Percent	Valid Percent	Cumulative Percent
High School	2	9.1	9.1	9.1
Valid First Degree	16	72.7	72.7	81.8
Second Degree and Above	4	18.2	18.2	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.3 it can be observed that out of the total 22 respondents 2 (9.1%) were High school graduates, 16 (72.7%) has attained Tertiary education and 4 (18.2) has Second degree and above qualifications.

**Table 4.4 – What is your position?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Top Level Management	5	22.7	22.7	22.7
Middle Level Management	12	54.5	54.5	77.3
Officer	5	22.7	22.7	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

Table 4.4 shows that out of the total 22 respondents 5 (22.7%) are Top level management, 12 (54.5%) are Middle level managers, and 5 (22.7) are officers.

**Table 4.5 – How long have you been with Electoral Commission?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1-5	5	22.7	22.7	22.7
6-10	15	68.2	68.2	90.9
Above 10 years	2	9.1	9.1	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

When asked how long the respondents has been in the organization, Table 4.5 shows that out of the 22 respondents 5(22.7%) were in the range of 1 to 5 years, 15 (68.2%) were in the range of 6 to 10 years, while 2 (9.1%) were above 10 years. Majority of the respondents has been in the company more than 5 years, and this is a positive indication that majority of them has experience in the operations of the organization.

#### **4.2.2 Research Related questions**

This section assesses the respondent's ideas on E-voting systems

**Table 4.6 - Rate you level of understanding of E-voting**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Very high	7	31.8	31.8	31.8
High	9	40.9	40.9	72.7
Medium	6	27.3	27.3	100.0
Total	22	100.0	100.0	

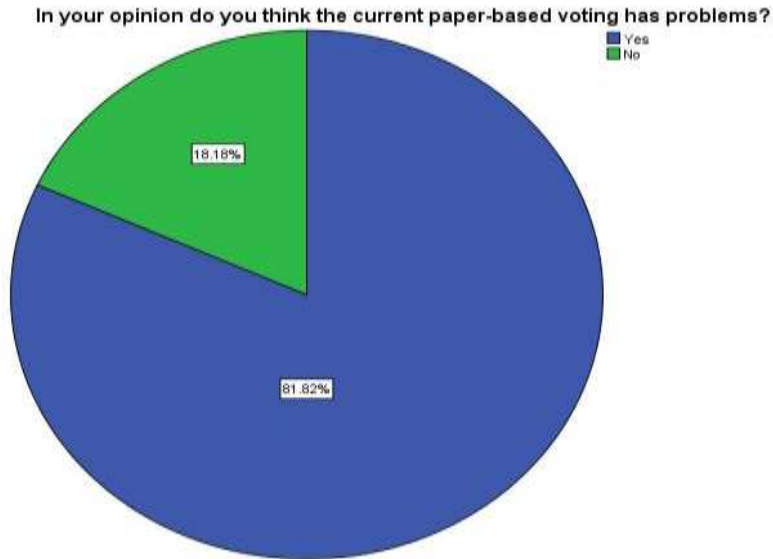
**Source: Fieldwork, 2019**

Table 4.6 shows that out of the 22 respondents, 7 (31.8%) has very high level understanding of e-voting system and 9 (40.9%) has high understanding of e-voting system and 6 (27.3%) has average understanding of the subject area. This gave indication that all the respondents can give meaningful contribution in this survey.

**Table 4.7 - In your opinion do you think the current paper-based voting has problems?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	18	81.8	81.8	81.8
Valid No	4	18.2	18.2	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**



**Figure 4.1 – Percentage of respondents who think the current paper-based voting has problems or not.**

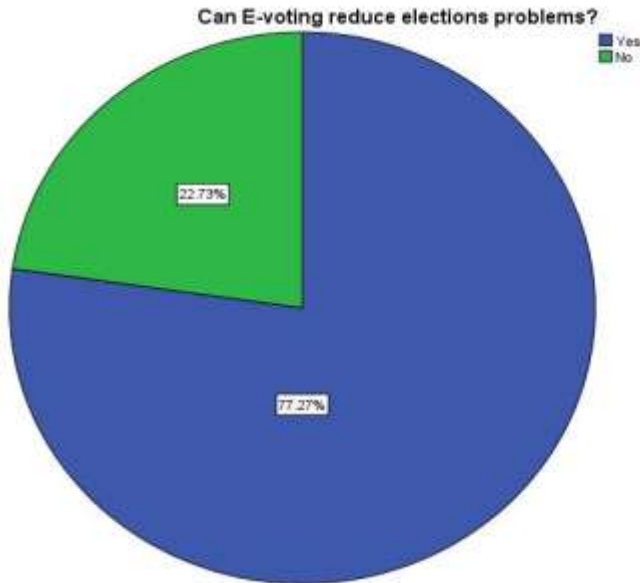
From table 4.7 and figure 4.1, it can be observed that 81.8% of the respondents believes the current paper-based voting has problems, while 18.2% thinks there are no problems with the system that could impact on elections results.

**Table 4.8 - Can e-voting reduce elections problems?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	17	77.3	77.3	77.3
Valid No	5	22.7	22.7	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.8 it can be observed that 77.3% of the respondents believes e-voting implementation can reduce election problems while 22.7% says no. This shows that majority of the respondents believes e-voting adoption can reduce elections problems.



**Figure 4.2 – Percentage of respondents who think e-voting can reduce elections problems or not.**

**Table 4.9 - Are you willing to use e-voting system?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	22	100.0	100.0	100.0

Source: Fieldwork, 2019

Table 4.9 shows all 22 (100%) respondents indicating their willingness to use an e-voting system. This indicates that even with their reservation on e-voting they are willing to use the system when implemented.

#### **4.2.3 Potential Benefits of E-voting implementation**

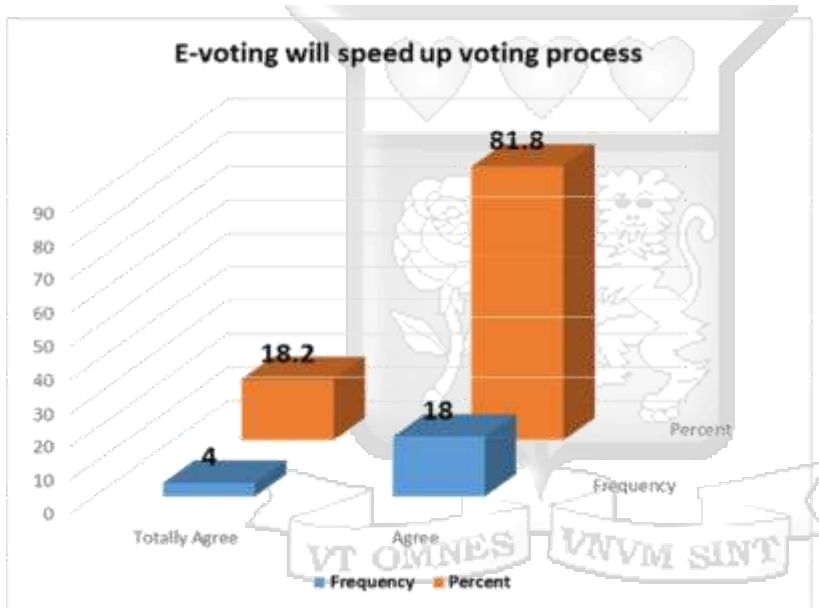
In this section, the respondents were questioned on the potential benefits of e-voting and the response has been shown below.

**Table 4.10 - E-voting will speed up voting process**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	4	18.2	18.2	18.2
Valid Agree	18	81.8	81.8	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

Table 4.10 and Figure 4.10 shows that out of the 22 respondents, 4 (18.1%) Totally agree, and 18 (81.8%) agree that e-voting will speed up voting process. This goes to show that all respondents believes that e-voting when implemented will speed up voting process.

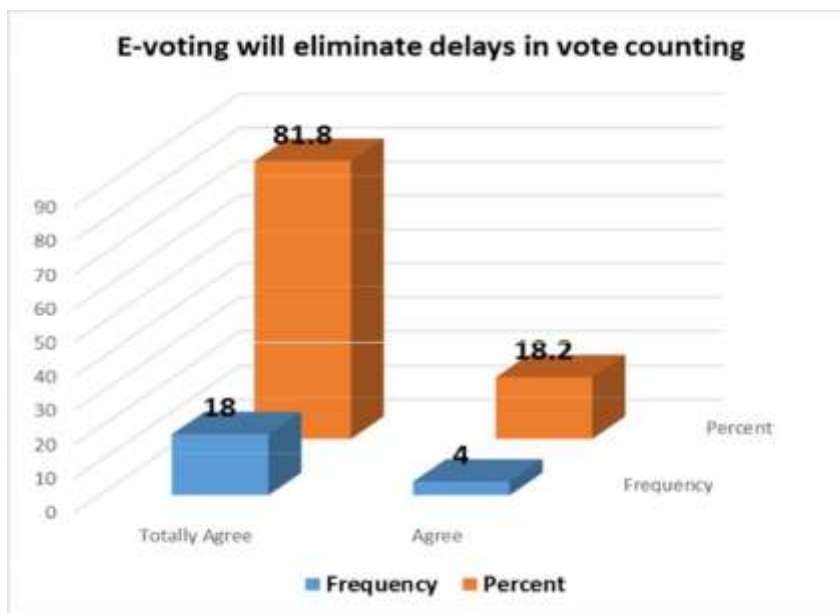


**Figure 4.3 - E-voting will speed up voting process**

**Table 4.11 - E-voting will eliminate delays in vote counting**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	18	81.8	81.8	81.8
Valid Agree	4	18.2	18.2	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**



**Figure 4.4 - E-voting will eliminate delays in vote counting**

Table 4.11 and figure 4.11 shows that 18 (81.8%) respondents totally agree and 4 (18.2%) agree that e-voting will eliminate delays in vote counting. This a positive indication that e-voting implementation will eliminate delays in vote counting.

**Table 4.12 - E-voting will eliminate voting fraud (double voting and results manipulation)**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	1	4.5	4.5	4.5
Agree	14	63.6	63.6	68.2
Disagree	7	31.8	31.8	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

Table 4.12 shows that out of the 22 respondents 1 (4.5%) Totally Agree, 14 (63.6%) agree and 7 (31.8%) disagree that e-voting can eliminate voting fraud). This shows that majority of the respondents believes e-voting can eliminate voting fraud.

**Table 4.13 - E-voting will eliminate voting errors due to wrong thumb printing**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	9	40.9	40.9	40.9
Agree	13	59.1	59.1	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

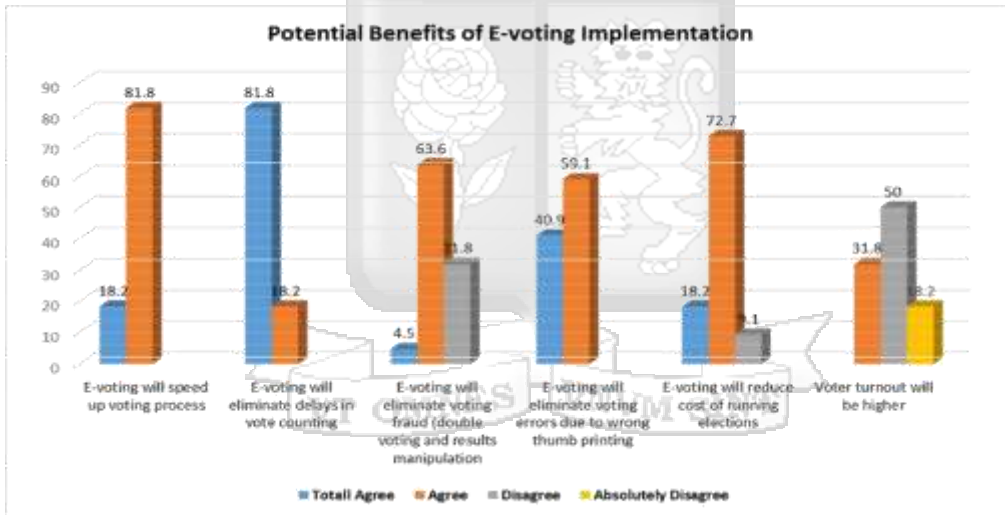
Table 4.13 shows that out of the 22 respondents, 9 (40.9%) Totally agree, and 13 (59.1%) agree that E-voting will eliminate voting errors due to wrong thumb printing. This indicate that the respondents believe when e-voting is introduce spoilt votes will be eliminated.

**Table 4.14 - E-voting will reduce cost of running elections**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Totally Agree	4	18.2	18.2
	Agree	16	72.7	90.9
	Disagree	2	9.1	100.0
	Total	22	100.0	100.0

**Source: Fieldwork, 2019**

As shown in table 4.14 4 (18.2%) of the respondents totally agree that e-voting will reduce the cost of running election, 16 (72.7%) of the respondents agree and 2 (9.1%) disagree that election running cost will reduce due to e-voting adoption. The indication is that 90.9% of the respondents believes the cost will reduce.



**Figure 4.5 – Potential Benefits of E-voting Implementation**

**Source: Fieldwork, 2019**

**Table 4.15 - Voter turnout will be higher**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	7	31.8	31.8
	Disagree	11	50.0	81.8
	Absolutely Disagree	4	18.2	100.0
	Total	22	100.0	100.0

**Source: Fieldwork, 2019**

From table 4.15 shows that out of the 22 respondents, 7 (31.8%) agree that voter turnout will be higher with the introduction of e-voting, 11 (50%) of the respondents disagree and 4 (18.2%) absolutely disagree. The majority 68.2% who disagree believes e-voting won't be the motivating factor to compel a voter to vote.

From figure 4.12 and figure 4.13 below, the potential advantages has been grouped and ranked and it can be observed that the highest rank of the benefits are e-voting eliminating voting errors, eliminating delays in vote counting and speeding up voting process. All these had 100% response from the respondents.

It was followed by reduction of election running cost (90.9% response), and e-voting eliminating voting fraud (68.1%). The majority of the respondents believes e-voting will not be a factor to increase voter turnout.

#### 4.2.4 Potential Challenges of e-voting implementation

##### *Technical Challenges*

**Table 4.16- EC don't have skill set to support e-voting implementation**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	2	9.1	9.1	9.1
Agree	11	50.0	50.0	59.1
Valid Disagree	9	40.9	40.9	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

**Table 4.17- Lack of ICT resources by EC to support e-voting implementation**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	2	9.1	9.1	9.1
Agree	12	54.5	54.5	63.6
Valid Disagree	8	36.4	36.4	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

**Table 4.18- Unstable Communication link on Election Day**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	3	13.6	13.6	13.6
Agree	13	59.1	59.1	72.7
Valid Disagree	6	27.3	27.3	100.0
Total	22	100.0	100.0	

Source: Fieldwork, 2019

**Table 4.19 - Power Outages to disrupt Elections**

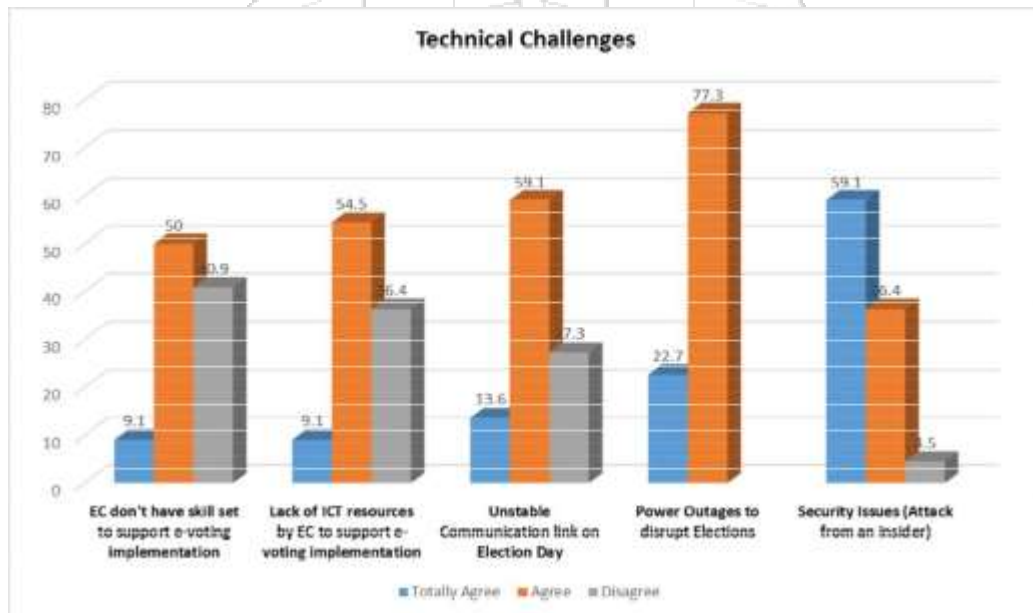
	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	5	22.7	22.7	22.7
Valid Agree	17	77.3	77.3	100.0
Total	22	100.0	100.0	

Source: Fieldwork, 2019

**Table 4.20 - Security Issues (Attack from an insider)**

	Frequency	Percent	Valid Percent	Cumulative Percent
Agree	13	59.1	59.1	59.1
Valid Disagree	8	36.4	36.4	95.5
Absolutely Disagree	1	4.5	4.5	100.0
Total	22	100.0	100.0	

Source: Fieldwork, 2019



## Figure 4.6 – Technical Challenges

Source: Fieldwork, 2019

From table 4.16 and figure 4.14 above, out of the 22 respondents 2 (9.1%) Totally agrees that EC do not have the skill set to support e-voting and this could be a potential challenge, 11 (50%) agree, and 9 (40.9%) disagree and opposed the submission to be a challenge.

From table 4.178 and figure 4.14 above, out of the 22 respondents 2 (9.1%) totally agrees that Lack of ICT resources by EC can be a potential challenge, 12 (54.5%) agree and 3 (36.4) disagree and opposed the submission that lack of ICT resources by EC will be a challenge.

From table 4.18 and figure 4.14 above, out of the 22 respondents 3 (13.6%) totally agree unstable communication link on Election Day can be a challenge, 13 (59.1%) agree and 6 (27.3%) disagree and opposed to the submission. From table 4.19 and figure 4.14 above, out of the 22 respondents 5 (22.7%) totally agrees that power outages will be a challenge, and 17 (77.3%) agrees.

From table 4.20 and figure 4.14 above, out of the 22 respondents 13 (59.1%) totally agree that security issues can be a challenge, 8 (36.4%) agree and only 1 (4.5%) disagree to the submission.

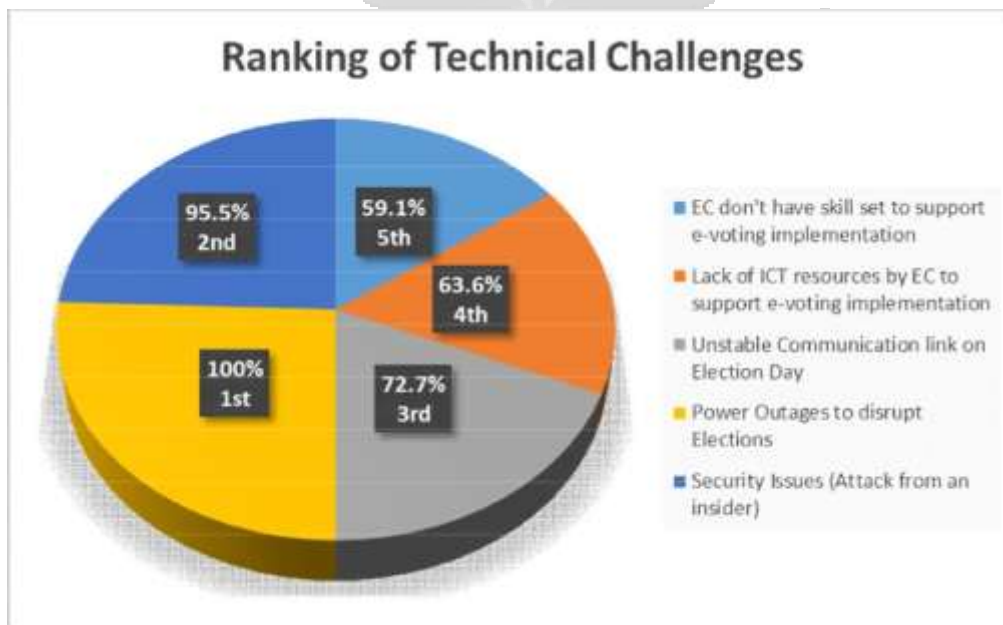


Figure 4.7– Ranking of the Technical Challenges

Source: Fieldwork, 2019

*General Challenges*

**Table 4.21- Cost of E-voting Implementation**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	5	22.7	22.7	22.7
Agree	11	50.0	50.0	72.7
Valid Disagree	6	27.3	27.3	100.0
Total	22	100.0	100.0	

Source: Fieldwork, 2019

**Table 4.22 - E-voting will be difficult to be used due to high illiteracy rate**

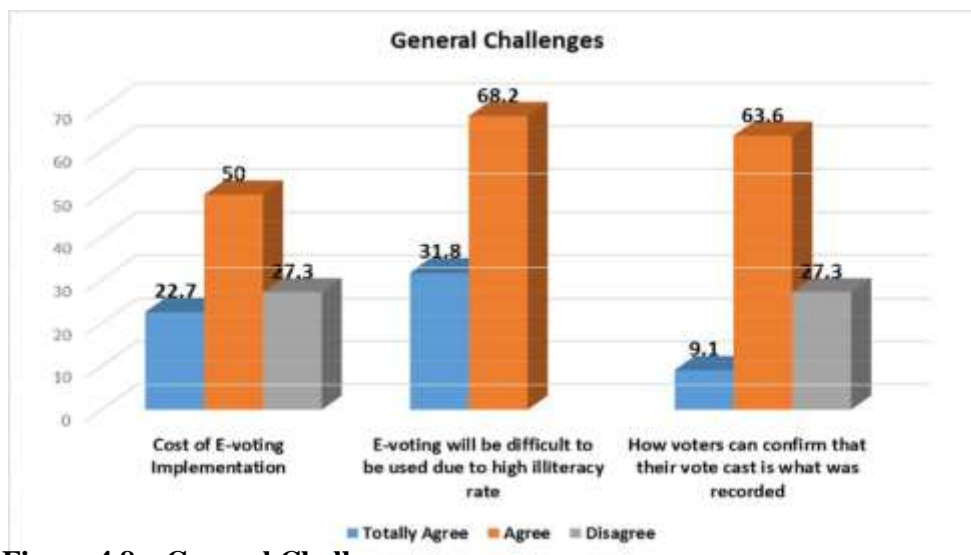
	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	7	31.8	31.8	31.8
Valid Agree	15	68.2	68.2	100.0
Total	22	100.0	100.0	

Source: Fieldwork, 2019

**Table 4.23 - How voters can confirm that their vote cast is what was recorded**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	2	9.1	9.1	9.1
Agree	14	63.6	63.6	72.7
Valid Disagree	6	27.3	27.3	100.0
Total	22	100.0	100.0	

Source: Fieldwork, 2019



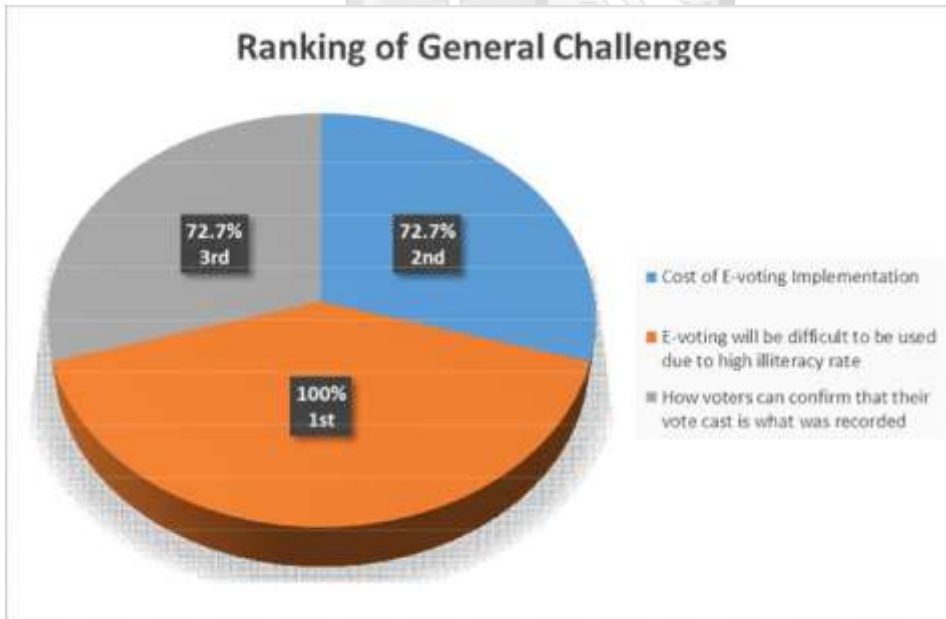
**Figure 4.8 – General Challenges**

**Source: Fieldwork, 2019**

From table 4.21 and figure 4.16 above, out of the 22 respondents 5 (22.7%) totally agrees that cost of e-voting implementation can be a challenge, 11 (50%) agrees to the submission, and 6 (27.3%) disagree and opposed to the submission.

From table 4.22 and figure 4.16 above, out of the 22 respondents 7 (31.8%) totally agrees that e-voting will be difficult to be used due to high of illiteracy rate among the voting populace, 15 (68.2%) agrees to the submission, but suggested that there should be massive sensitization and education of the use of e-voting system before embarking on e-voting.

From table 4.23 and figure 4.16 above, out of the 22 respondents 2 (9.1%) totally agrees that how voters can confirm that their vote cast is what is recorded may be a challenge, 14 (63.6%) agrees whiles 6 (27.3%) disagree and opposed to the submission. This indicates that majority (72.7%) of the respondents agrees to this submission. They are of the opinion that to mitigate this challenge the system must be able to provide a printout to confirm the voter's choice.



**Figure 4.9 – Ranking of General Challenges**

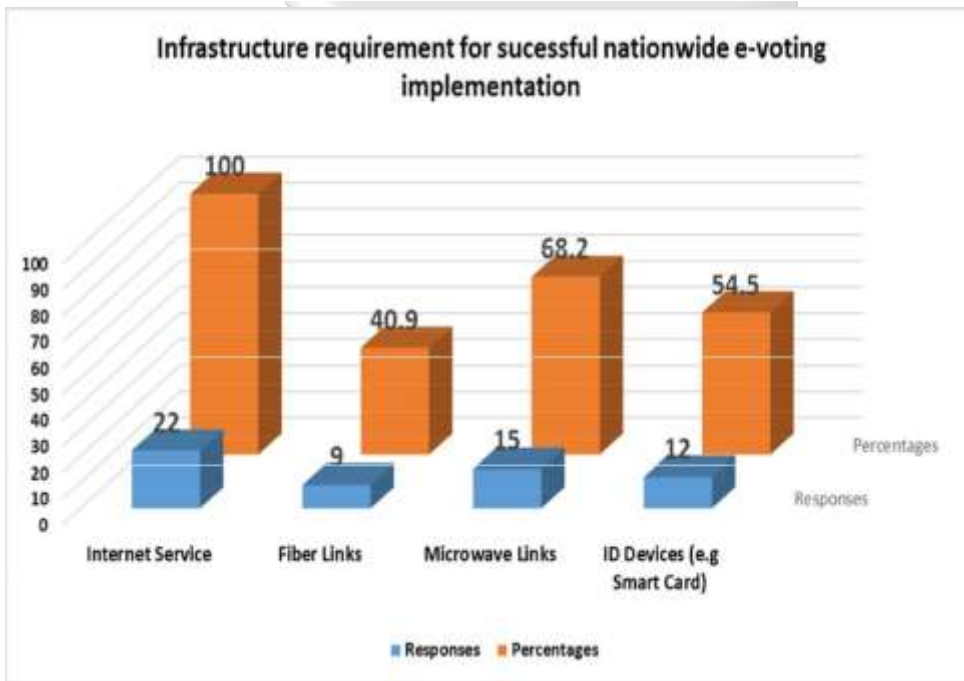
#### **4.2.5 Infrastructural Support**

This section shows the respondents view on the needed ICT infrastructure and whether the current available infrastructure can support e-voting nationwide.

**Table 4.24 – Infrastructure requirements for successful nationwide e-voting implementation**

Responses	Total Respondents	Percentage
Internet Services	22	100
Fiber Links	9	40.9
Microwave Links	15	68.2
ID Devices	12	54.5

Source: Fieldwork, 2019



**Figure 4.10 - Infrastructure requirements for successful nationwide e-voting implementation**

Source: Fieldwork, 2019

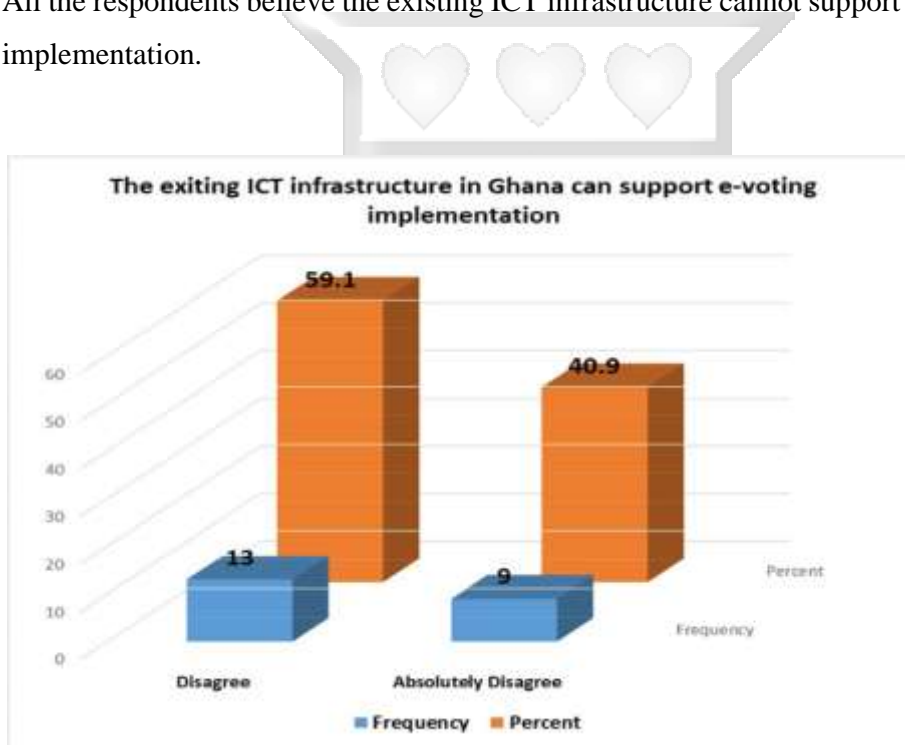
From the table 4.24 and figure 4.21 out of the total 22 respondents 22 (100%) indicated Internet services as one of the needed infrastructure for e-voting implementation, 9 (40.9%) selected fiber link, 15 (68.2%) selected Microwave link and 12 (54.5%) selected ID Devices. This gives an indication that Internet service is the highest requirement needed for successful nationwide e-voting implementation.

**Table 4.25 - The exiting ICT infrastructure in Kenya can support e-voting implementation**

	Frequency	Percent	Valid Percent	Cumulative Percent
Disagree	13	59.1	59.1	59.1
Valid Absolutely Disagree	9	40.9	40.9	100.0
Total	22	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.25 and figure 4.22 it can be observed that 13 (59.1%) disagree that there existing infrastructure can support nationwide e-voting implementation, 9 (40.9%) Absolutely disagree. All the respondents believe the existing ICT infrastructure cannot support nationwide e-voting implementation.



**Figure 4.11 - The exiting ICT infrastructure in Kenya can support e-voting implementation**

### 4.3 Findings from Voting Populace

#### 4.3.1 Demographic Information

This section shows the survey response base on demographic details of respondents, which includes their gender, age, educational background and region where the respondents. Most of

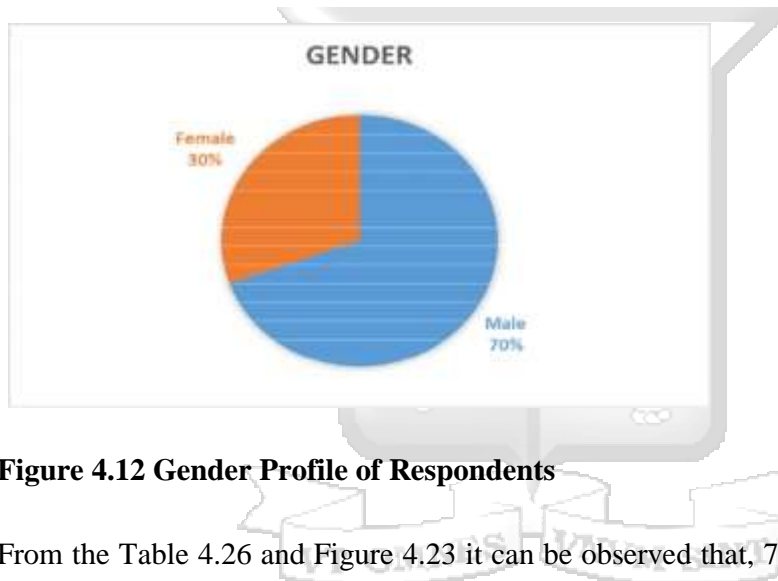
the survey were conducted in Nairobi. In all the researcher had a total of 256 respondents across these selected regions.

**Table 4.26 – Gender Profile of Respondents**

**Sex**

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	178	69.5	69.5	69.5
Valid Female	78	30.5	30.5	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2018**



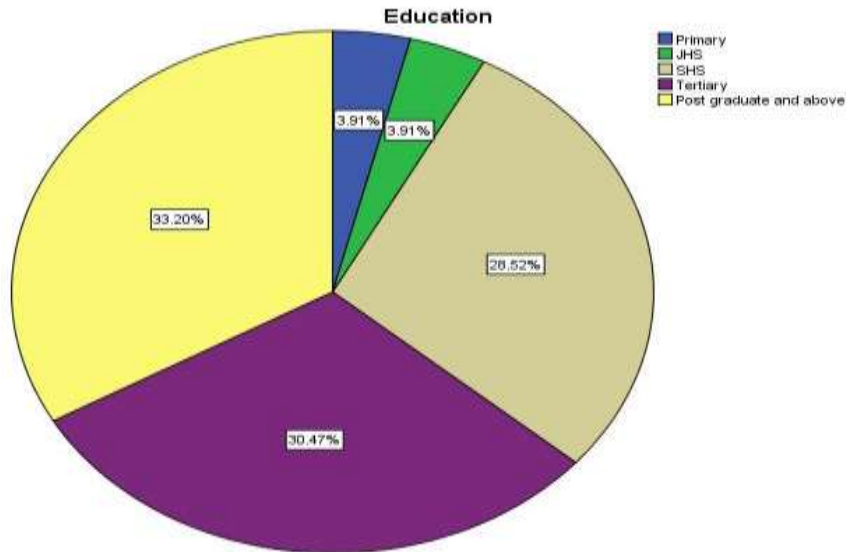
**Figure 4.12 Gender Profile of Respondents**

From the Table 4.26 and Figure 4.23 it can be observed that, 70.3% of the respondents were male while the remaining 29.7% were female. This shows male were in the majority of the population studied while the female were in the minority.

**Table 4.27 – Education of respondents**

	Frequency	Percent	Valid Percent	Cumulative Percent
Primary	10	3.9	3.9	3.9
JHS	10	3.9	3.9	7.8
SHS	73	28.5	28.5	36.3
Valid Tertiary	78	30.5	30.5	66.8
Post graduate and above	85	33.2	33.2	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**



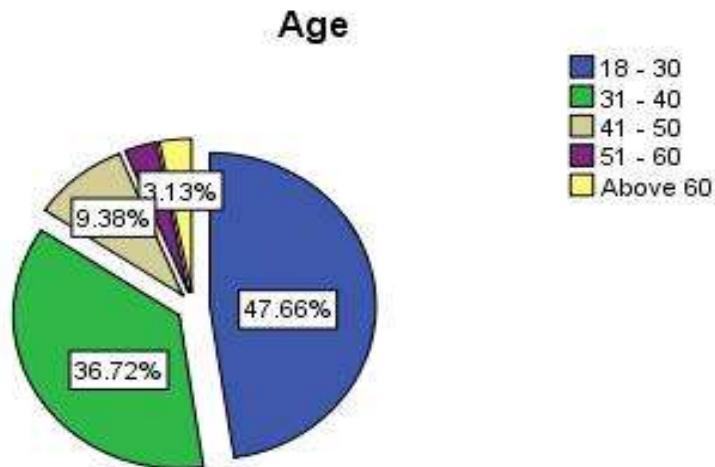
**Figure 4.13 – Education of respondents**

From the table 4.27 it could be observed that people who responded to this survey were having mixed educational background. We had ten (10) representing 3.9% having primary educational background, ten (10) representing 3.9% with JHS background, seventy three (73) representing 28.5% having SHS educational background, seventy eight (78) representing 30.5% with Tertiary educational background and eighty five (85) representing 33.2% having Post graduate and above educational background. About 92% of the respondents at least has attained SHS or higher education.

**Table 4.28– Age of respondents**

	Frequency	Percent	Valid Percent	Cumulative Percent
18 - 30	122	47.7	47.7	47.7
31 - 40	94	36.7	36.7	84.4
41 - 50	24	9.4	9.4	93.8
Valid 51 - 60	8	3.1	3.1	96.9
Above 60	8	3.1	3.1	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**



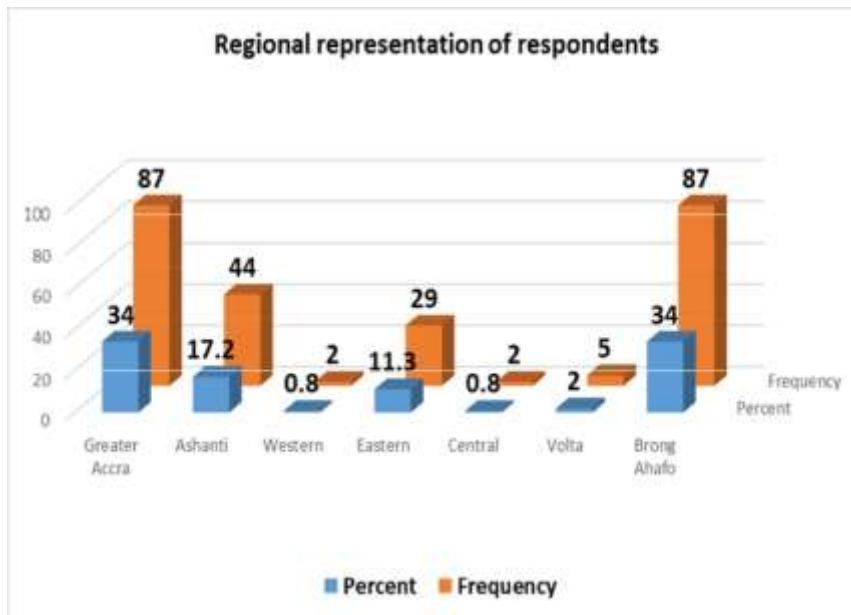
**Figure 4.14 – Age group of respondents**

From table 4.28 we can observed that a total of 122 representing 47.7% of the respondents are in the age group of 18 to 30, a total of 94 respondents representing 36.7% within 31 to 40, total of 24 respondents representing 9.4% within 41 to 50, a total of 8 respondents representing 3.1% within 51 to 60 and a total of 8 respondents representing 3.1% were above 60 years. Higher percentage of respondents were between the ages of 18 to 30.

**Table 4.29 – Regional Representation of respondents**

	Frequency	Percent	Valid Percent	Cumulative Percent
Greater Nairobi	87	34.0	34.0	34.0
Nairobi CBD	44	17.2	17.2	51.2
Western	2	.8	.8	52.0
Eastern	29	11.3	11.3	63.3
Valid Central	2	.8	.8	64.1
South	5	2.0	2.0	66.0
other	87	34.0	34.0	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**



**Figure 4.15 Regional Representation of respondents**

Table 4.29, and figure 4.26 shows the regional distribution of the respondents. Greater Nairobi had 87 (34%) respondents, Nairobi CBD had 44 (17.2%), Western had 2 (0.8%), Eastern had 29 (11.3%), Central 2 (0.8%), Southern had 5 (2%) and other had 87 (34 %).

#### 4.3.2 The preferred voting technology

In this section, the researcher was trying to determine if there are problems in the current paper-based voting and if e-voting can reduce these problems. Secondly the researcher finds out which technology the respondents are likely to use, and also to know their level of computer literacy, and to determine their willingness to use e-voting system if implemented. The first question was to determine if the respondents has ever voted in any general elections in Kenya since 1992.

**Table 4.30 – Have you ever voted in any general elections in Kenya since 1992?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	256	100.0	100.0	100.0

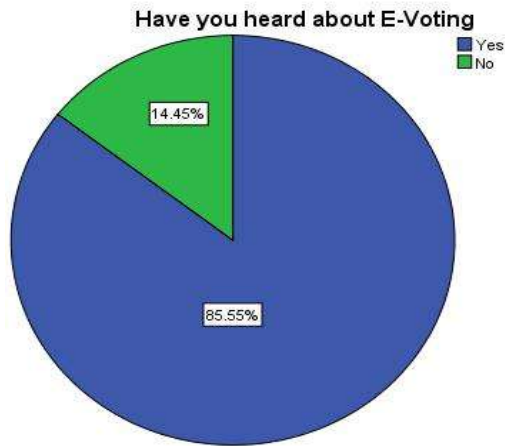
**Source: Fieldwork, 2019**

From table 4.30 we can observed that a total of 256 respondents, representing 100% has voted before.

**Table 4.31 – Have you heard about E-Voting?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	219	85.5	85.5	85.5
No	37	14.5	14.5	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**



**Figure 4.16 – Percentage respondents who have heard about e-voting**

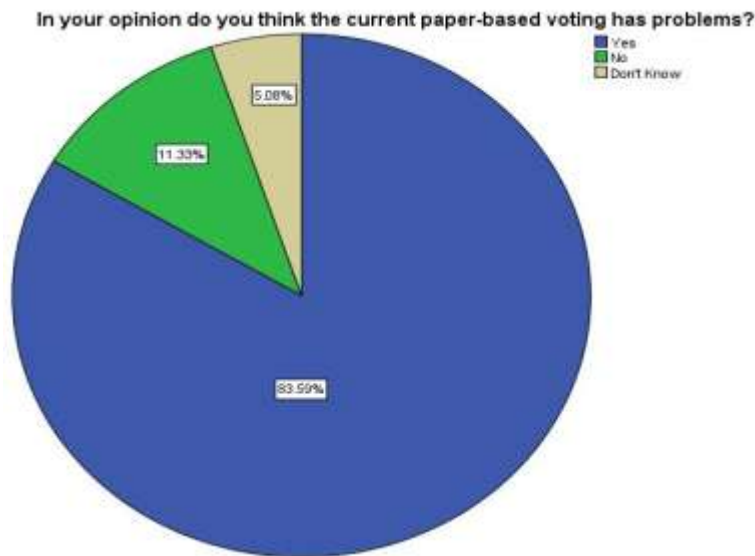
From table 4.31 and figure 4.28, it can be observed that a total of 219 respondents, representing 85.5% have already heard about e-voting system and they are aware of how it works, while a total of 37 respondents, representing 14.5% have not heard of e-voting system.

**Table 4.32 – In your opinion do you think the current paper-based voting has problems?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	214	83.6	83.6	83.6
No	29	11.3	11.3	94.9
Don't Know	13	5.1	5.1	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.32 and figure 4.29, it can be observed that 83.6% of the respondents believes there are problems with current system, while 11.3% thinks there are no problems. 5.1% had no idea of the subject.



**Figure 4.17 – Percentage respondents who think current paper based has problems**

**Table 4.33 – Do you believe e-voting can reduce elections problems in Kenya?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	207	80.9	80.9	80.9
Valid No	28	10.9	10.9	91.8
Valid Don't Know	21	8.2	8.2	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.33 and figure 4.30 below shows that, 80.9% of the respondents believes e-voting can reduce elections problems, while 10.9% does not believe e-voting can reduce election problems. 8.2% had no idea on the topic.

**Table 4.34 – Do you think it's necessary to have e-voting?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	224	87.5	87.5	87.5
Valid No	32	12.5	12.5	100.0
Total	256	100.0	100.0	

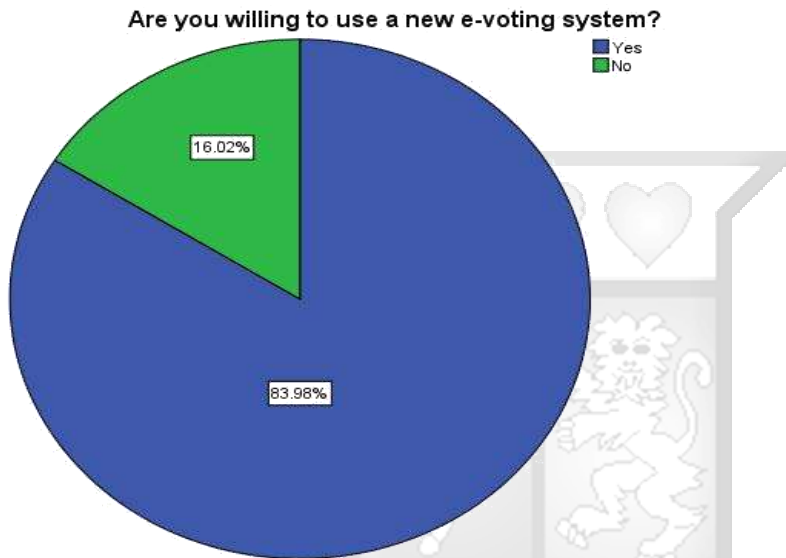
**Source: Fieldwork, 2019**

It can be observed from table 4.34 and figure 4.31 that out of the total 256 response, a total of 224 respondents, representing 87.5% believes it's necessary to have electronic voting system for national elections, and a total of 32 respondents, representing 12.5% thinks it's not necessary to have e-voting system.

**Table 4.35 – Are you willing to use an e-voting system?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	215	84.0	84.0	84.0
No	41	16.0	16.0	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**



**Figure 4.18 - Are you willing to use an e-voting system?**

From table 4.35, out of the 256 response received, a total of 215 respondents, representing 84% agreed to use the new e-voting system if implemented, while a total of 41 (16%) respondents says no.

**Table 4.36 – Can you rely on the results of an e-voting system?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Yes	203	79.3	79.3	79.3
No	53	20.7	20.7	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.36, a total of 203 respondents, representing 79.3% agreed they can rely on the results from the e-voting system, while 53 respondents, representing 20.7% responded no because they

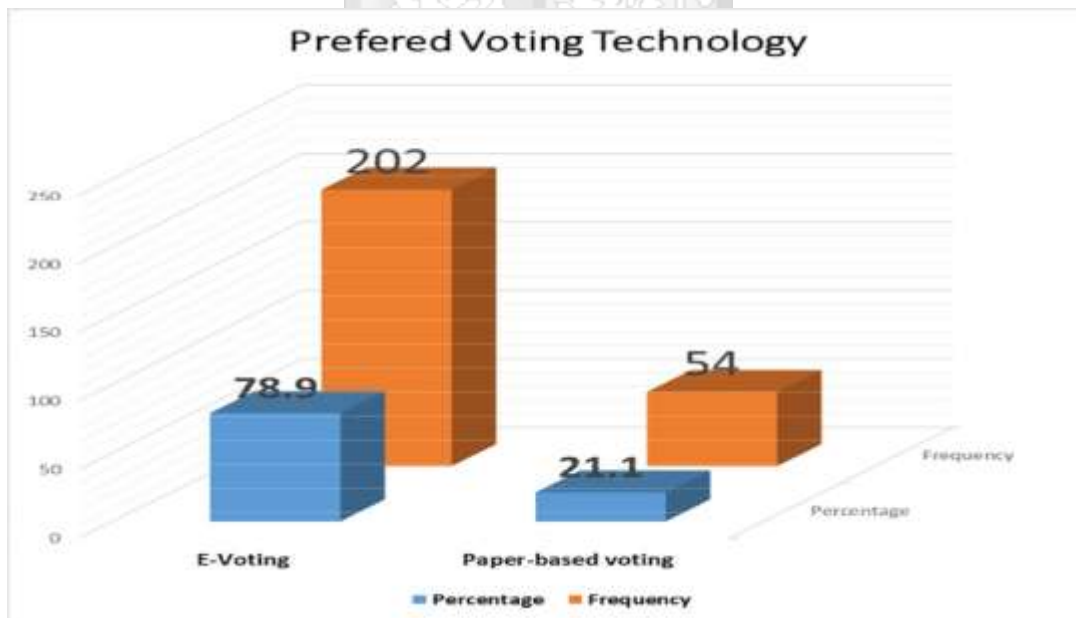
cannot rely on the results from the e-voting system. Majority of the respondents thinks they can rely on the results of the e-voting system.

**Table 4.37 – What voting technology will you prefer?**

	Frequency	Percent	Valid Percent	Cumulative Percent
E-Voting	202	78.9	78.9	78.9
Valid Paper-based voting	54	21.1	21.1	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.37 and figure 4.33, a total of 202 respondents, representing 78.9% preferred E-Voting technology, while 54 respondents, representing 21.1% preferred paper-based voting technology. Higher percentage (78.9% as shown in figure 4.33) of respondents support the idea of e-voting and prefer to use e-voting system to cast their vote.



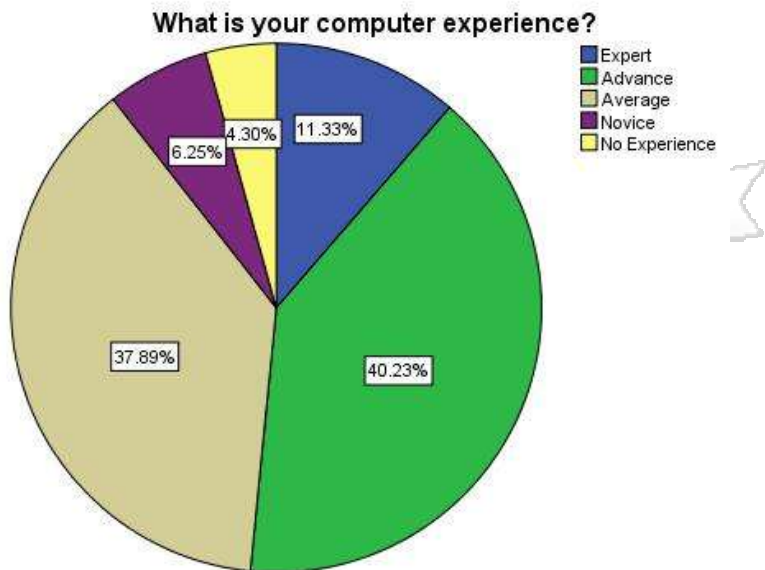
**Figure 4.19 - What voting technology will you prefer?**

**Table 4.38 – What is your computer experience?**

	Frequency	Percent	Valid Percent	Cumulative Percent
Expert	29	11.3	11.3	11.3
Advance	103	40.2	40.2	51.6
Average	97	37.9	37.9	89.5
Novice	16	6.3	6.3	95.7
Valid No Experience	11	4.3	4.3	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

As shown in table 4.38 and figure 4.34, a total of 29 respondents, representing 11.3% are expert users, a total of 103, representing 40.2% are advance users, a total of 97, representing 37.9% are average users, a total of 16 respondents, representing 6.3% are novice users, and a total of 11 respondents, representing 4.3% have no computer experience. It is assume that majority of the respondents can use computer to perform basic operations.



**Figure 4.20 - What is your computer experience?**

### 4.3.3 Potential Challenges of E-voting adoption

In this section, the respondents were questioned on the potential challenges of e-voting and the response has been shown below.

**Table 4.42 - I don't think e-voting is appropriate since I don't believe vote will be kept secret**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	22	8.6	8.6	8.6
Agree	46	18.0	18.0	26.6
No Opinion	35	13.7	13.7	40.2
Disagree	83	32.4	32.4	72.7
Absolutely Disagree	70	27.3	27.3	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.42, 22 (8.6%) respondents totally agreed, 46 (18%) respondents agreed, 35 (13.7%) respondents had no opinion, 83 respondents, representing 32.4% disagreed, and 70 respondents, representing 27.3% absolutely disagreed. As can be observed from Majority of the respondents (59.8%) do not agree that vote cast from e-voting system won't be kept secret. They believe measures will be in place to prevent any such occurrence.

**Table 4.43 - E-voting is not appropriate because of security reasons (Insider hacking into e-voting system to manipulate votes)**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	27	10.5	10.5	10.5
Agree	34	13.3	13.3	23.8
No Opinion	27	10.5	10.5	34.4
Disagree	92	35.9	35.9	70.3
Absolutely Disagree	76	29.7	29.7	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

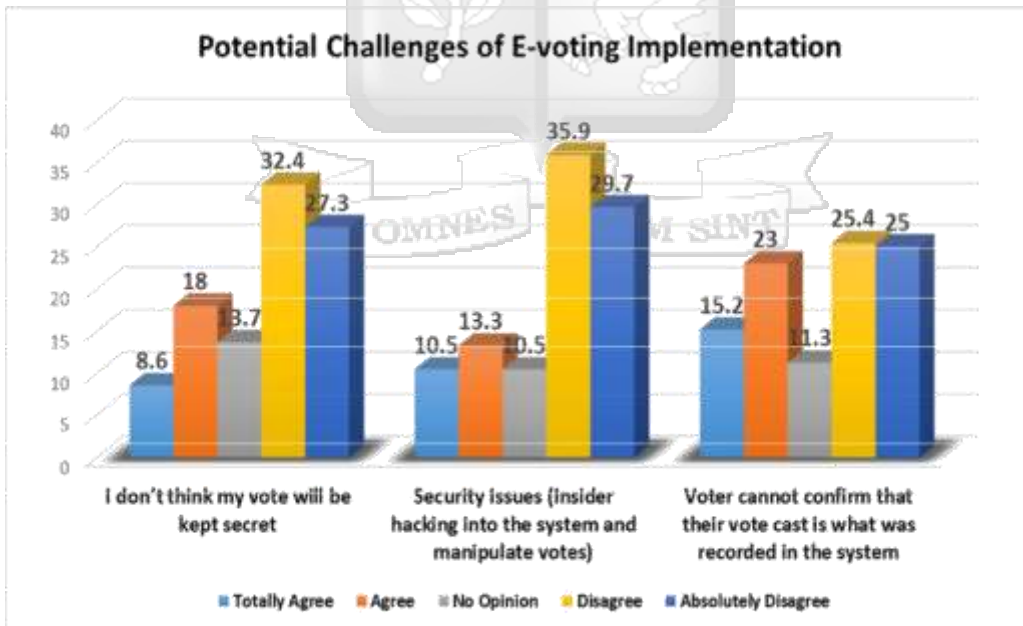
For the next question as presented in table 4.43 and figure 4.41a, a total of 27 respondents, representing 10.5% totally agree that e-voting is not appropriate because of security reasons, 34 (13.3%) respondents agree, 27 (10.5%) respondents had no opinion, 92 respondents, representing 35.9% disagree that e-voting is not appropriate because of security reason and 76 respondents, representing 29.7% totally disagree. It can be observed from figure 4.41a that over 65% of the respondents did not think security will be a challenge for e-voting implementation.

**Table 4.44 - Voter Cannot Confirm his vote has been recorded correctly**

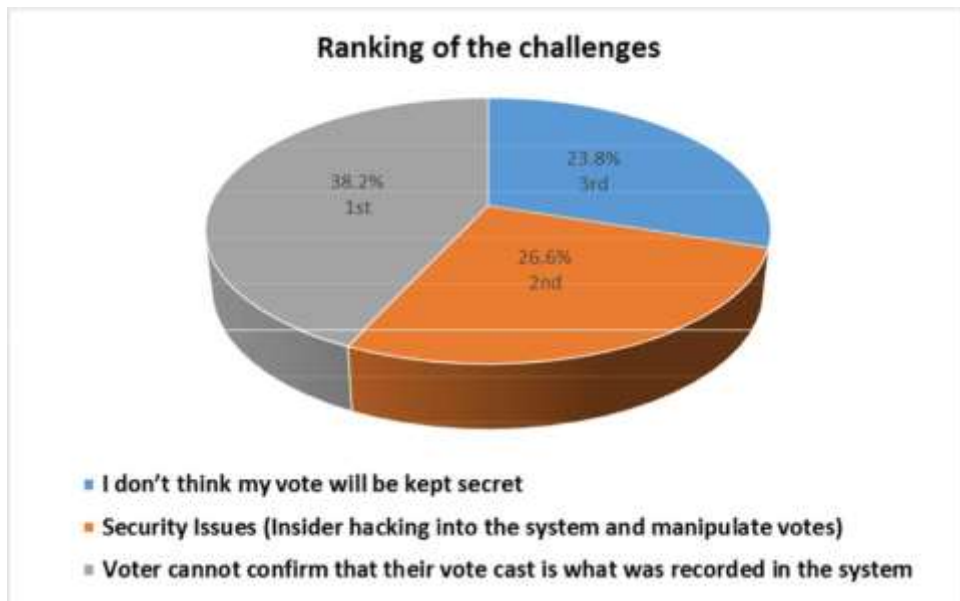
	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	39	15.2	15.2	15.2
Agree	59	23.0	23.0	38.3
No Opinion	29	11.3	11.3	49.6
Disagree	65	25.4	25.4	75.0
Absolutely Disagree	64	25.0	25.0	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.44, 39 respondent representing 15.2% totally agreed, 59 respondents representing 23.0% agreed, 29 (11.3%) had no opinion on the issue, 65 respondents, representing 25.4% disagreed, and 64 respondents, representing 25.0% absolutely disagreed. It can be observed from the figure 4.41a that the difference between the respondents who agree or disagree of the challenge was very narrow, which is 38.28% agree this could be a challenge, 11.33% had no opinion and 50.39% disagree. But all this respondents believe to allay the fears of voters, the system should be able to provide some sort of proof that the voters vote has been recorded correctly (i.e. paper audit trail).



**Figure 4.21– Potential Challenges of E-voting Implementation Source: Fieldwork, 2019**



**Figure 4.22 – Ranking of the Potential Challenges Source: Fieldwork, 2019**

#### 4.3.6 Potential Benefits of E-voting Implementation

This section the researcher wants to know from the respondents the potential benefits they perceived can be derived from e-voting adoption in national elections.

**Table 4.45 - E-voting will eliminate delays in vote counting**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	145	56.6	56.6	56.6
Agree	72	28.1	28.1	84.8
No Opinion	13	5.1	5.1	89.8
Valid Disagree	18	7.0	7.0	96.9
Absolutely Disagree	8	3.1	3.1	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

As can be observed from table 4.45 a total of 145 respondents, representing 56.6% totally agree that e-voting will eliminate delays in vote counting, a total of 72 respondents, representing 28.1% agree to the question, 13 respondents, representing 5.1% had no opinion about this question, 18 respondents (7%) disagree with this question and 8 respondents (3.1%) absolutely

disagree. It is assume that majority of the people believes e-voting will eliminate delays in vote counting.

**Table 4.46 - E-Voting will prevent voting fraud**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	113	44.1	44.1	44.1
Agree	72	28.1	28.1	72.3
No Opinion	16	6.3	6.3	78.5
Valid Disagree	47	18.4	18.4	96.9
Absolutely Disagree	8	3.1	3.1	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.46, a total of 113 (44.1%) respondents totally agreed to that e-voting will prevent voting fraud such as double voting and results manipulations, 72 (28.1%) respondents agree, 16(6.3%) had no opinion about the question, 47 (18.4%) disagree that e-voting will prevent voting fraud and 8 (3.1%) absolutely disagree. Those who disagree were of the opinion that vote manipulation can also be done electronically.

**Table 4.47 - E-voting Will Speed up voting process**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	60	23.4	23.4	23.4
Valid Agree	196	76.6	76.6	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.47, a total of 60 respondents, representing 23.4% totally agreed to this assertion, 196 respondents, representing 76.6% agreed. All the respondents believe with the implementation of e-voting the voting process will be faster.

**Table 4.48 - E-voting will eliminate voting errors**

	Frequency	Percent	Valid Percent	Cumulative Percent
Totally Agree	87	34.0	34.0	34.0
Valid Agree	169	66.0	66.0	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From Table 4.48 when asked if e-voting will eliminate voting errors, a total of 87 respondents, representing 34% totally agree to this assertion, 169 respondent, representing 66% agree. This indicates that the respondents have the belief that with the introduction of e-voting system voting errors due to wrong thumb printing by voters will be eliminated.

**Table 4.49- E-voting will eliminate vote counting errors**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid				
Totally Agree	29	11.3	11.3	11.3
Agree	169	66.0	66.0	77.3
No Opinion	58	22.7	22.7	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

As can be observed from table 4.49, a total of 29(11.3%) respondents totally agree that e-voting will eliminate vote counting errors, 169 (66%) agree and 58 (22.7) had no opinion about this question. Majority of the respondents believe with e-voting vote counting errors will be eliminated and if there is even a need for recount it won't be a challenge.

**Table 4.50 - Voter turnout would be higher if e-voting were possible**

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid				
Totally Agree	84	32.8	32.8	32.8
Agree	70	27.3	27.3	60.2
No Opinion	41	16.0	16.0	76.2
Disagree	46	18.0	18.0	94.1
Absolutely Disagree	15	5.9	5.9	100.0
Total	256	100.0	100.0	

**Source: Fieldwork, 2019**

From table 4.50 it can be observed that 84 (32.8%) of the respondents totally agree that voter turnout will be higher if e-voting is possible, 70 (27.3%) agree, 41 (16%) had no opinion. 46 (18%) of the respondents disagree that e-voting would increase voter turnout and 15 (5.9%) absolutely disagree. The minority that disagree indicates that the fact that e-voting is implemented does not mean people will be motivated to go and vote, since there a several other factors that contributes to voter apathy.

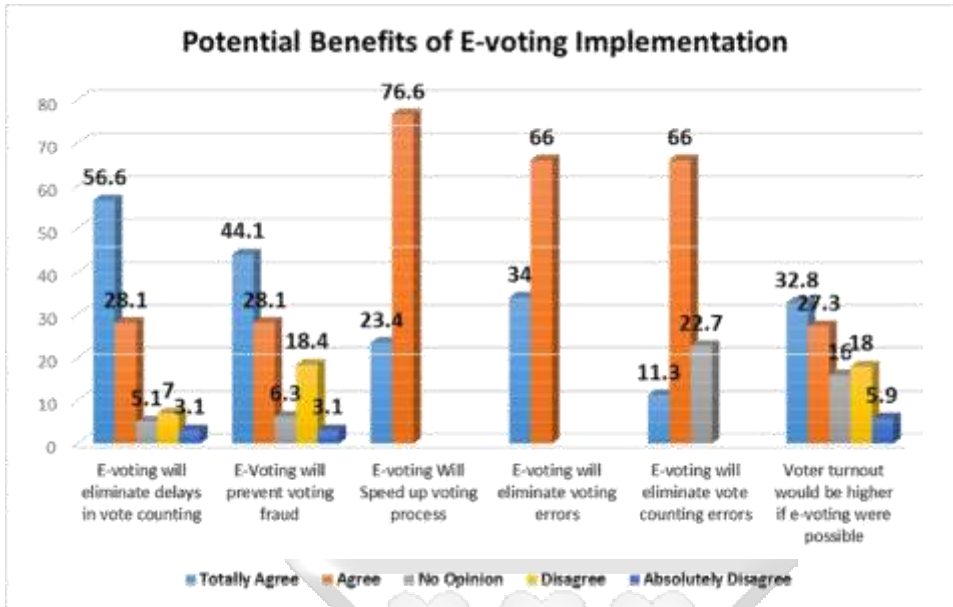


Figure 4.23 – Potential Benefits of E-voting Implementation Source: Fieldwork, 2019

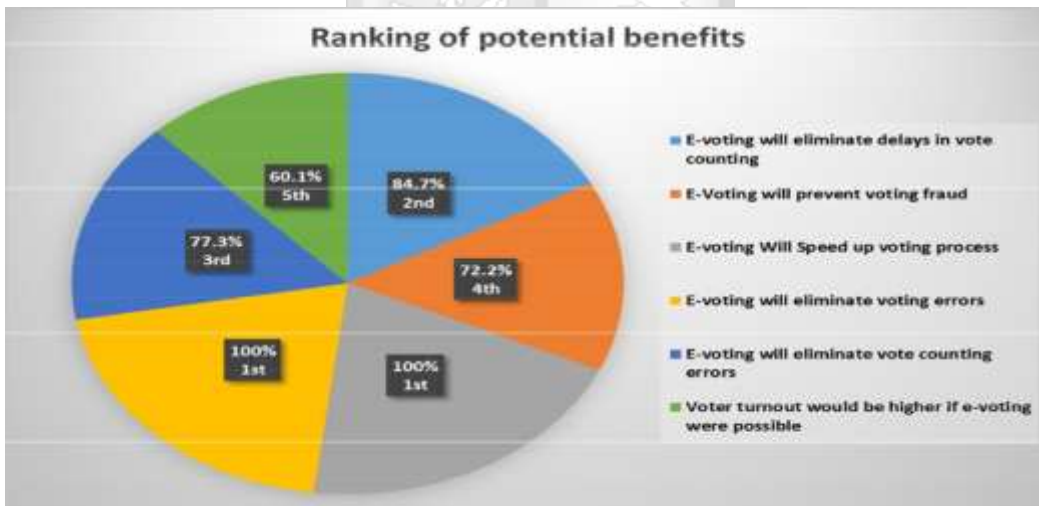


Figure 4.24 – Ranking of potential benefits Source: Fieldwork, 2019

#### 4.4 Response from Interviews

This section presents the results of the interviews conducted with selected top management of Electoral Commission (EC) officials.

##### 4.4.1 Organizational Factors

The respondents were asked if in their professional opinion they think Kenya needs e-voting system, they were of the opinion Kenya may need an e-voting system in the future, but for now we are not yet ready to implement e-voting system in 2016 election period. It was obvious from their responds that even though they all support e-voting system in principle they think Kenya is not there yet ready to vote electronically. They indicated that even the Chairman of EC, Dr Afari Gyan has categorically stated that he does not support the use of e-voting system in Kenya at the moment because of the low level education of majority of the voters, but thinks it can be implemented in the future. They quoted the EC boss saying that Kenya cannot afford to introduce more technological systems in it voting for now considering the numerous challenges EC encountered during the 2012 elections with the biometric verification system.

For the question on whether EC has the adequate ICT infrastructure to support e-voting adoption and implementation, it was confirmed that EC will definitely need to upgrade their systems to support e-voting and also train their staff and polling station officials who will operate the e-voting system.

#### **4.4.2 Technological factors**

When the interviewer asked what challenges in the current paper-based voting they think e-voting will eliminate, they indicated that if e-voting is well implemented it will definitely speed up voting process, it will eliminate spoils votes due to wrong thumb printing, it will also eliminate the delays in vote counting and also make recounts of vote much simple (if the need be). They were also of the opinion that e-voting can reduce double voting and results manipulation.

Again when asked about the potential benefits of e-voting implementation, they indicated numerous benefits that could be gained from it. Some of the benefits they mention are as follows:

1. E-voting will prevent multiple voting
2. It will eliminate spoilt ballots
3. It will speed up the voting process and reduce the long queues at the polling stations
4. It will make counting of results easier, faster, and reliable

5. It will reduce the number of polling officers at various polling stations thereby reducing the cost incurred to run an election

They were however of the opinion that e-voting will not guarantee that voter turnout will be higher, since voting electronically may not be a motivating factor to compel voters to vote.

The interviewee were asked if they foresee any challenges of e-voting implementation in Kenya. They indicated that from EC point of view the main challenges they are likely to face if they implement e-voting now will be the high illiteracy rate among the voting population and the lack of electricity power supply at various polling station in remote areas. They were of the opinion that most voters in the rural areas are not educated hence if massive education on the use of e-voting is not done, it will be difficult for such people to understand and use the e-voting system. They also agreed that cost of implementation can also be a challenge, but believe when they are ready to implement there will be government support.

The researcher asked if the EC will need additional ICT infrastructure before e-voting implementation will be possible. Their response shows that they will definitely have to invest in additional infrastructure since this is a new innovation, but the magnitude of the investment will depend of the model of e-voting system EC will decide to adopt. Some of the possible models they spoke about were the Indian EVM, which runs on 6V battery, and US AccuVote (by Dieblod) DRE voting machine that runs on electricity. They further argue that the Indian EVM cost less (around \$250 per system) as compare to US DRE machine which is around \$3350. And also Indian EVM runs on 6V battery and US model runs on electrical power and since not all polling stations has electricity supply, the Indian model will be more suitable for adoption. They indicated that we could have a blend of the US and Indian e-voting system, but the system must be able to run on both battery and electricity. They also cited some basic infrastructure like stable internet connections at various polling station will be required.

#### **4.4.3 External factors**

When the researcher asked if the existing ICT infrastructure can be able to support e-voting implementation, all the respondents disagreed that the existing infrastructure can fully support e-voting implementation. They were of the opinion that there must be infrastructural improvement in

the country to enable nationwide e-voting implementation be a reality. They were of the view that even when this technology is introduced it will be done on pilot basis at areas where adequate infrastructure are available. They indicated that it is absolutely important to do a pilot project before actual implementation, since the pilot test will bring to bear any challenges and it will help to find a way to resolve it as well. They were also of the view that the pilot test will help build the voters confidence in the system.



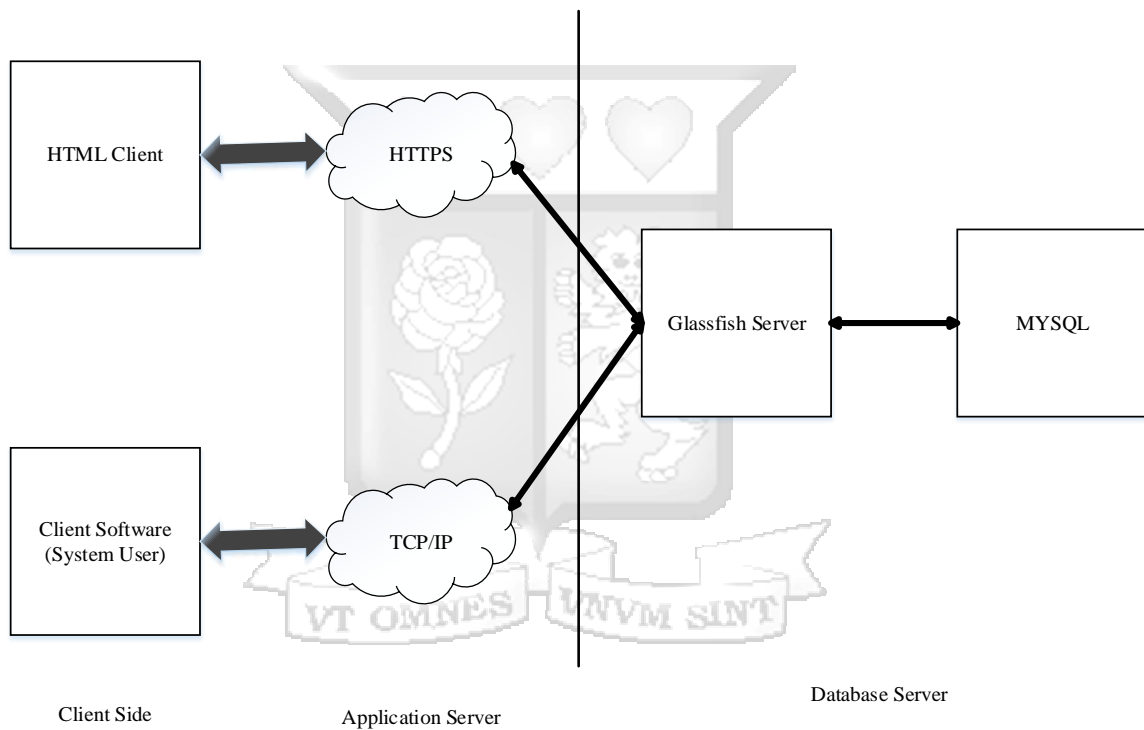
## CHAPTER FIVE: SYSTEM DESIGN, ANALYSIS, AND PROTOTYPE

### Introduction

This chapter discusses the aspect of software modelling for the electronic voting system

### 5.1 Communication Interface

The above below shows the connectivity between the client side, application server and database server. The voters will access the system using a user interface that is built in HTML.



**Figure 5.1 – Communication Interface Diagram: Source (Author, 2019)**

## 5.2 DFD Level 0

The diagram below is a level 0 DFD (Data Flow Diagram) that shows the flow of data between the components of the system. In this system, the administrator controls the core functionality of the system. The Administrator is responsible to perform core functions like starting and stopping the electoral process, performing password resets for voters who are not able to login to the system among other administrative duties.

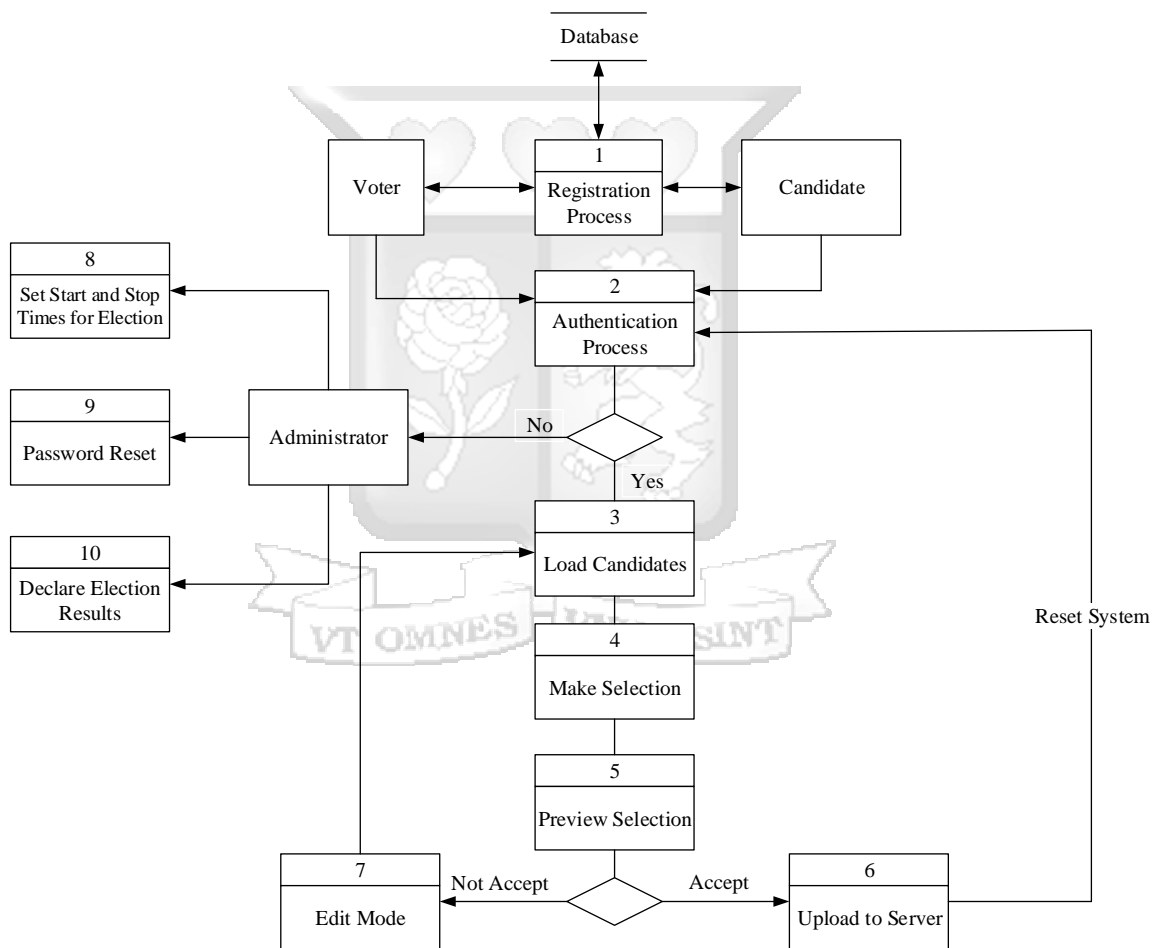
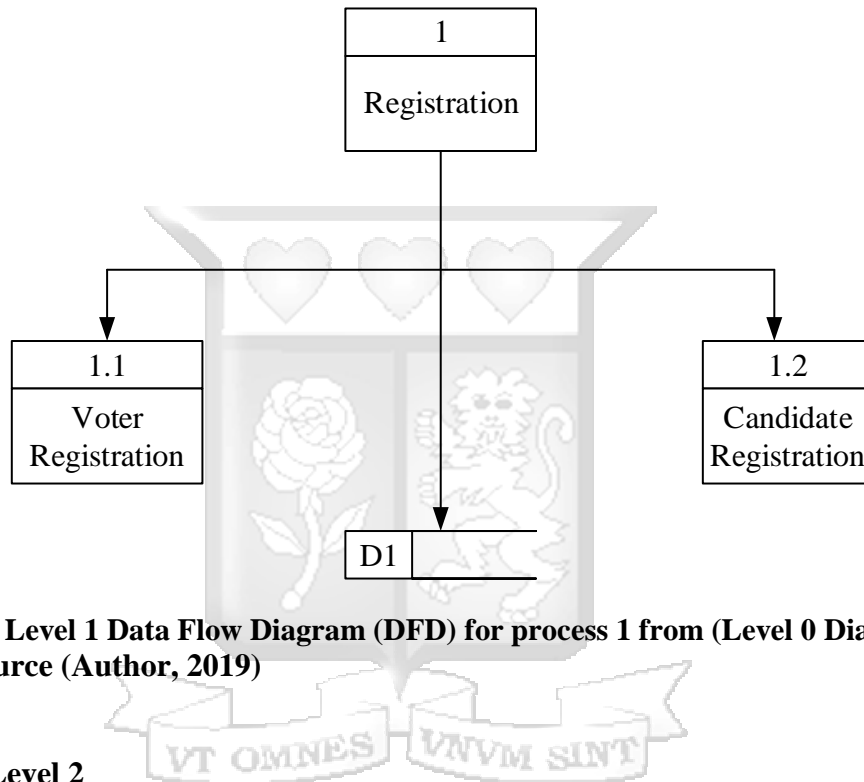


Figure 5.2 – DFD Level 0 Diagram: Source (Author, 2019)

### 5.3 DFD Level 1

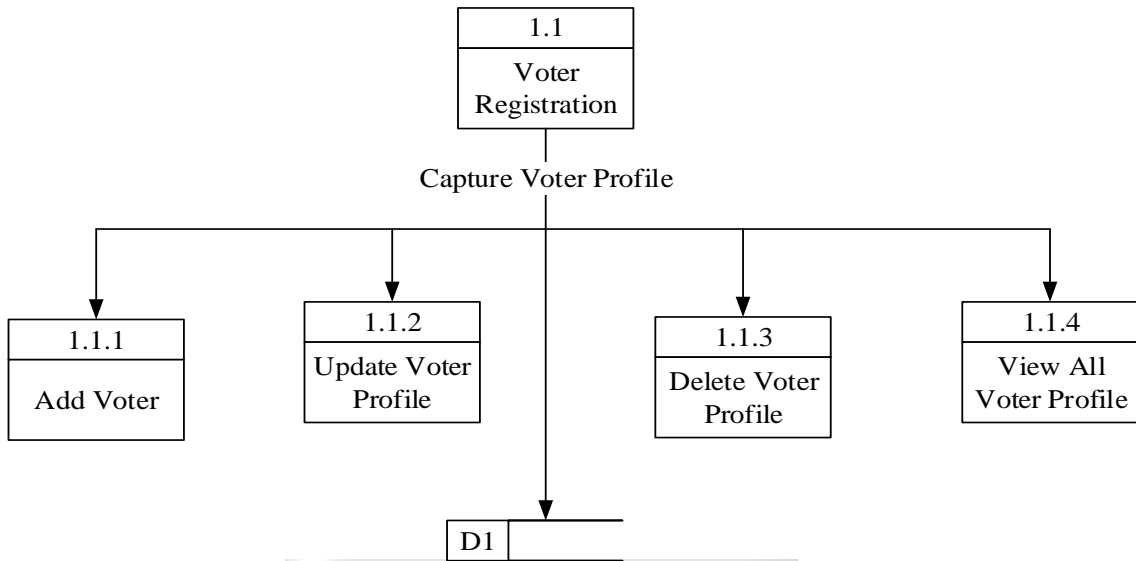
The diagram below is level 1 Data Flow Diagram for the registration process. According to this DFD, registration is mainly done voters who wish to exercise their democratic right of participating during a general election and candidates who are vying for various electoral positions.



**Figure 5.3 Level 1 Data Flow Diagram (DFD) for process 1 from (Level 0 Diagram) above: Source (Author, 2019)**

### 5.4 DFD Level 2

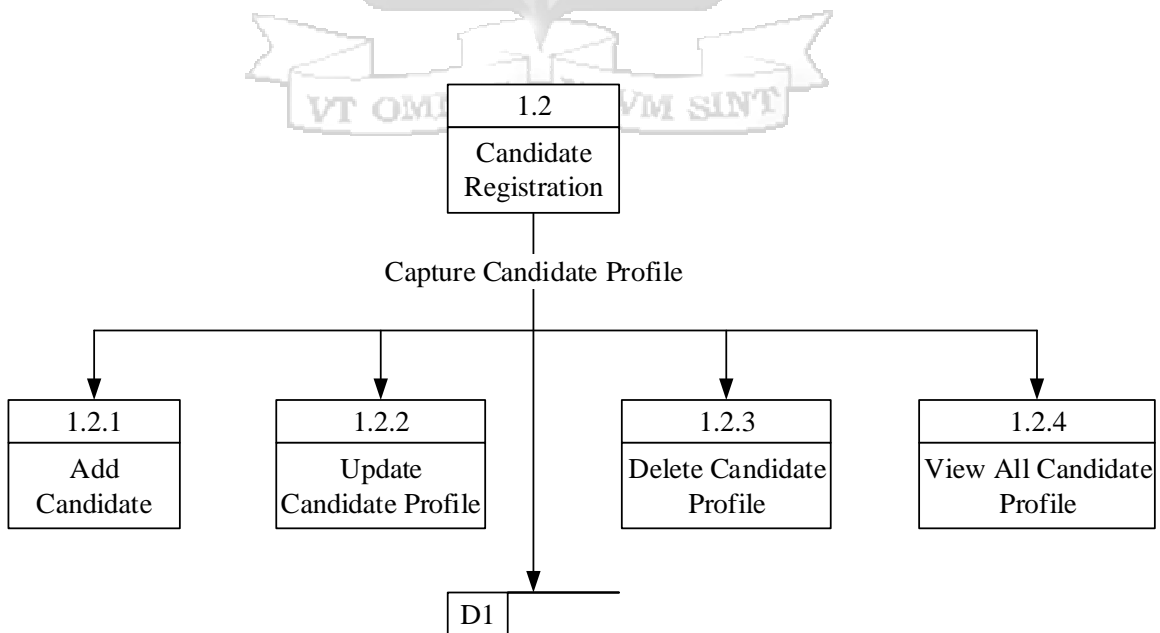
The diagram below is level 2.1 Data Flow Diagram for the voter registration process. According to this DFD, voter registration entails, adding a new voter, updating an existing voter profile, deleting an existing voter profile and viewing all voter profiles captured in the system.



**Figure 5.4 Level 2.1 DFD for process 1.1: Source (Author, 2019)**

### 5.5 DFD Level 2

The above diagram is level 2.1 Data Flow Diagram for the candidate registration process. According to this DFD, candidate registration entails, adding a new candidate, updating an existing candidate profile, deleting an existing candidate profile and viewing all candidate profiles captured in the system.



**Figure 5.5 Level 2.1 DFD for process 1.2: Source (Author, 2019)**

## 5.6 IDENTIFICATION OF ACTORS

Actors represent the users who are using the system. They actually help in giving a clear picture of what the system does. For these system, the following actors are identified,

1. Administrator
2. Candidate
3. Server
4. Voter

### 1. Administrator

This is the person who is in charge of the core system functionality. His duties include but not limited to, start and stop the system to vote, perform password resets for users, review audit logs among other duties.

### 2. Voter

This is a user in the system who is exercising their democratic right of voting.

### 3. Candidate

This is a system user who has expressed interest to vie for an electoral position.

### 5. Server

The core function of the server is to maintain the database and manage the electronic voting system.

## 5.7 IDENTIFICATION OF USECASES

Use cases identified are:

1. Declare an election
2. Create profiles
3. Update profiles
4. View profiles
5. Voting
6. Results

### 1. Declare an election

The electoral body in charge of conducting the general election will announcement the date for the election date, produce a list of candidates who are eligible to vie for different positions.

## 2. Create profiles

Voters have to be enrolled into the system by visiting different centers that have been designated for registration

## 3. Update profiles

In case of any changes on the existing profiles, voters can update their profiles at the registration centers

## 4. View profiles

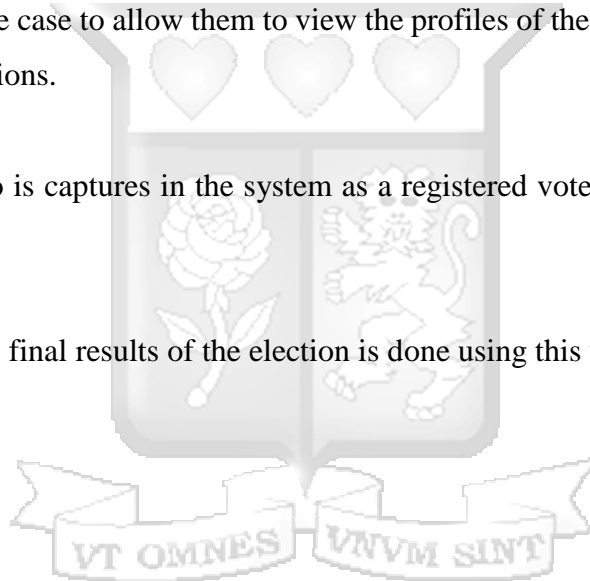
Voters use this use case to allow them to view the profiles of the candidates who are vying for different positions.

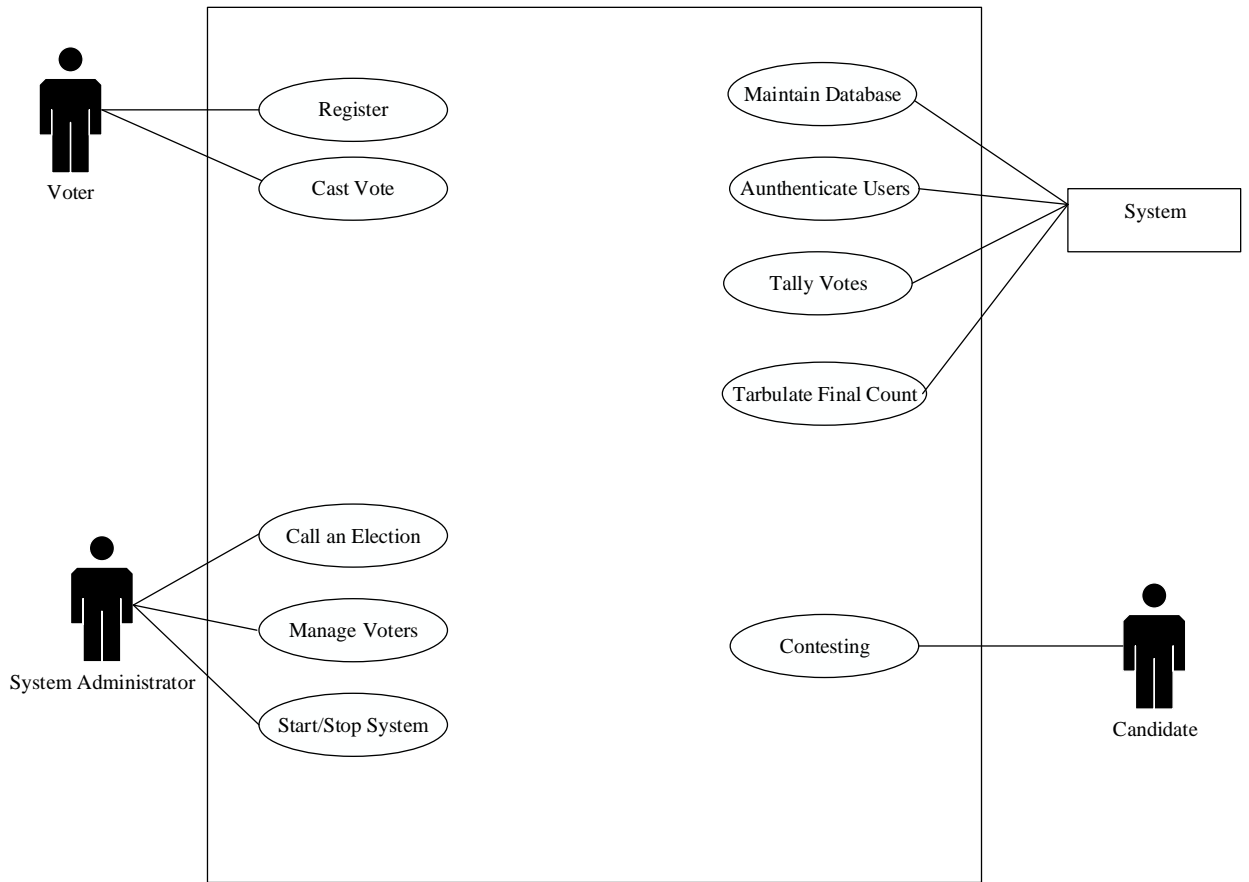
## 5. Voting

Any member who is captured in the system as a registered voter will use this use case to cast their vote.

## 6. Results

Declaration of the final results of the election is done using this use case.



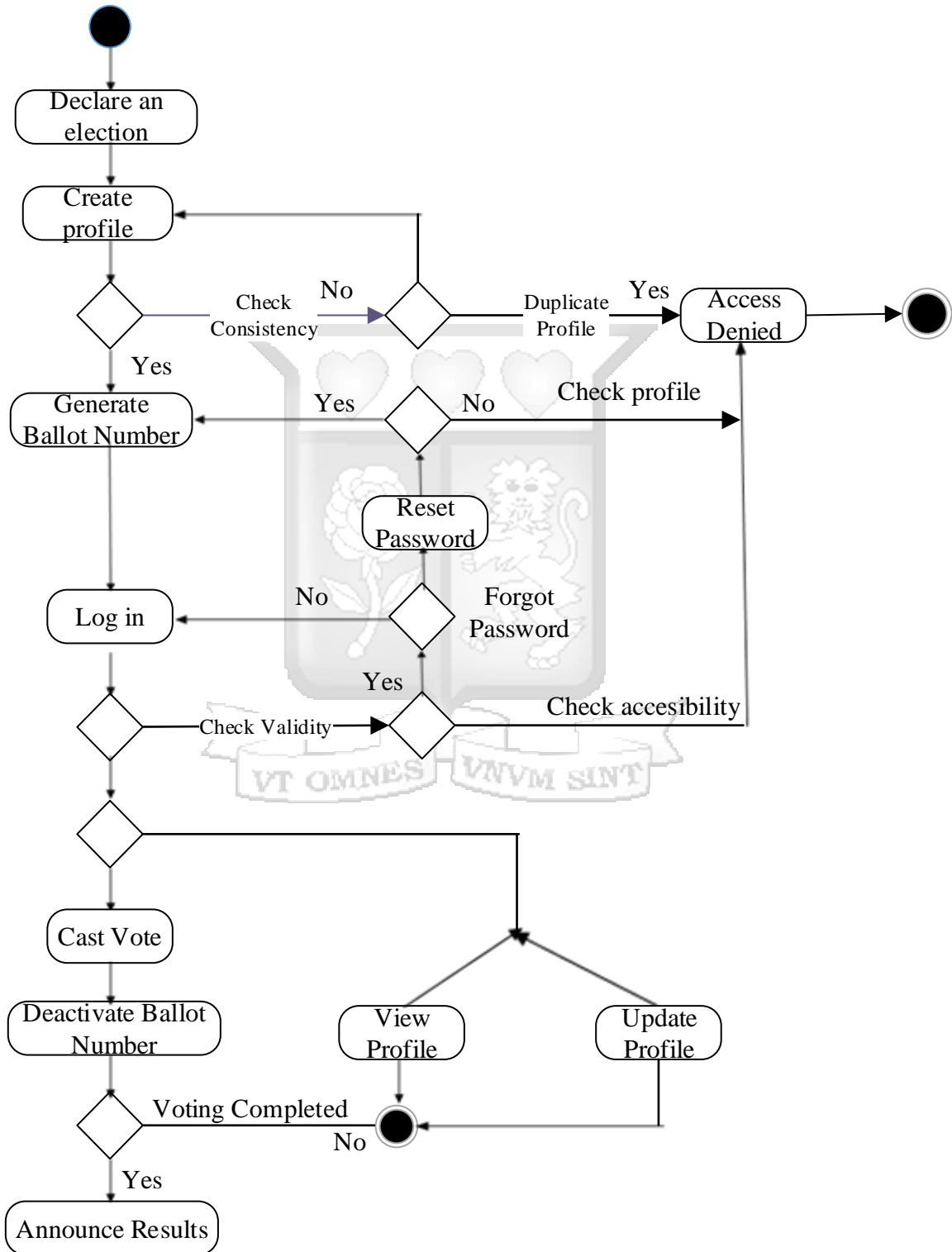


**Figure 5.6 Use case diagram for the system: Source (Author, 2019)**



## 5.8 FLOW OF EVENTS

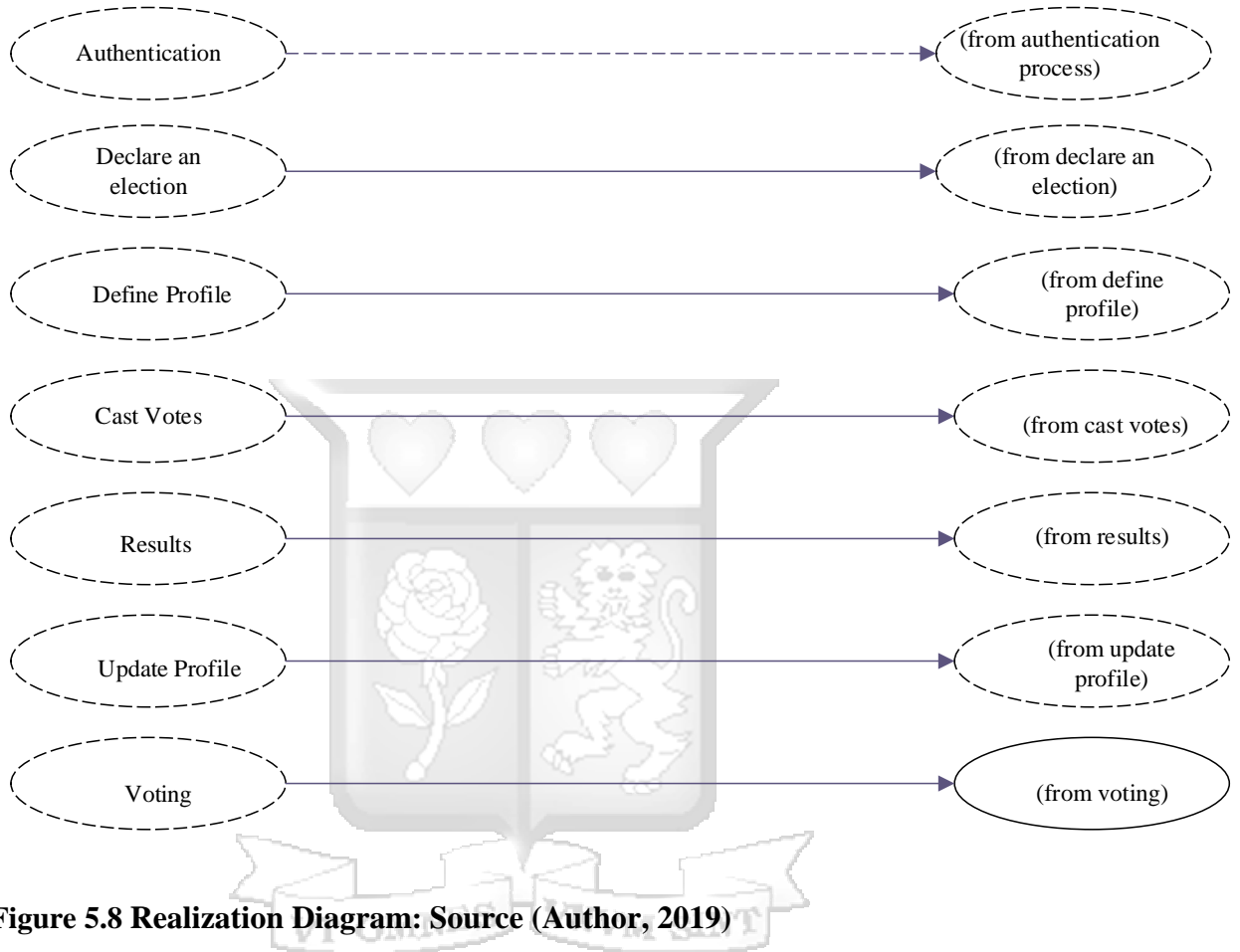
For this system, the flow of events will outline a sequence of transactions carried out by the system



**Fig 5.7 Activity Diagram: Source (Author, 2019)**

## 5.9 CONSTRUCTION OF USE CASE REALIZATIONS

A use case realization of this system a step by step. Below is a construction of the case realization of the system.



## 5.10 CONSTRUCTION OF UML STATE CHART DIAGRAM

State chart diagram for this system shows a model of individual classes or any other kind of object.

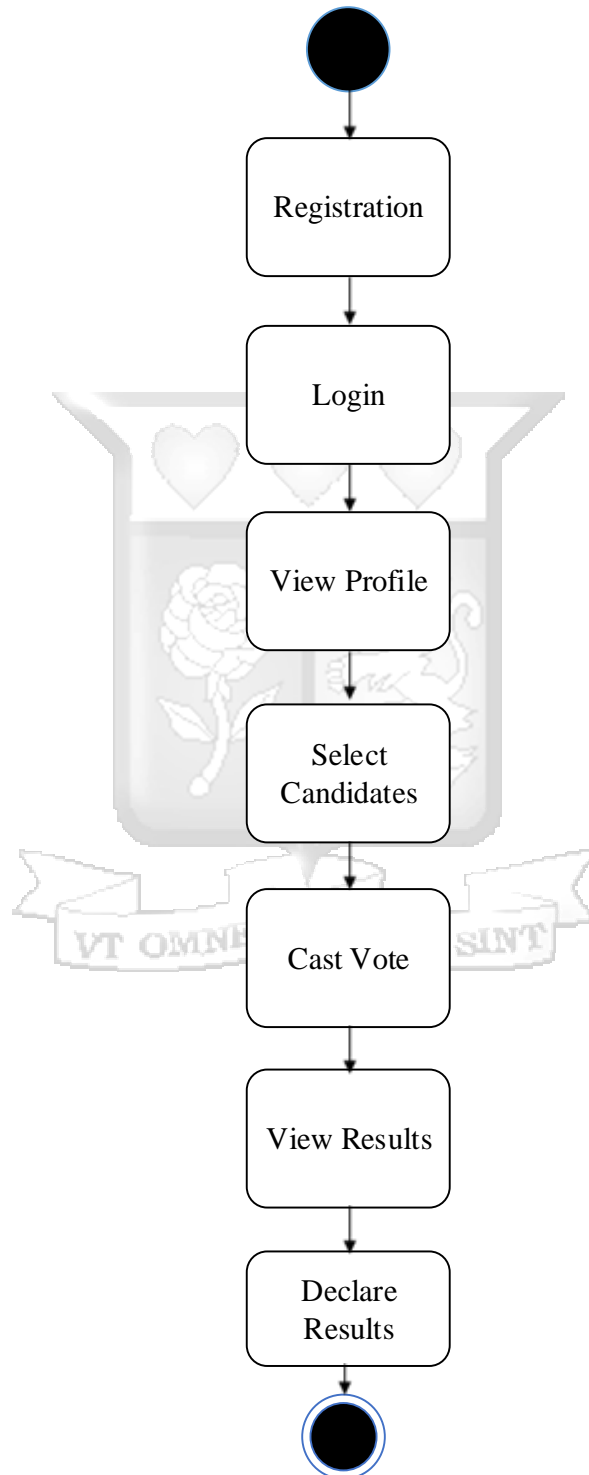


Figure 5.9 UML State Chart Diagram: Source (Author, 2019)

## 5.11 CONSTRUCTION OF SEQUENCE DIAGRAM

A sequence diagram for this system shows a graphical view of how the objects flow in a time sequence step by step.

Below is the sequence diagram of the system

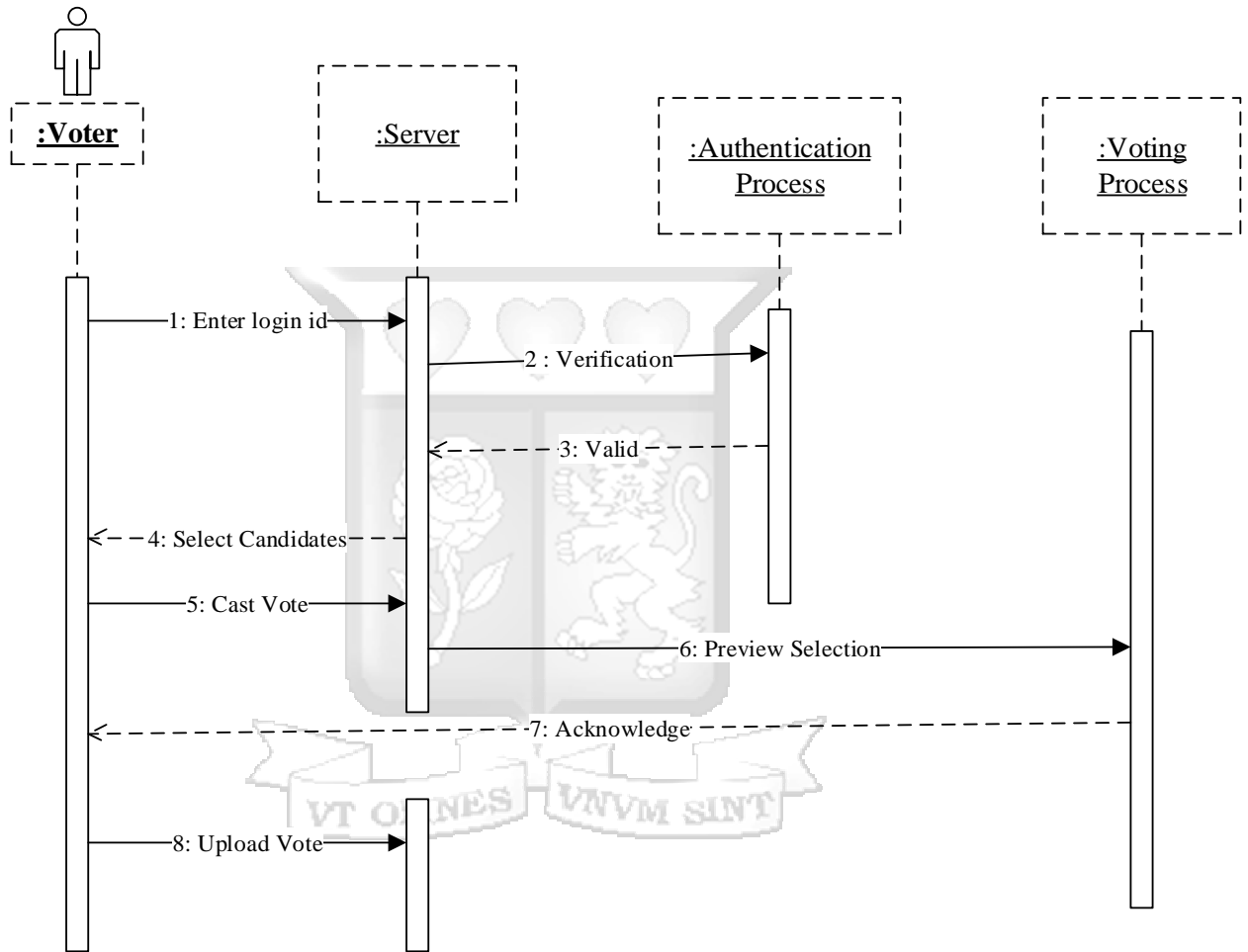


Figure 5.10 Sequence Diagram: Source (Author, 2019)

## CHAPTER SIX: SYSTEM IMPLEMENTATION

### Introduction

Following the system design, the system was implemented. This involved coding and construction of the system components. System testing was also conducted to ensure it met functionality as well as user requirements.

### 6.1 Prototype design of E-voting System

#### 6.1.1 System description

All code is written entirely in java programming language. The system employs a java enterprise application standard which makes use of the tiered design pattern allowing for scalability using distributed approach. . All components are an extension of the server to the client machine, allowing for dynamic content delivery. Voters are only allowed to vote once. After voting, the user identity is flagged to prevent another attempt. Any further attempted logins will be denied access.

Communication between the client machines and the servers are secured preventing eavesdropping or snooping on the user's identity in transit.

Further once the data is delivered to the server, the application environment also provides added layer of security ensuring that only authorized personnel have permission to view data.

To further enhance security all user actions on the client terminals are relayed to the server based on event response model.

The system can be easily audited. It keeps track of all the events performed by the user from the moment they login to the moment they logout. Security logs can be generated based on user activity. These logs can only be viewed by users with administrative rights.

#### 6.1.2 System Functionality

Authenticate users. The login username will be the national ID number since it will be a unique identifier that cannot be shared.

When the voter accounts are first created, personal information is collected from each voter that will be used to capture their profiles in the system. The system then generates a user

name and password for each voter. Once the user has logged in, they are presented with different groups of political candidates to vote for. All voters across the country will get the same political candidates for presidential candidates. For governors, senators and women representatives, each voter will get different candidates depending on which county they are registered to vote. For members of county assembly, voters will get different candidates depending on which wards they are registered in.

Also key to the system is that all political candidates are required to be registered as voters before they can be registered as political candidates.

Once a voter has selected all the candidates of choice, they are presented with a preview window, if they agree with the selection, then they can complete the process by clicking on the “Cast Vote” button. If they want to make any changes, they will have to click on the “Edit Selection” button which will then allow them to edit either a certain section (Presidential candidates, Governors, Senator, Women Representatives or Members of County Assembly) or start all over again. Once this is complete, they will return to the preview selection and cast their votes.

After successful casting of the vote, the login credentials for the user are then flagged. The user cannot be allowed to login back to the system.

### **6.1.3 Web Application**

The web application was developed using Hypertext Preprocessor (PHP), HTML, and CSS. These languages were used to create the web site that is the user interface of the system. The website was hosted on glassfish server mainly because it is an open source platform

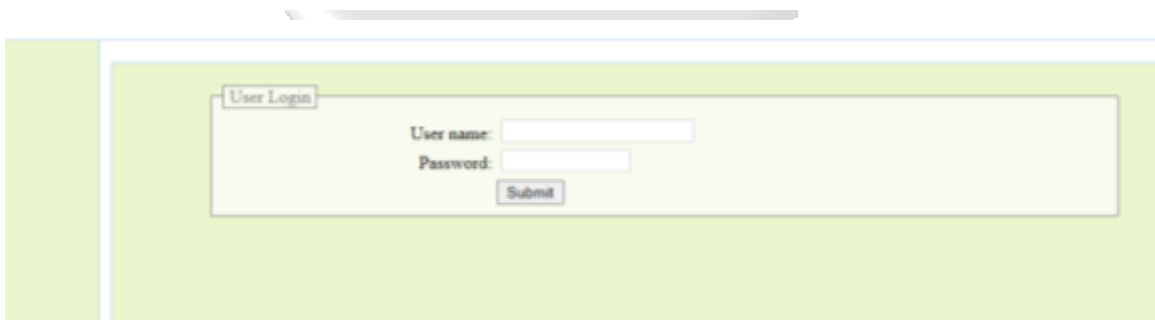
### **6.1.4 Database**

The system is using two different databases. The electoral process that involves capturing data is managed using election database. The security aspect that involves starting/stopping the election, managing and viewing of security logs is managed using a security database. Both of them run on MySQL platform. This platform was used because of its compatibility with PHP and other platforms as well as the ability to encrypt passwords before storage. This ensures that confidentiality and integrity aspects are enforced.

## 6.2 Major System User Interface

To demonstrate system functionality and how the system can be used in managing the electoral process, including capturing data, casting votes, and managing system security, the following screenshots were captured.

All system users login to the system using the same login page. What determines the information that loads is the type of account of the user. There are three different two of accounts; Voter account which has the lowest level of clearance, and Administrative Account.



**Figure 6.1 Showing Login Page of the system**

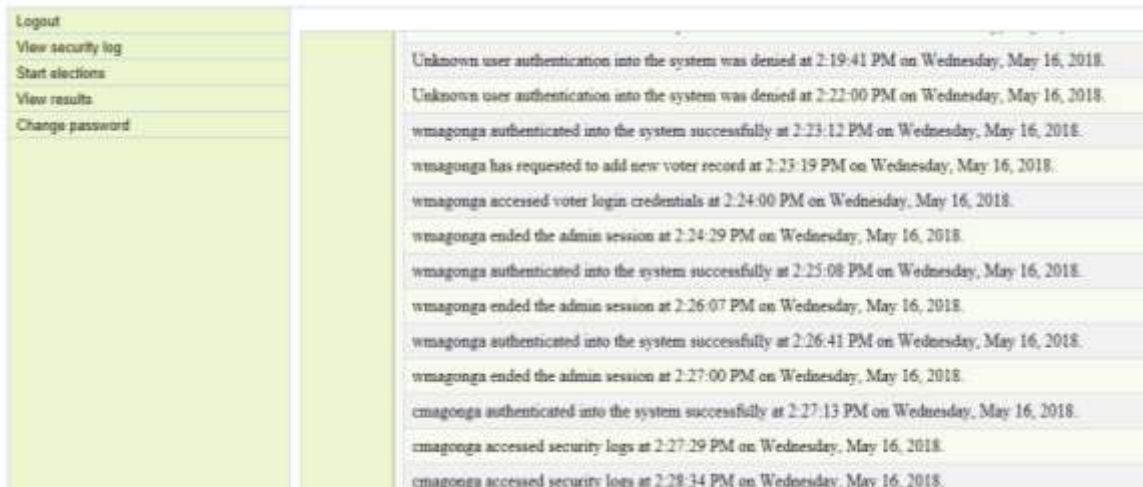
The administrator account is able to perform the following functions,

- 1) Start/Stop an election,
- 2) View security logs, and
- 3) View election Results



**Figure 6.2 Showing Functions of an Administrator**

The system can actually be audited. It captures all the activities performed by system users and generates system logs.



**Figure 6.3 shows a log file of the system logs of activities performed by the user**

After the election has been stopped, the system tabulates the final count and provides the election result. The system administrator is required to choose the candidate group from the drop down list and query the system for the result



**Figure 6.4 shows the Election Result Selection by group**



**Figure 6.5 shows the tabulated result of the presidential candidates**  
For security purposes, the system makes provision for change of password for the administrator account



**Figure 6.6 shows capability for Password Reset**

For purposes of capturing data, the system makes provision for data entry account to capture voter and candidate details.



**Figure 6.7 shows Summary of data that can be captured by the system**

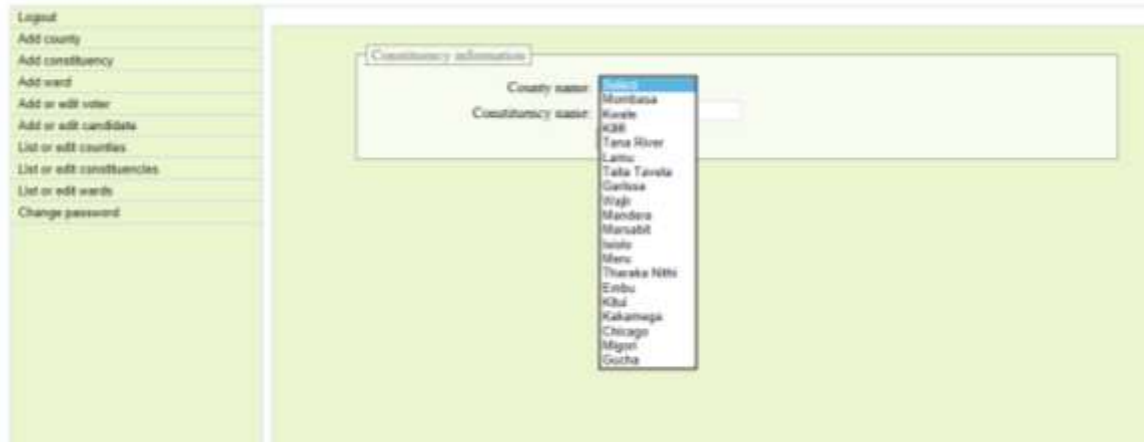


To add a county, click on the Add County button



**Figure 6.8 shows Capturing County Details**

Once a County is added, it is added to a drop down list. To add a constituency, one must select which county the constituency belongs to.



**Figure 6.9 shows Capturing of constituency details**

To capture voter details, one must have a valid ID number. The system will also require the ward that the voter belongs to so that it can capture the correct county and constituency.



**Figure 6.10 shows data collection form for capturing voter details**

Upon submitting the data to the system, the system generates a username and password which will be used for login credentials to the system. Just in case voters forget their login credentials; the administrator can retrieve the information as long as they have their voter number. Once the voter number is entered the Get Credentials button becomes active.



**Figure 6.11a Shows voter record successfully captured and login credentials generated.**

**Figure 6.11b shows voter information is valid.**

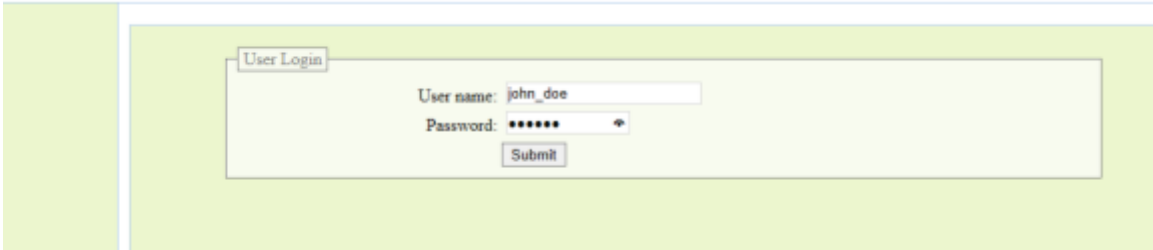
**Figure 6.12 shows voter login credentials retrieved**

To capture information for a candidate, one must be a registered voter. Once the voter number is entered in the system, the system will display the data. The elective position and photograph are then captured.

**Figure 6.13 shows candidate capturing information**

## Voting Process

Voters who are registered in the system and have the correct login credentials can login in to the system and cast their votes.



**Figure 6.14 Showing voter accessing the system**

Voting can only happen if the system has already been prompted for voting. If the system is not open for voting, voter login request will be denied.



**Figure 6.15 showing voter login attempt declined**

The system administrator logs in to start the election process. From the screenshot above, it shows that the election process has not started because the start elections button is active

Logout
View security log
Start elections
View results
Change password

**Figure 6.16 showing functions that can be performed by a system administrator**

Once the admin starts the election, the caption of the start election now changes to stop election. This implies that the system is open for voting and voters can now login and cast their votes

Logout
View security log
Stop elections
View results
Change password

**Figure 6.17 showing the system is open and the voting process can start**

Any login attempt after the system has been opened for voting will allow the voter to cast their vote

The screenshot shows a 'User Login' form. It contains two input fields: 'User name: john\_doe' and 'Password: \*\*\*\*\*'. Below the password field is a 'Submit' button. The form is set against a light green background.

**Figure 6.18 showing a voter trying to login to the system**

If authentication is valid, a page to select various candidates is provided

The screenshot displays an 'Authorized task list' page. It features a heading 'Authorized task list' and a sub-heading 'Your authorization grants you access to perform the following task:'. Below this is a numbered list of six tasks: '1. Elect the president', '2. Elect the governor', '3. Elect the deputy governor', '4. Elect the senator', '5. Elect the member of parliament', and '6. Elect the councillor'. At the bottom of the list is a button labeled 'Proceed to voting page'. The page has a light green background.

**Figure 6.19 showing voter has logged in to the system and can select the respective candidates**

Once the voter clicks proceed to voting page, the system loads a page that will allow the voter to select various candidates

Elect president
Elect governor
Elect woman representative
Elect senator
Elect member of parliament
Elect councillor
Vote Summary

**Figure 6.20 showing different categories of candidates to vote for**

Once the voter clicks on the presidential candidate, the registered presidential candidates are loaded. The system will load the same presidential candidates across the country. The green arrow enables the voter to scroll through the list of presidential candidates



**Figure 6.21 showing candidates for presidential category**

Once the voter makes a selection, the choice is indicated by a red line surrounding the selected candidate image



**Figure 6.22 shows a candidate that has been selected**

After the voter has selected all the candidates, the summary page allows the voter to review the selection



**Figure 6.23 showing summary page of the candidates selected by the voter**

Once the user has voted, the account is flagged and disabled. If the user tries to login again, the request is denied and the message below is displayed



**Figure 6.24 showing access denied to a voter to has already cast their vote**

### **6.3 System Testing**

System testing was carried out to test the behaviour of the system based on electronic voting system requirements specifications. Various tests were conducted including the logic and accuracy test, functionality test, compatibility test and usability tests. The tests were undertaken to determine its suitability to the voters and electoral body in Kenya.

#### **6.3.1 Logic and Accuracy Test**

Logic and Accuracy testing was conducted to ensure that the electronic voting system was properly configured, tested, and certified for accuracy prior to an election. The software was tested to ensure that the system's counting software was tallying the casted votes properly, guaranteeing that each casted vote was accounted for. The logic and accuracy test involved two phases;

The first phase, the system was tested for potential voter choices are tested for accuracy. Mainly this portion of testing focused on the voter declining to votes, voter attempting to vote for more than one candidate in a specific group of candidates, and voter attempting to vote more than once. This phase is passed only when there is a perfect match between the test votes cast counts and the predetermined test vote counts.

The second phase of testing was ballot voting. This test was conducted multiple times and the results were compared. A group of testers was selected and requested to vote twice using different methods. The first method was to select their choice of candidates by marking ballot papers. This is the manual voting system. The second method was to login

to the electronic voting system and cast their votes ensuring that their selection was exactly the same as the previous method. The results were checked and compared.

### 6.3.2 Functionality Test

The main focus of this test was to establish whether the developed solution met all the functionalities as per the expectations and user requirements. A group of selected voters that involved the IEBC staff was selected to ensure that the correct system software and firmware were loaded. This test was instrumental in ensuring that the system was free of software bugs and hence confirm that key objectives of study were met.

**Table 6.1 shows test conditions and results for system testing:**

S/NO	Test	Expected Result	Achieved Result
1	System Loading	The system to correctly launch the web interface and display the login screen	The system successfully launched the web interface and login page
2	Load Presidential Candidates for Voters	The system to load the same Presidential candidates for all voters	The system successfully loaded the same Presidential Candidates for all registered voters
3	Load other candidates based on location	The system to load other candidates based on the ward that the voter is registered	The system successfully loaded candidates based on the location where the voter is registered
4	Ability to vote during a specified period	The system should limit voters to vote during a specified period	The system made provision for the system administrator to start and stop the system during voting

5	Ability for the system to track all actions performed in the system	The system should make provision for auditing	The system generates a log file of all activities performed
6	Ability for a user to cast their vote only once	Voters should not be allowed to vote more than once	The system flags voter accounts after voting and does not allow them to login after voting until the election period is closed

### 6.3.3 Compatibility Test

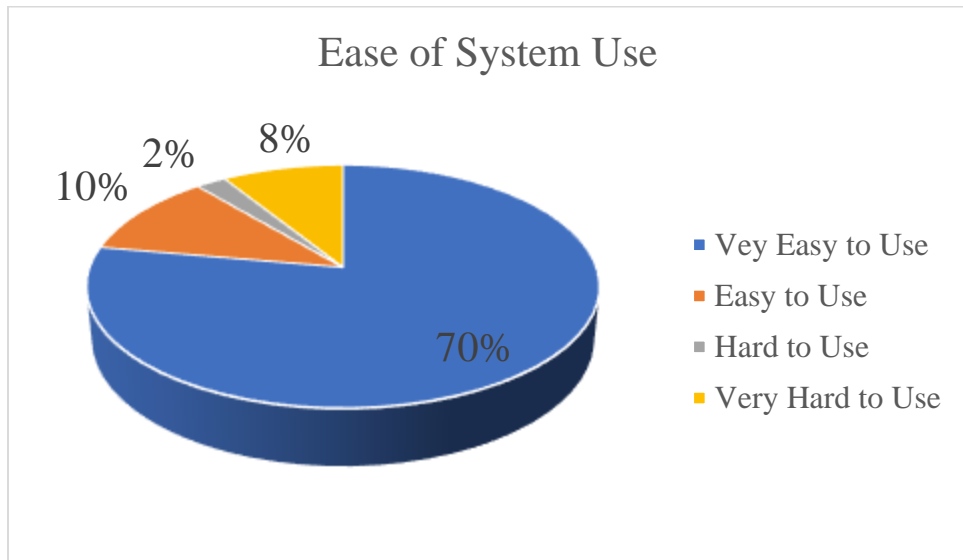
During this test, the system was tested for access from different platforms and web browsers to confirm that they were actually compatible. Some of the platforms that were tested included mobile phone and tablets, Macintosh and Windows computers. The results actually proved that the system was compatible with all platforms and web browsers that were tested.

### 6.3.4 Usability Test

This testing was conducted by potential system users and their feedback was analysed to determine whether the system met their needs and requirements. The users were given access to the system and asked to test. Thereafter, they were presented with a short questionnaire which required them to respond to questions regarding how they rated the system in terms of usability.

#### a) Ease of System Use

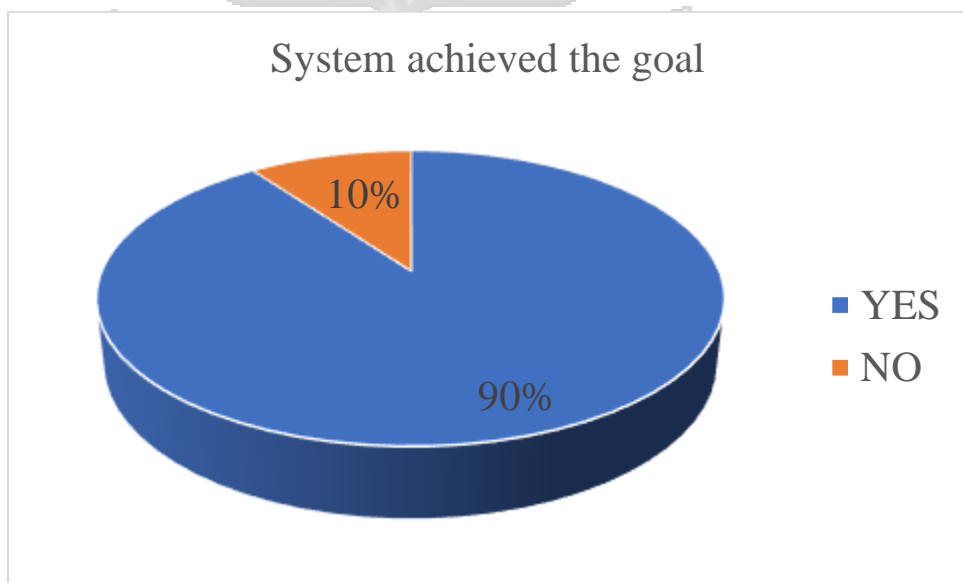
The users were asked to rate the ease of use of the developed electronic voting system solution, 70% of the respondents indicated that the solution was very easy to use, 20% said it was easy to use while 10% felt that the system was somewhat hard to use. The results are as shown in Figure 6.25. This therefore confirms that the solution is user-friendly.



**Figure 6.25 usability test**

**b) System achieved the goal**

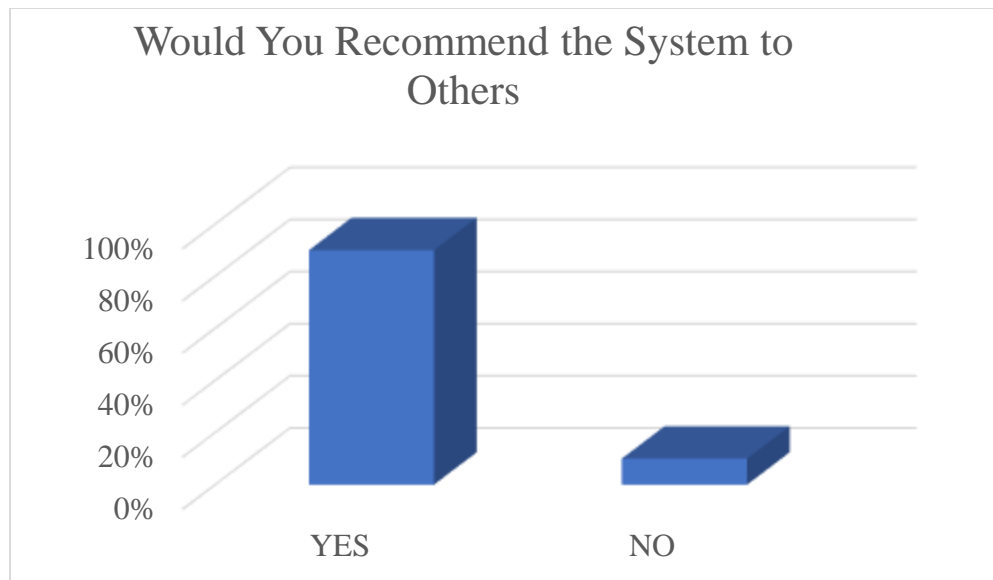
As shown in Figure 6.26, 90% of the respondents said they felt the solution was fit for the purpose is intended to, while 10% felt it was not. This goes to show that the developed electronic voting system meet the user requirements.



**Figure 6.26 system achieved the goal**

**c) Willingness to Recommend the System to Others?**

When asked whether they would recommend the electronic voting system to other people, 90% of the respondents said would recommend, whereas 10% felt they wouldn't, as shown in Figure 6.27. This willingness of a vast majority to recommend the system to others shows the confidence that the respondents have hence a proof that it is a value-adding solution and hence a contribution Kenyan electoral body.



**Figure 6.27 would you recommend the system to others**



## CHAPTER SEVEN: CONCLUSION AND RECOMMENDATION

### Introduction

This chapter discusses the summary conclusion and recommendations of the study.

### 7.1 Conclusion

The previous two chapters have proposed the new e-voting scheme which enriches the existing e-voting systems, and presents a more improved e-voting system. The system employs a java enterprise application standard which makes use of the tiered design pattern allowing for scalability using distributed approach. All components are an extension of the server to the client machine, allowing for dynamic content delivery. Voters are only allowed to vote once. After voting, the user identity is flagged to prevent another attempt. Any further attempted logins will be denied access.

The system can be easily audited. It keeps track of all the events performed by the user from the moment they login to the moment they logout. Security logs can be generated based on user activity. These logs can only be viewed by users with administrative rights. In the proposed system users are authenticated using login username will be the national ID number since it will be a unique identifier that cannot be shared.

When the voter accounts are first created, personal information is collected from each voter that will be used to formulate security questions. These security questions are essential for voters during the initial login and to reset their passwords just in case they forget login information. Part of the account creation process is to set temporary passwords which the voter is required to change upon the first successful login to the system. All these information (username, security questions, and temporary password) is then communicated to the voter via their emails.

Once the user has logged in, they are presented with different groups of political candidates to vote for. All voters across the country will get the same political candidates for presidential candidates. For governors, senators and women representatives, each voter will get different candidates depending on which county they are registered to vote. For members of county assembly, voters will get different candidates depending on which wards they are registered in.

Once a user has successfully cast their vote, their login credentials are flagged. They are not able to log back into the system

Voters will not be able to vote unless the system has been prompted for voting. This will ensure that voters can only vote within a specific time frame that will be set.

## **7.2 Recommendations**

The study recommends use of e-voting systems to overcome the challenges of manual voting systems. The study proposes a new e-voting platform that can be used to carry out elections and recommends the use of the system for elections particularly in Kenya and in other countries that intend to adopt the use of e-voting systems.

The study recommends abolishment of manual voting system particularly in Kenya that have for a long time contributed to bungled elections with the adverse effects of post-election violence due to disputed general election results. It is imperative that modern e-voting systems are adopted by the electoral body in Kenya to address the myriad of challenges that have been caused by manual voting systems.

## **7.3 Suggested Areas for future work**

This study leaves a lot of opportunities for future studies. There are available areas that need more improvement and better system design. This system has been programmed using Java. Future studies can explore development of systems using other programming languages and different security architecture and test whether the results are similar or varied. This system is also designed for people with at least basic internet and technology knowledge and is not user friendly to persons who are completely illiterate in this domain. Future systems can also encompass other voters such as persons with disability.

In a normal voting framework, other personnel are usually involved in the voting process and a system that incorporates other actors in the voting system would be a worthy area to conduct future research

## REFERENCES

Aboelnaga, H., Hussein, H. (2013). Design of a Secured E-voting System. *IEEE*

Bruneton, E., Coupaye, T., Leclercq, M., Qu'ema, V. and Stefani, J.B. (2004). An Open Component Model and its Support in Java, in *Proceedings of the International Symposium on Component-based Software Engineering (CBSE'2004)*, Edinburgh, Scotland.

Carter Center Report. (2017). *2017 Kenya General and Presidential Elections*, Final Report.

Cooper, C. R., & Schindler, P. S. (2008). *Business research methods*(10<sup>th</sup> ed.). Boston: McGraw Hill.

Ebaid, S.M., Hayajneh.S.T., Al-Jarrah, O., Malkawi,M. &Khasawneh, M. (2008). A Biometric-Secure e-Voting System for Election Processes. *Proceeding of the 5th International Symposium on Mechatronics and its Applications (ISMA08)*, Amman, Jordan

Essths, A.T. (2012). Building reliable security systems: the case of an e-voting system. *International Conference on Information Technology and e-Services.IEEE*.

Everett, S., Greene, K.& Byrne, M. (2008). Electronic voting machines versus traditional methods: Improved preference, similar performance. In *CHI 2008 Proceedings Measuring, Business, and Voting*. pp. 883–892. Available at:

<http://dl.acm.org/citation.cfm?id=1357195>

Goldsmith, B. (2011). Electronic Voting & Counting Technologies, *International Foundation for Electoral Systems (IFES)*.

Gupta, V. (2011). E-voting Move to Intelligent Suffrage. *SETLabs Briefings*, 9(2): 3-9.

- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7<sup>th</sup> Ed.). Upper Saddle River, New Jersey: Prentice Hall.
- Ham, C. (2007). Green Labelling: Investigation into the marketing of FSC certified timber along the domestic timber value chain in South Africa. MBA thesis work, Stellenbosch University South Africa.
- Jegade, A.J., Aimufua, G.I. & Akosu, N.I. (2012). Electronic Voting: A Panacea for electoral irregularities in developing countries, *Internaltional J. Sci. Knowl*, vol. I, no. I, pp. 17- 37.
- Kiayias, A., Zacharias, T. & Zhang, B. (2017). An Efficient E2E Verifiable E-voting Systemwithout Setup assumptions.IEEE. DOI 10.1109/MSP.2017.265093752.
- Marshall,J., Lassen, D.D. &Alt.E.J. (2015). Credible Sources and Sophisticated Voters: When Does New Information Induce Economic Voting? *The Journal of Politics*, volume 78, number 2, p.327.
- Mozibuko, B.N. & Nyuykonge, C. (2017). Opportunities and Challenges of Ensuring Stability in Kenya's 2017 General Elections, African Center for the constructive resolution of disputes (ACCORD), *Policy and Practice Brief*.
- Mutiga, M. 2017. Kenya: Avoiding another electoral crisis. International Crisis Group [Internet], 3 March. Available from: <<https://www.crisisgroup.org/africa/horn-africa/kenya/kenya-avoiding-another-electoral-crisis>>.
- Ojo, A. &Adeshina.A.S. (2014). Design Imperatives for E-voting as a Sociotechnical System. IEEE

- Qadah, G. &Taha, R. (2007). Electronic voting systems: Requirements, design, and implementation. *Computer Standards Interfaces*, 29(3):376–386. Available at: <http://linkinghub.elsevier.com/retrieve/pii/S0920548906000754>.
- Saebo, O., Rose, J. &Skiftenes Flak, L. (2008). The shape of eParticipation: Characterizing an emerging research area. *Government Information Quarterly*, 25(3):400–428.
- Sekaran, U., & Bougie, R. (2010). *Research methods for business: A skill building approach* (5<sup>th</sup> ed.). New Jersey: John Wiley and Sons.
- Smith, J. (2005). Schuckers, Improving Usability & Testing Resilience to Spoofing of Liveness Testing Software for Fingerprint Authentication.
- Stenbro, M. (2010). A survey of modern electronic voting technologies, *Master's thesis, Institute for telematikk*.
- Takoua, A. (2012). Building reliable security systems: the case of an e-voting system, 2012 *International Conference on Information Technology and e-Services*, DOI: 978-1-4673-1166-3/12
- Tamura, S., Alam, K. (2009). Electronic voting using confirmation numbers systems, *IEEE International Conference on System, Man and Cybernetics*, SMC pp. 4535 – 4540.
- Venkatesh, V., Morris, M. G., Davis, G. B. & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly*, vol. 27, no. 3, pp. 425-478.
- Vogt, A., Truderung, T. & Kusters, R. (2012). Clash Attacks on the Verifiability of E-Voting Systems, *2012 IEEE Symposium on Security and Privacy*, DOI 10.1109/SP.2012.32

- Yatin, D., Sameer, S., Vinaye, A. & Sheeba, A. (2012). Comparative study of Electronic Voting models and A Proposed Security Framework for the Implementation in Mauritius. *IEEE Symposium on Humanities, Science and Engineering Research*, pp. 594-599. DOI:978-1-4673-1310-0/12/\$31.00
- Youssef, M. & Abdelkader, R. (2012). U-Vote: A Ubiquitous E-Voting System. *Third FTRA International Conference on Mobile, Ubiquitous, and Intelligent Computing*.



## Appendix I

### Questionnaire for IEBC Staff Demographic information

1. Gender  
 Female                       Male
2. Age bracket  
 18 – 30  
 31 – 40  
 41 – 50  
 51 – 60  
 60 and above
3. Highest level of education achieved  
 KCSE    Graduate    Masters and Above
4. Position at work  
 Top Management    Middle level Management                       Junior  
Others (Indicate)  
\_\_\_\_\_
5. How long have you worked for IEBC  
 1- 5                       5-10 Years                       10 years and above

### Part A

6. What is your understanding of e-voting systems?  
 Very knowledgeable    Highly knowledgeable    Medium knowledge     
Low knowledge    No Knowledge
7. In your own opinion, are there any challenges with the current manual based voting systems?  
 Yes                       No    Don't know  
Please explain your choice  
\_\_\_\_\_  
\_\_\_\_\_
8. Can election problems be reduced with the introduction of e-voting systems?  
 Yes                       No                       I am not sure                       Don't know

9. Will you be willing to use an e-voting system if it is introduced?

Yes

No

10. Will you be able to rely on the results of an e-voting model?

No  Yes

**Objectives 1: Potential challenges of e-voting implementation (Organizational factors)**

11. In your opinion rate how the following challenges can affect use of e-voting systems.(On a scale of 1 to 5; 1- Strongly Agree, 2- Agree, 3- Not sure, 4- Disagree 5-Strongly Disagree)

Statement	1	2	3	4	5
EC don't have the necessary knowledge and technical expertise to run and manage e-voting systems					
There are no enough ICT resources to enable implementation of e-voting system.					
On election day, communication network breaks are bound to happen					
There can be a failure of e-voting systems on election day					
Disruption of voting can occur on election day due to power outage					
Threats to the e-voting system pose great security challenges					
High levels of illiteracy will hamper use of e-voting systems					
The voters will find thee-voting interface to be very complex to use					

Other possible challenges

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**Questionnaire for Voters**  
**Demographic information**

1. Gender  
 Female                       Male
2. Age bracket  
 18 – 30  
 31 – 40  
 41 – 50  
 51 – 60  
 60 and above
3. Highest level of education achieved  
 KCSE    Graduate    Masters and Above

**Research related questions**

1. What is your understanding of e-voting systems?  
 Very high                       High                       Low                       No Knowledge
2. Are there any problems with the current manual voting?  
 Yes    No                       Don't know  
Please explain your choice

- 
3. Will e-voting address election challenges?  
 Yes                       No                       Don't know
  4. Will you prefer using an e-voting system?  
 No                       Yes
  5. Will you be able to rely on results of e-voting?  
 Yes                       No
-

**Objective 1: The potential benefits of e-voting implementation in Kenya**

**(Technological factors)**

1. Which are potential benefits of using e-voting ?

(On a scale of 1 to 5; 1- Strongly Agree, 2- Agree, 3- Not sure, 4-Disagree 5- Strongly Disagree)

Statement	1	2	3	4	5
The cost of running elections will be reduced because of e-voting					
Statement	1	2	3	4	5
The process of voting will become more faster.					
There will be higher voter turnout when e-voting is used					
Delays in vote counting will be eliminated					
Manipulation, fraud and malpractices will reduce with e-voting					
Eros in voting will be eliminated using e-voting					
Errors in counting of votes will be eliminated using e-voting					

Are there any other benefits?

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**Objectives 2: Potential challenges of e-voting implementation**

2. In your opinion will the unmentioned challenges hamper e-voting?

(On a scale of 1 to 5; 1- Strongly Agree, 2- Agree, 3- Not sure, 4-Disagree 5- Strongly Disagree)

Statement	1	2	3	4	5
EC don't have the necessary knowledge and technical expertise to run and manage e-voting systems					

There are no enough ICT resources to enable implementation of e-voting system.					
On election day, communication network breaks are bound to happen					
There can be a failure of e-voting systems on election day					
Disruption of voting can occur on election day due to power outage					
Threats to the e-voting system pose great security challenges					
High levels of illiteracy will hamper use of e-voting systems					
The voters will find the e-voting interface to be very complex to use					

Other possible challenges



## Appendix II: Plagiarism Checker Report

### a) Originality Report

The screenshot below was captured from the TurnItIn report, plagiarism checking returned a similarity report of 15%. This was well within the acceptable maximum similarity percentage allowed by the University's School of Graduate Studies (SGS).



**b) Digital Receipt**

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