

# **Election Markup Language (EML) Based Tele-voting System**

**By**

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# KEYWORDS

**Election Markup Language (EML)**

**Telephone Voting System**

**Automatic Speech Recognition (ASR)**

**Text to Speech (TTS)**

**Voting by voice**



# ABSTRACT

Elections are one of the most fundamental activities of a democratic society. As is the case in any other aspect of life, developments in technology have resulted changes in the voting procedure from using the traditional paper-based voting to voting by use of electronic means, or e-voting. E-voting involves using different forms of electronic means like; voting machines, voting via the Internet, telephone, SMS and digital interactive television.

This thesis concerns voting by telephone, or televoting, it starts by giving a brief overview and evaluation of various models and technologies that are implemented within such systems. The aspects of televoting that have been investigated are technologies that provide a voice interface to the voter and conduct the voting process, namely the Election Markup Language (EML), Automated Speech Recognition (ASR) and Text-to-Speech (TTS).

The primary purpose of the study is to determine, the feasibility and usability of the EML based voting system. EML was developed by the Organization for the Advancement of Structured Information Standards (OASIS). It is the recommended voting standard for member states by the Council of Europe and proposed as a standard to the International Standards Organization (ISO). It has been used in public elections in several countries since 2003, such as UK e-voting pilots, the UK CORE project, and Belgium local elections in Flanders on 8<sup>th</sup> October 2006.

It is anticipated that the results of this research would contribute significantly towards the development of a better real-time voice interface into the voting system and provide a step forward in improving the integrity of the election system by minimizing the occurrence of undervotes, overvotes and write-in votes. This would result in reduction of the election cost and most importantly, make the voting process easier for the old, illiterate or disabled people. Finally, voting would be made more convenient for all citizens and would be able to be administered more easily across wide cultural context.

# DECLARATION

I declare that *EML Based Televoting System* is my own work, which has not been submitted before for any degree or examination in any other university and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

Full name: XiangQi Gong

Date: May 2009

Signed.....



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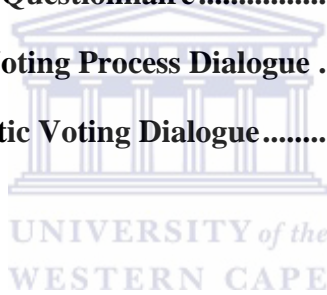
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# GLOSSARY

<b>AR</b>	<b>Action Research</b>
<b>API</b>	<b>Application Programming Interface</b>
<b>ASR</b>	<b>Automated Speech Recognition</b>
<b>ATM</b>	<b>Automatic Teller Machine</b>
<b>COE</b>	<b>Council of Europe</b>
<b>CORE</b>	<b>Coordinated Online Register of Electors</b>
<b>CSAQ</b>	<b>Caregiver Self-Assessment Questionnaire</b>
<b>DRE</b>	<b>Direct Recording Electronic</b>
<b>EML</b>	<b>Election Markup Language</b>
<b>GUI</b>	<b>Graphical User Interface</b>
<b>HMM</b>	<b>Hidden Markov Models</b>
<b>ID</b>	<b>Identification</b>
<b>IP</b>	<b>Internet Protocol</b>
<b>IR</b>	<b>Iteration Research</b>
<b>ISO</b>	<b>International Organization for Standardization</b>
<b>OASIS</b>	<b>Organization for the Advancement of Structured Information Standards</b>
<b>PAR</b>	<b>Participatory Action Research</b>
<b>PIN</b>	<b>Personal Identification Number</b>
<b>PSTN</b>	<b>Public Switched Telephone Network</b>
<b>SMS</b>	<b>Short Message Servers</b>
<b>SR</b>	<b>Surveys Research</b>
<b>SERVE</b>	<b>Secure Electronic Registration and Voting Experiment</b>
<b>TTS</b>	<b>Text to Speech</b>
<b>UPS</b>	<b>United Parcel Service</b>
<b>USA</b>	<b>United States of America</b>
<b>UWC</b>	<b>University of the Western Cape</b>
<b>WWW</b>	<b>World Wide Web</b>
<b>XML</b>	<b>Extensible Markup Language</b>

# Chapter 1

## INTRODUCTION

In any democratic society, free and fair voting is considered a fundamental dispensation. In the recent decades technology has filtered into the political field [1, 2]. In the traditional paper voting, a voter casted her/his vote anonymously, sealed it, placed the voting paper into a box or mailed it to the election office. Supervised manual ballot counting took time and it was costly. However as a result of technological advances in this field, the voting process has improved, and a ballot could be just a telephone call away [2, 3]. Technology has made voting faster, more cost effective and convenient. Some examples of technology based voting are: voting by telephone; the Internet; voting machine; kiosk; post and short messages servers (SMS) [2, 4].

This thesis concerns on voting by using the telephone, or televoting. It explores integration of Election Markup Language (EML) [5], Automated Speech Recognition (ASR) [6] and Text-to-Speech (TTS) [7] to prove the technical and operational feasibility of such voting system. In this voting system, the voter casts his/her vote verbally, over the telephone, while being guided by a voice during the whole voting process. The security and some other related problems are left for the future work.

### 1.1 Background

Electronic voting has been in use since 1960 [8]. With recent technological advancements, the method has improved advancing from the punch card, optical scan machine to the network. At the present moment, Internet voting is a common method of voting currently used in the United States of America (USA), Europe and various other continents in the world. In the year 2000, general elections in the USA, the direct-recording electronic voting system was used for the first time in public elections for the Presidential Election in Florida. In the recent past few

years, more and more countries have adopted e-voting as a method for conducting elections, examples of which are Ireland, Australia, Canada, and New Zealand, all these countries have replaced the traditional paper elections with e-voting [9]. The reasons for this decision are that e-voting makes the voting process easier, more affordable and convenient for everybody [10]. Normally two kinds of e-voting are used. The first is audited voting which involves use of electronic equipment for polling purpose. In the polling stations, voters use the Direct Recording Electronic (DRE) voting machines, touch screens, the Internet or Automatic Teller Machines (ATMs) to cast their vote [11, 12]. This would be effected online or offline. The officers would audit the process of vote in the same way as in paper voting. An example of which is shown in figure 1.1. This shows the touch screen vote machine that is used in the USA. The second method is remote non-auditing e-voting. This facilitates the voter to vote online from anywhere in the world using the Internet, telephone networks, and cell phone networks. There is nobody to audit this process.



**Figure 1.1 Electronic Election Machines**

A direct result of e-voting is that people have been paying more attention to remote voting, because of its many benefits [12, 13, 14], like allowing voters to cast their vote from anywhere around the world through the internet or telephone network; releasing people from long queue and long-time waiting. Remote voting seems to be attractive to many people because one does not need to wait in a long voting queue. It also enables one to vote anywhere and anytime during the voting period by using the Internet or telephone [15, 16]. It is also easier for the

governments or the election officers to control and manage the voting process [7]. In the recent few years, some companies have designed new e-voting systems like VoteHere [6], Secure Electronic Registration and Voting Experiment (SERVE) [17], and Coordinated Online Register of Electors (CORE) project [18].

Generally, the turnout of election is the indicator of the government's democratization level. Use of more convenient, reliable means of voting with no queues will encourage people from all walks of life to participate voting hence increasing the voter turnout [19]. Table 1.1 shows the voter turnout of USA Presidential Elections from 1972 to 2004 [20]. The numbers of voters increased during the time. It had increased by 2.9% in the 2000 elections, compared to 1996 as a result of government using e-voting. This number increased by 6.4% in the 2004 elections. Also, in 2004, there was a big turnout amongst the younger contingent of voters [21]. Under-30 voters' turnout had visibly increased from that of when the e-voting was first used in the Presidential Elections in 2000[21].

**Table 1.1: Voter Turnout in Recent Presidential Elections in USA**

Year	Eligible to Vote	Total Vote	% Eligible Voted
2004	201,541,000	122,265,430	60.7
2000	194,285,000	105,399,313	54.3
1996	187,033,000	96,277,634	51.5
1992	179,775,000	104,428,377	58.1
1988	172,540,000	91,594,805	53.1
1984	165,341,000	92,653,000	56.0
1980	158,143,000	86,497,000	54.7
1976	147,980,000	81,603,000	55.1
1972	137,318,000	77,625,000	56.6

*(Source: Committee for the Study of the American Electorate. Note that prior to the 2004 election CSAE had used Voting Age Population rather than Eligible Citizens so that in 2000 for example it had reported turnout as 51.2% of VAP.)*

As e-voting got more popular, a global standard for e-voting systems was required. As a result the Organization for the Advancement of Structured Information Standards (OASIS) [22], which is the international XML interoperability consortium, was formed by the Election and Voter Services Technical Committee. Its function was to standardize election and voter services information using XML. In 2003 it was announced that its members had approved the Election Markup Language (EML) version 4.0 as an OASIS Standard [23, 24]. EML was recommended as the international e-voting system standard by Committee of Ministers of the Council of Europe (COE) [25].

The developments of Automatic Speech Recognition (ASR) [26] and Text to Speech (TTS) [27] technologies have given more choices for improving the voting process. They have made it possible for people to “talk” directly to machines. The developments of telecommunication made telephone voting not only possible but convenient.

## 1.2 Motivation

Telephone voting has become the most attractive way of remote voting. It is significantly easier than the three-step process of a mail ballot election (receipt of ballot packet, preparation of ballot, and return of ballot) or a trip to a polling station for an in-person election [28, 29]. In addition, it is arguably more democratic than traditional methods because it increases voter accessibility. A vote can be cast from any telephone twenty-four hours a day, seven days a week [3, 12]. In contrast, polling hours and stations for in-person elections are always limited - a fact that could be considered unfair. Unfair elections may become basis of a legal challenge to overturn an election [10].

Nowadays almost everybody has a telephone or a mobile phone at home or in the office. In the traditional physical polling booth situation lot of people required assistance in casting their vote this was particularly so for the blind, the old, the partially sighted and the illiterate. This practice caused certain problems, because the guides could mislead the voters, which could lead to voting fraud. The best way to help such people especially the blind is casting vote by voice. Voting by



voice will make the voting much more simple and reliable [29]. Inclusive of this is the fact that the previously disadvantaged voters, like the blind, the illiterate and other disabled people would now be able to enjoy their rights. The new approach would get more people involved in the election [30] and increase the election turnout. The ASR and TTS technologies make it possible for communication to take place between the speaking endpoint and the text endpoint. The OASIS offers an international standard for electronic voting named the Election Markup Language (EML).

The number of undervotes is viewed as an indication of the performance of the voting system [19, 31]. Under voting refers to selecting less choice than permitted on the ballot, or returning an empty ballot. Over voting involves selecting more choices than permitted, and write-in vote (voter writes a new choice on the ballot). All of these aspects will have an effect on the turnout of the e-voting [28]. Making the voting system more accessible and reducing the void votes will also improve the integrity of the voting system.

This research seeks to combine the existing widely-used Traditional Public Switched Telephone Network (PSTN) and mobile technologies with the new ideas of EML and advancement of the computer technology to provide a new, simple, and easy to use voting system. It is anticipated that the system will not only be of help to disadvantaged people, including the blind, illiterate, and people with other forms of challenges but it will also help to promote the integrity of the voting system itself

### **1.3 Statement of the Problem**

This thesis seeks to research and implement an EML based telephone voting system. The system is based on communication between speaking telephone users connected to PSTN or mobile network and a voting system which works within the Internet Protocol (IP) domain. The voting system will concurrently enable voters to cast their vote by voice and provide them with voice guidance. Furthermore the system will manage data exchange between the voice stream and text. The system will be able to perform a number of functions including;

managing of data exchange between voice stream and text, capture data and perform conversion between voice streams and EML XML database, and allow voters to cast, cancel, and look back during the voting process.

This research was limited to the investigation of integration of EML, ASR, and TTS technologies to prove the technical and operational feasibility of the telephone based voting system. It did not concern itself with the problems of security, privacy, and quality of ASR/TTS software.

This study was guided by the following specific research questions:

- How can software and hardware of ASR, TTS and EML technologies be integrated in order to build real-time telephone based voting system?
- How can real-time communication and data conversion between voice streams and EML XML database be captured?
- How can the voting system be made reliable and voter friendly?

## **1.4 Thesis Outline**

This thesis consists of seven chapters. The subject of each chapter is presented below:

Chapter 1-Introduction: This chapter presents an introduction of the televoting system. Furthermore it discusses the motivation behind this research endeavor. It also provides the problem statements and constraints of the research.

Chapter 2- Literature Review: Provides an overview of e-voting history and telephone voting system, Automatic Speech Recognition (ASR) engine, Text to Speech (TTS) engine and Election Markup language (EML). It also reviews different e-voting methods and shows the advantages and disadvantages of each aspect. The software used for the ASR and TTS in our system----Nuance are also explained.

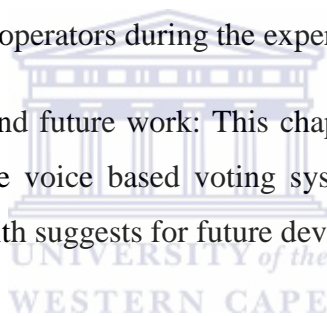
Chapter 3- Methodology: In this chapter, the research question is elaborated. The methodology for the experimentation is presented. Also the methodologies applied in this research are described.

Chapter 4- System Design: This chapter discusses the technical design of the voting system according to the problem statements and motivations. It also describes and explains the related EML messages. The operator interface for auditing the system is also described and explained.

Chapter 5- Experimental Implementation: This chapter presents a detailed experimental implementation based on the methodology discussed in Chapter 3. Furthermore it shows the case studies starting from the initial to the final trials.

Chapter 6- Televoting System Results: This chapter presents the results that were collected from users and operators during the experiment.

Chapter 7- Conclusion and future work: This chapter discusses the results of the investigation on how the voice based voting system could be used in real-life elections. It concludes with suggests for future development.



## **Chapter 2**

# **LITERATURE REVIEW**

Exercising one's democratic right by voting is an important part of modern society civil life. Since the beginning of the eighteenth century, with the developing of the democracy voting has become an integral part of western society [32]. In the early voting systems the paper ballot system was used. The system used uniform official ballots on which the names of all candidates and issues were printed. Voters were required to mark the boxes next to the candidate of their selection and dropped the ballot in a sealed ballot box [8]. To date this method is still in use in many parts of the world. However with the advancement in technology the electronic voting system is slowly replacing paper ballots.

### **2.1 Electronic Voting**

Electronic voting (also known as e-voting) refers to various types of voting technologies, which imply both electronic means for casting a vote and counting votes. Electronic voting systems for electorates have been in use since the 1960s [8], when punch card systems debuted. Electronic voting technology involves a lot of different kinds of ways of casting vote, such as punch cards, optical scan voting systems and specialized voting kiosks. Nowadays electronic voting involves a lot more different channels like Direct-Recording Electronic (DRE) voting machine, SMS (Short Messaging Service), the Internet, ATM kiosks and so on.

#### **2.1.1 Punch Card Voting System and Optical Scan System**

“Punch card systems employ a card (or cards) and a small clipboard-sized device for recording votes [33].” Punch card systems still use the paper ballot. Voters punch holes in the ballot with a supplied punching device opposite the candidate they intend to choose. The voter may place the ballot in a ballot box (the ballot will be counted by a special device afterwards, or the ballot may be fed into a

computer vote-tabulating device immediately [33]. The punch card system uses a technical way to count the vote, but it still uses the paper ballot for casting vote.

“Optical scan systems (also known as marksense) employ a ballot card on which candidates and issue choices are preprinted next to an empty rectangle, circle, oval, or an incomplete arrow [8].” Voters directly mark their choice in the rectangle, circle or oval, or complete the arrow on the ballot. After marking the ballot is collected by the voting officers and place in a sealed box for counting, which is done by fed into a counting device. The tabulating device reads the votes using "dark mark logic". The computer selects the darkest mark within a given set as the correct choice or vote and ignores other choice. [8] However the computer can sometimes make mistakes for example when the ballot is dirty. Marksense technology is the only method that recognizes marks on paper through optical reading techniques. “Marksense systems were used by 24.6% of registered voters in the United States for the 1996 Presidential election [8].”

The Punch card and optical scan (marksense) systems are not true electronic voting systems because both of them still use paper ballots. They do use electronic means for counting votes, but not for casting votes. Hence they are referred to as a semi – electronic voting systems.

### **2.1.2 Direct Recording Electronic Voting System**

The real electronic voting should allow the voter to cast a non-printed electronic ballot and be conducted via electronic machines. The direct recording electronic (DRE) voting systems are an electronic implementation of the old mechanical lever systems. As with the lever machines, there is no printed ballot; the possible choices are visible to the voter on the front of the machine or computer. The voter directly enters choices into electronic storage with the use of a touch-screen, push buttons, or similar device. An alphabetic keyboard is often provided with the entry device to allow for the possibility of write-in votes. The voter’s choices are stored in these machines via a memory cartridge, diskette or smart card and added to the choices of all other voters [34]. DRE voting machines are used by voters in all elections in Brazil, and also on a large scale in India, the Netherlands, Venezuela,

and the United States [9]. In 2004, 28.9% of the registered voters in the United States used some type of direct recording electronic voting system (up from 7.7% in 1996 [34]). Figure 2.1 shows the Diebold Election system that was used in 2004 Nevada elections. It includes a model AccuVote-Tsx DRE voting machine and Voter Verified Paper Audit Trail (VVPAT) attachment [35].



*Figure 2.1 Diebold Election Systems DRE Voting Machine*

With the advent of the Internet and the WWW (World Wide Web) network, a new means for the DRE was developed, namely public network DRE voting system. The public network DRE voting system is an election system that uses electronic ballots and transmits vote data from the polling place to another location over a public network [36]. Vote data may be transmitted as individual ballots as they are cast, periodically as batches of ballots throughout the Election Day, or as one batch at the close of voting. This includes the Internet voting as well as the telephone voting. The public network DRE voting system can utilize either the precinct count or a central count method. The central count method tabulates ballots from multiple precincts at a central location. The Internet voting can use remote locations (voting from any Internet capable computer) or can use traditional polling locations with voting booths consisting of the Internet connected voting systems.

The DRE voting also has its disadvantages. The effectiveness of DRE depends of voter's age, education background, computer experience, or previous voting

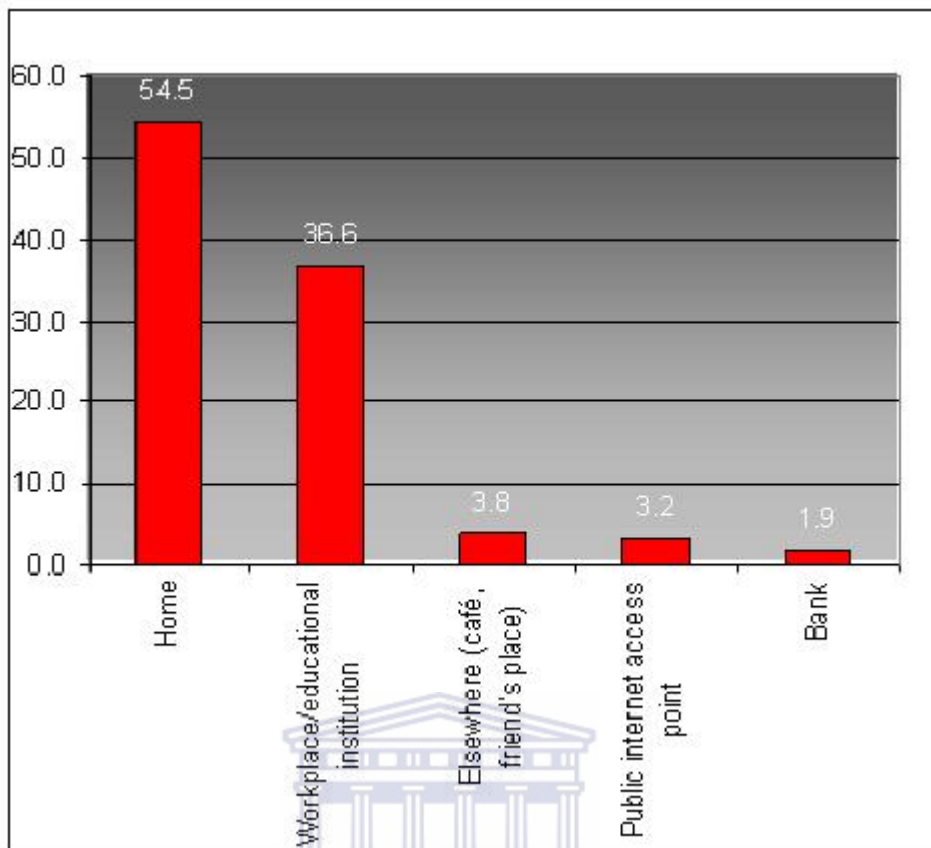
experience. Due these factors, the DRE error rate is higher than in traditional paper voting, although voters are very satisfied with these electronic systems. [37]

Corporations and organizations routinely use Internet voting to elect officers and board members or for some other proxy elections [8]. The Internet voting systems have gained popularity and have been used for government elections and referendums in the United States, the UK, Ireland, Switzerland and Estonia. In Switzerland, where it is already an established part of local referendums, voters use their passwords to access the ballot through the postal service. It was also used for municipal elections in Canada and party primary elections in the United States and France [38].

The number of e-voting methods and techniques are increasing with the technology development. People are always interested in the new ways of voting. They want to use the latest technologies to make life easier. It can be even ego related, thus showing that if you are updated in the newest technological innovations that you are seen as fashionable.

### **2.1.3 An E-voting Case Study**

As a case study, this study will look at the 2005 Estonia's local elections. Following years of preparation and both political and legal controversy, Estonian citizens equipped with an electronic ID-card were able to cast their vote via the Internet. The Internet voting in this election took place from Monday, October 10 to Wednesday, October 12 2005. Overall, 9317 voters had participated in elections by this means. This corresponds to 1.85% of the participating voters. The overall turnout at these elections was 47.4% [39]. Most voters in Estonia can cast their vote in local and parliamentary elections via the Internet, as most of those on the electoral roll have access to an e-voting system. It is possible because the Estonians national identity card is equipped with a computer-readable microchip. All a voter needs is a computer, an electronic card reader, their ID card and its PIN, and they can vote from anywhere in the world.

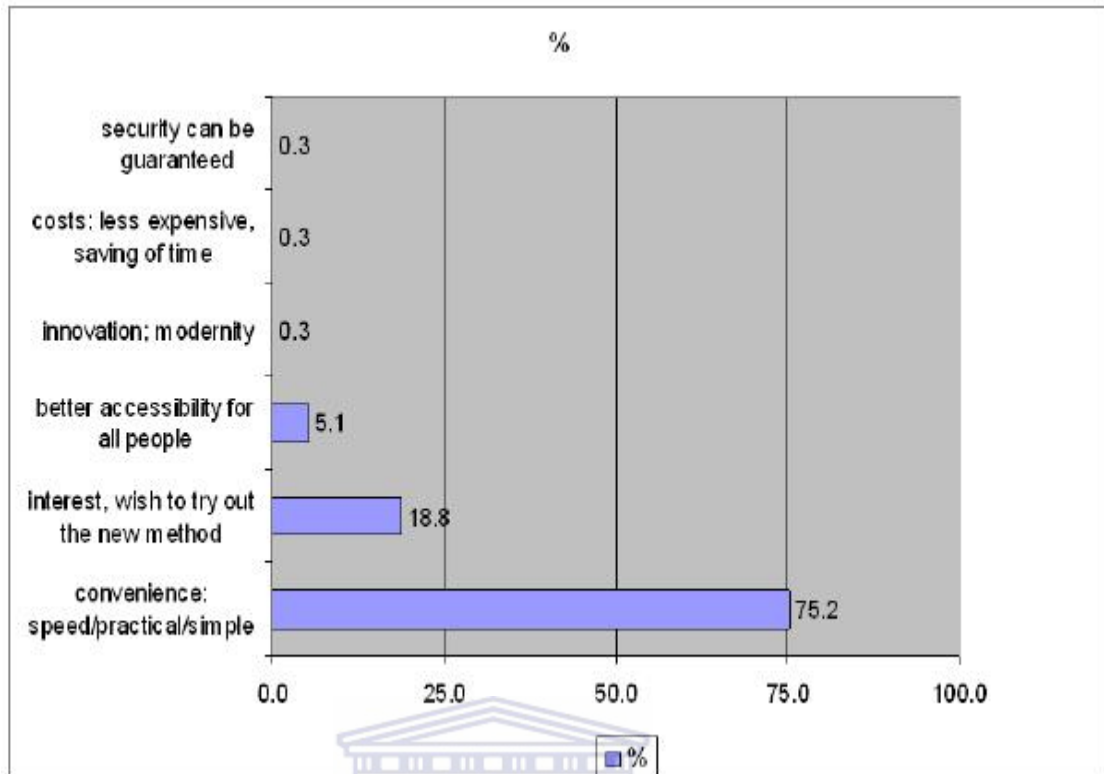


**Figure 2.2 Where E-voter Cast Their Ballots [39]**

As figure 2.2 shows, a large majority of e-voters cast their e-ballot from home (54.5%) or at their workplace (36.6%). Only a very limited number of e-voters (8.9%) logged onto the system in order to vote from other places, i.e. a café a friend's place, a bank or a public Internet access point [39].

What are the reasons for the voters choosing to use the e-voting, especially the remote Internet voting?





*Note: N=315. Valid cases=314, missing cases=1.*

**Figure 2.3 Subjective Reasons for Choosing E-voting [39]**

Figure 2.3 clearly reveals that e-voting was above all perceived as something that was convenient, fast, practical and overall simplified [39]. Three quarters of e-voters mentioned this reason as a factor that influenced their choice for voting over the Internet [39]. It remains to be seen if this “first time curiosity” will fade away over consecutive experiences or if these “curious voters” become faithful to e-voting.

#### **2.1.4 Televoting System**

Accessibility is an important characteristic of the voting system. The case study clearly shows the advantages of the remote e-voting. It is accessible to most people, but it is still not accessible to all citizens, like the blind, illiterate and visually-impaired people, and even for the old people who are not familiar with using the computer and the Internet [30]. There are some telephone voting systems that use the telephone keypad to make a selection. [40]. No matter which kind of voting is used, even in the traditional physical polling booth situation,

those people have had to be assisted to make their vote. This can sometimes be dangerous as the guide could mislead them. For them, probably the easiest and more reliable way to vote is using voice and has a system that will provide voice assistance. Today, the telephone especially mobile telephones are used by almost everybody. If we could vote through the telephone by voice, it would be much easier and convenient for everyone, especially for the disabled, blind and illiterate people [10, 12]. It would let them enjoy their rights and encourage more people to get involved in the election because of the convenience thus increasing the election turnout.

**Table 2.1: Comparison of the Internet and Voice Telephone Voting System**

	The Internet voting system	Telephone voting system (voice)
Accessibility	Using the websites, accessible for all the network user	Dial number and speak, accessible for all telephone users
Location	Anywhere the Internet can be accessed	Anywhere the phone communication servers supplied
Convenience	For most except blind, old, non-educated and other disable people	For all except mute people
Speed	fast	fast
Cost	Little cost	Little cost

Table 2.1 shows that voting by voice through the telephone is easier and less limited for users.

## 2.2 Election Markup Language

In the election industry today, there are a number of different service vendors around the world, all integrating different levels of automation, operating on different platforms and employing different architectures. With the global focus on e-voting system and initiatives, the need for a consistent, auditable, automated election system has never been greater [23]. From spring of 2001, OASIS, the

XML interoperability consortium, formed the Election and Voter Services Technical Committee who started to develop standards for election and voter services information using XML. This standard is called the Election Markup Language (EML). On the 20th September, 2004, the Council of Europe (CoE) stated that “E-voting system must be based on Open Standards”. They said: “Open standards shall be used to ensure that the various technical components or services of an e-voting system, possibly derived from a variety of sources, interoperate.”[41]

Hence the mission statement of EML says:

“Develop a standard for the structured interchange among hardware, software, and service providers who engage in any aspect of providing election or voter services to public or private organizations...” [23].

### **2.2.1 EML**

The introduction of open standards for election solutions is intended to enable election officials around the world to build upon existing infrastructure investments, to evolve their systems as new technologies emerge and to simplify the election process in a way that was never possible before. Open election standards aim to instill confidence in the democratic process among citizens and government leaders, particularly within emerging democracies where the responsible implementation of the new technology is critical.

Dr. Michael Ian Shamos researched on 50 different voting systems since 1980 and reviewed the election statutes in half the US states. He summarized a list of fundamental requirements for the e-voting system, also known as “six commandment”: [23]

1. To keep each voter’s choice a secret
2. Allow each eligible voter to vote only once, and only for those offices for which he/she is authorized to cast a vote

3. Do not permit tampering with voting system, nor the exchange of gold for votes
4. Report all votes accurately
5. The voting system shall remain operable throughout each election
6. Keep an audit trail to detect any breach of 2 and 4 but without violating 1

In his research, he also pointed out some other additional challenges of specifying requirements: [23]

- ❖ Multinational
- ❖ Effective across the different voting regimes
- ❖ Multilingual
- ❖ Adaptable
- ❖ Secure



The Election and Voter Services Technical Committee developed EML by following all the above requirements and operating under the general premise that any data exchange standards must be evaluated with constant reference to the public trust.

EML is a set of data and message definitions described as a set of XML schemas and covering a wide range of transactions that occur during an election. It includes specifications for: [23]

- Candidate Nomination, Response to Nomination and Approved Candidates lists
- Voter Registration information, including eligible voter lists
- Various communications between voters and election officials, such polling information, election notices, etc.

- Logical Ballot information (races, contests, candidates, etc.)
- Voter Authentication
- Vote Casting and Vote Confirmation
- Election counts and results
- Audit information pertinent to some of the other defined data and interfaces

EML is focused on defining open, secure, standardized and interoperable interfaces between components of election systems, thus providing transparent and secure interfaces between various parts of an election system.

At the present time EML is a global standard language, and it has been used in a number of e-voting systems, even some online voting systems depending on the Internet technology [42]. A number of companies are involved in the production of such a systems, like VoteHere [6], SEVER [17], CORE [18] to name a few.

EML has been designed to support most aspects of Election and Voter Services from electoral registration, through voting to counting. It is not restricted to electronic voting - many parts of the language are applicable to traditional voting methods [43].

EML is designed to support many types of public and private elections, including parliamentary elections, presidential elections, referenda etc. The OASIS Technical Committee that manages EML has a wide international participation, including governments, technology companies and world-wide election service providers. EML facilitates multi-vendor systems, preventing lock-in to a single vendor for all parts of a registration/voting/counting system [43]. EML is being submitted by OASIS to International Organization for Standardization (ISO) as a proposal for an international standard for Election and Voter Services messaging. This provides a context for the specifications without restricting their use in any way. EML supports multiple voting channels, including postal, kiosks, the Internet voting, SMS etc [23]. EML has been proven in a pilot trial in public

elections as the messages format standard for the UK Co-coordinated Online Register of Electors. EML also allows additional constraints to be applied for specific election scenarios and processes. EML is also extensible. Developers can add elements for specific uses without reference back to OASIS. EML is responsive to changing requirements - additional requirements can be piloted using the extensibility of the language and added to the core specification if agreed by the Technical Committee [43]. Furthermore it has elements to support some specific requirements such as voter authentication and rights management, advanced security features and audit requirements.

### **2.2.2 EML High Level Voting Model**

The Election and Voter Services Technical Committee defined a common terminology and definition of election processes models that could be understood internationally during the election. These processes are illustrative, covering the vast majority of election types and forming a basis for defining the Election Markup Language itself. EML has been designed in such a way that elections that do not follow this process model could still be able to use EML as a basis for the exchange of election-related messages [23].

EML introduced two complementary high level process models of an election exercise, based on the human and technical views of the processes involved. It was intended to identify all the generic steps involved in the process and to highlight all the areas where data is to be exchanged.

This high-level process model is derived from real world election and is designed to accommodate all the feedback and input from the members of the committee [23]. In the election process, there are three major areas, pre election, election, post election. Each area involves one or more election processes. One or more XML schemas are specified to support each of them, thus ensuring consistency with all the figures and the schemas required (number in the quote is EML message schemas sets number [24]):

- ❖ Pre election

- Election (100)
- Candidates (200)
- Options (600)
- Voters (300)
  
- ❖ Election
  - Voting (400)
  
- ❖ Post election
  - Results (500)
  
- ❖ Audit
  
- ❖ Analysis

Some functions belong to the whole process and not to a specific part:

- ❖ Administration Interface
  
- ❖ Help Desk

The figure 2.4 is the technical view of this high-level processes model.

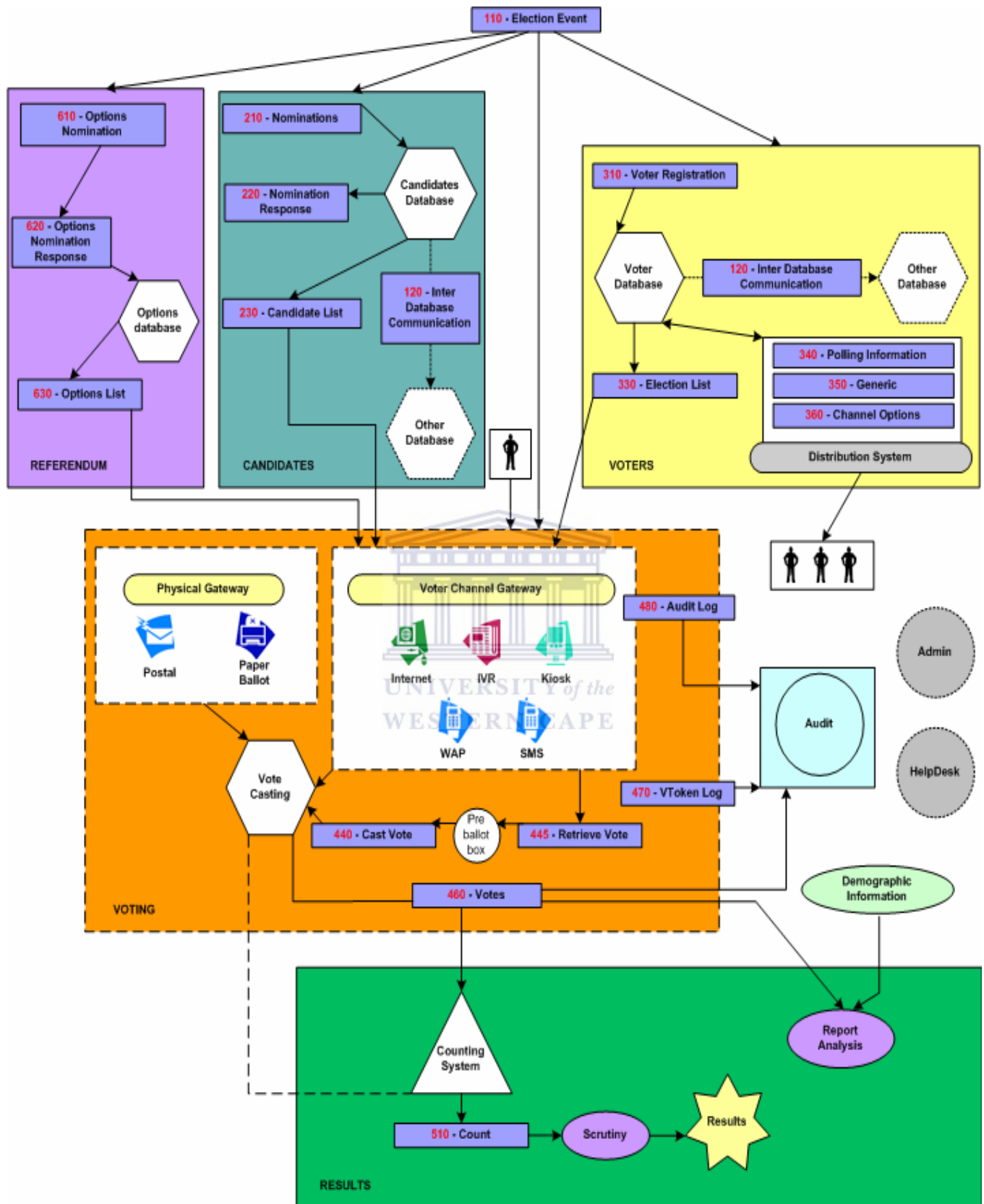


Figure 2.4 High-level Models -----The Technical View [23]



This model can be divided into the following processes:

- Candidate Nomination Process

This process approves nominees as eligible candidates for certain positions in an election. EML schema 210, 220 are specifically applicable to candidates' nominations. The outcome of this process is accepted candidates list that will be communicated using a message conforming to schema 230. It will be used to construct the contests and occurrence on the final ballots [23].

- Voter Registration

This process builds up the voters' databases. The input into this database is the outcome of communication between "a Voter" and "an Election Authority". The voter should use any of registration channels to make him / her become a legal voter [23].

- Voting Process

As the figure 2.5 shows, the voter will be voting using a choice of physical channels or electronic access methods to cast the vote. Each channel may have a gateway acting as the translator between the voter terminal and the voting system. Typically, these gateways are in proprietary environments. The following schemas are to be used when interfacing to such gateways: 410, 420, 430, 440 and 450.

- Vote Reporting

The voting system should communicate a bulk of data representing the votes to the counting system or the analysis system-using schema 460. The result is to be communicated by the schema 510. Recount can be simply be accommodated by a re-run of the schema 460.

- Auditing System

A count of ballots issued should match the total ballots cast, spoiled and unused.

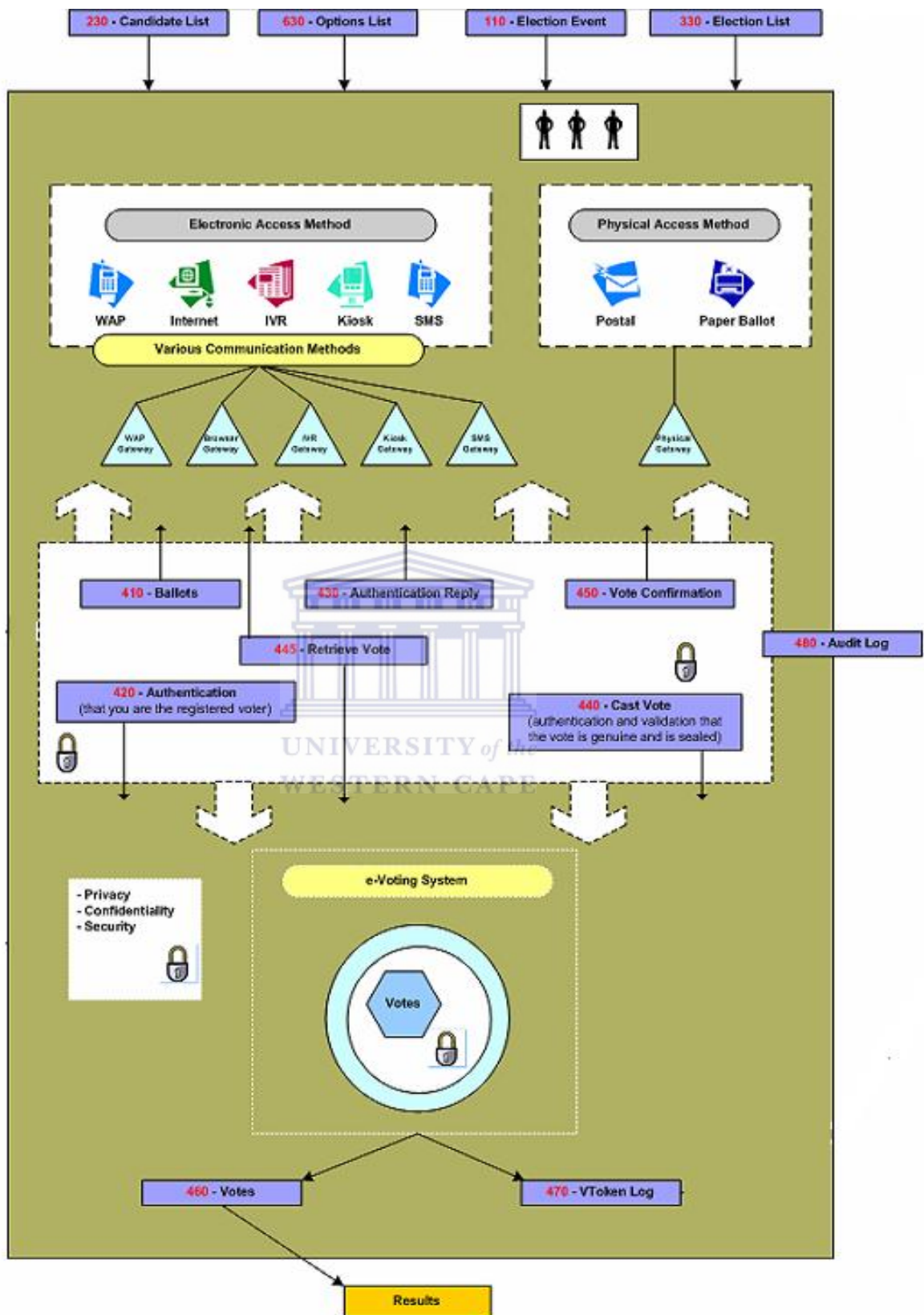
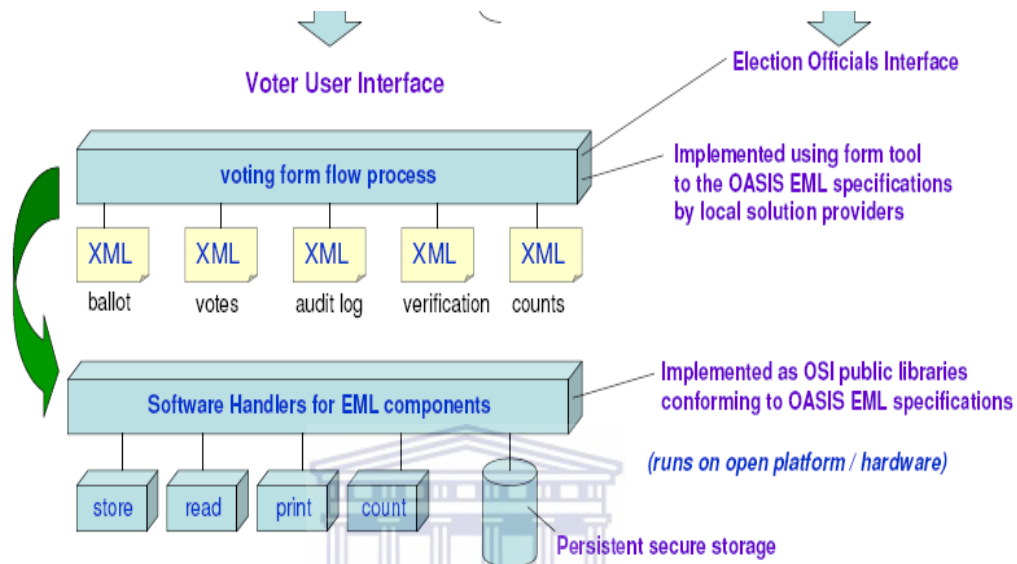


Figure 2.5 Voting Process [23]

The figure 2.5 shows the processes for EML voting model. In July of 2005, The Election and Voter Services Technical Committee also defined the OSI components for EML processes, as shown in figure 2.6. [44]



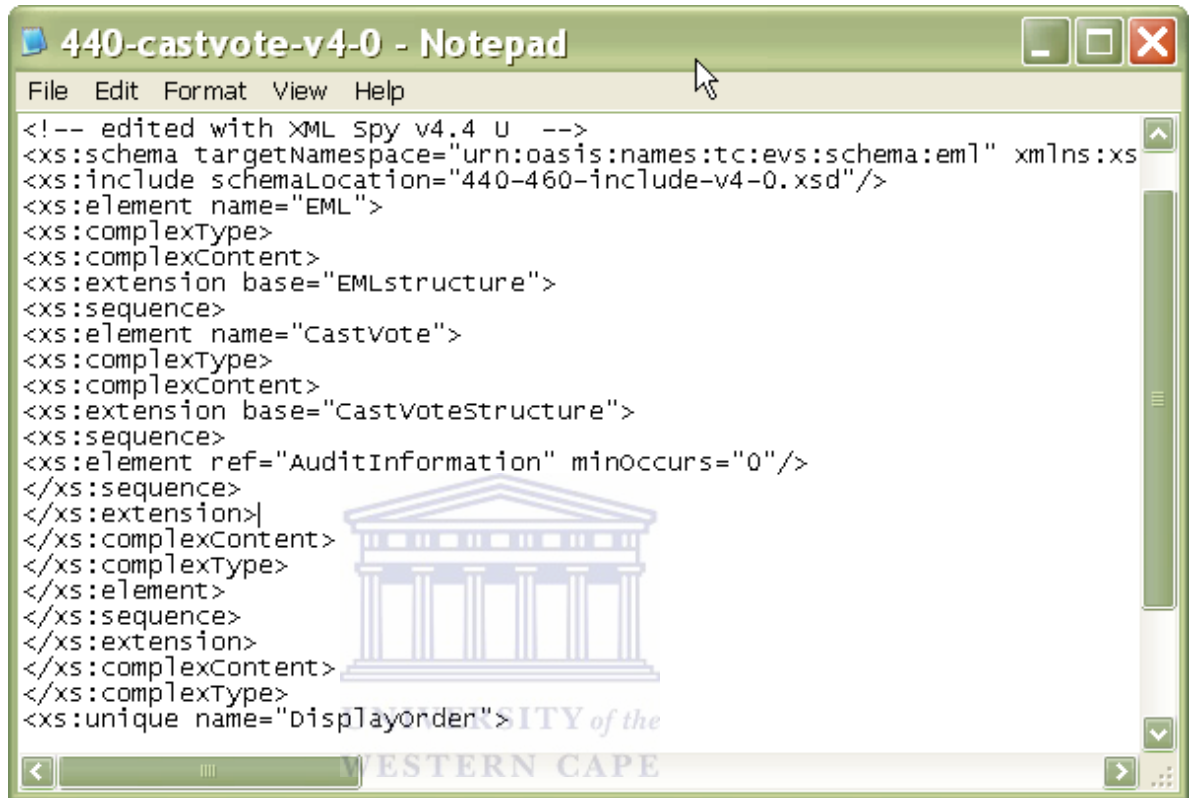
**Figure 2.6 OASIS Formed OSI Components for EML Processes [44]**

### 2.2.3 EML Schema Descriptions

The messages that form part of EML are intended for transfer between systems. It is not intended that all outputs of a registration or election system will have a corresponding schema [24]. EML has the message schemas and the core schemas. The core schema contains elements and data types that are used throughout the e-voting schemas. It has fifteen simple data types and forty-nine complex data types (version 4.0).

As an example, the figure 2.7 shows the “cast vote” (440) message and figure 2.8 is the schema figure. This message represents a cast vote, which comprises an optional voting token (which may be qualified) to ensure that the vote is being cast by an authorized voter, information about the election event, each election within the event and the vote or votes being cast in each election, an optional

reference to the ballot used, the identifier of the reporting unit if applicable and a set of optional audit information.



*Figure 2.7 Cast Vote (440) Message Schemas in Documents*

For each election, the content is identified, with a set of, possibly sealed, votes. The votes are sealed at this level if there is a chance that the message will be divided. For example votes in different elections can be counted in different locations.

The selection of candidates, affiliations or a referendum option uses the Selection Element. The Selection Element's content is the candidate's name that voter chosen. If an election requires preferences to be expressed between candidates, multiple Selection Elements will be used. Each of them has a suitable Value attribute [24]. Some elections allow write-in candidates, and these are handled in a similar way. Preferences can also be expressed between parties, using the

Affiliation Element. The PersonalIdentifier [24] is used in elections where each voter is given an individual list of codes to indicate their selection.

A more complex election might require the voter to vote for a party, and then express a preference of candidates within the party. In this case, the Affiliation Element is used to indicate the party selected, and multiple CandidateIdentifier Elements, each with a Value attribute are used to express candidate preferences. Preferences in a referendum are handled in the same way as they are for candidates and parties, using the ReferendumOptionIdentifier [23].

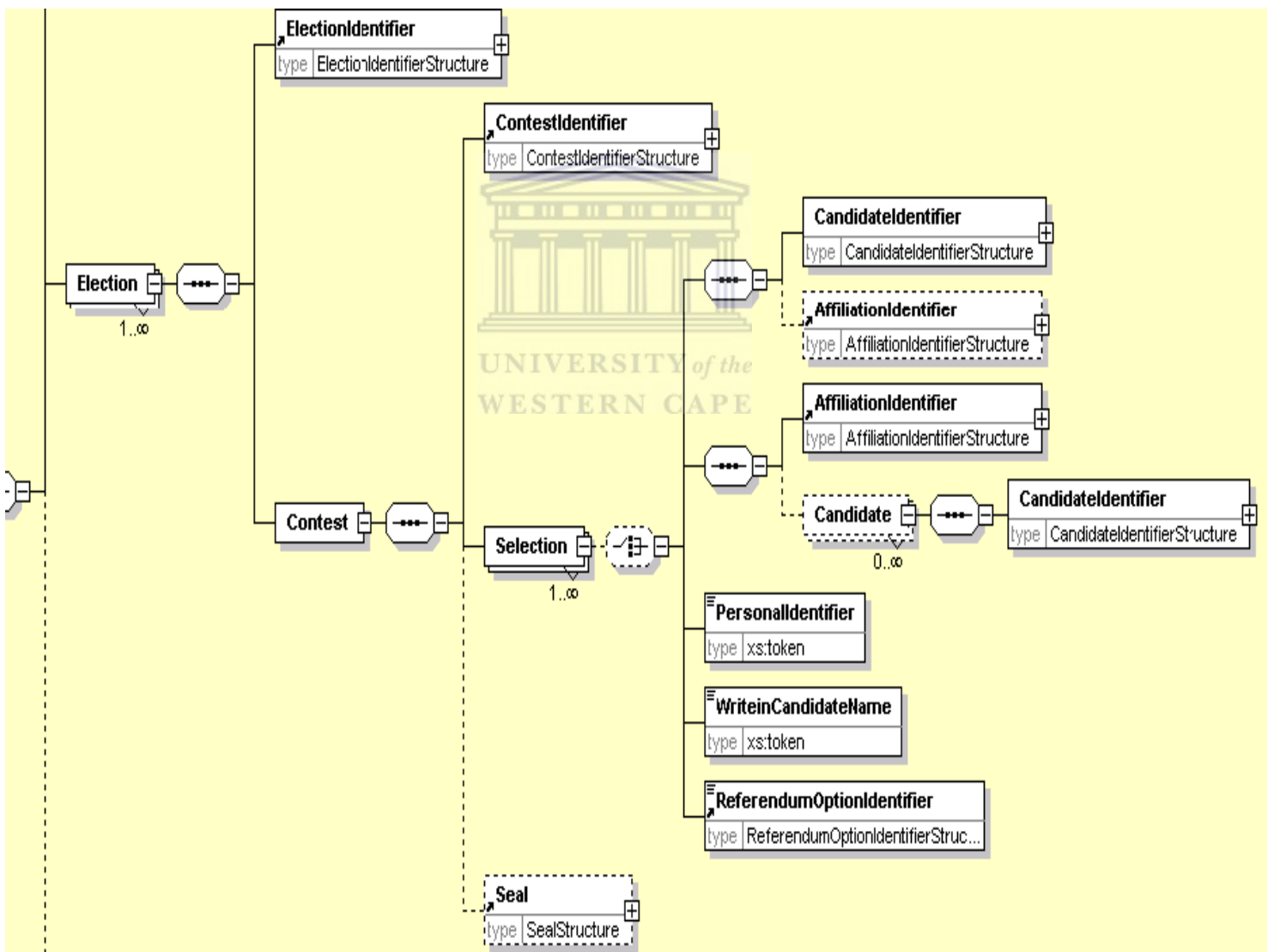
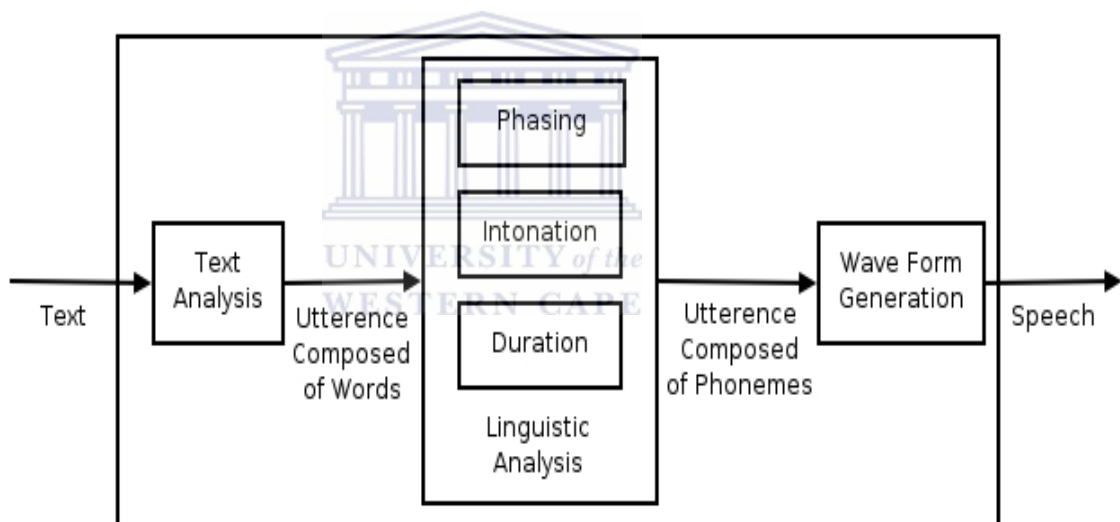


Figure 2.8 Cast Vote (440) Message Schemas [24]

## 2.3 Speech Synthesis

### 2.3.1 Text-to-Speech

Text-to-speech (TTS) is a type of speech synthesis application that is used to create a spoken sound version of the text in a computer document, such as a help file or a Web page [45]. TTS can enable the reading of computer display information for the visually challenged person, or may simply be used to augment the reading of a text message. Current TTS applications include voice-enabled e-mail and spoken prompts in voice response systems. TTS is often used with voice recognition programs. AT&T labs have one text-to-speech demo that can speak out your input that you type in the writing area [46].



*Figure 2.8 Text-to-Speech Processing [47]*

As shown in figure 2.8, a text-to-speech system (or "engine") is composed of two parts: a front-end and a back-end. The front-end has two major tasks. First, it converts raw text containing symbols like numbers and abbreviations into the equivalent of written-out words. This process is often called text normalization, pre-processing, or tokenization [47]. The front-end then assigns phonetic transcriptions to each word, and divides and marks the text into prosodic units, like phrases, clauses, and sentences. The process of assigning phonetic

transcriptions to words is called text-to-phoneme or grapheme-to-phoneme conversion [47].

### **2.3.2 Automated Speech Recognition**

“Automated speech recognition (ASR) is defined as a technology that allows users of information systems to speak entries rather than punch numbers on a keypad. It is used primarily to provide information and to forward telephone calls [26].” There are two types of speech recognitions, front-end and back-end. In front-end speech recognition, the provider dictates into a speech-recognition engine, and the recognized words are displayed right after they are spoken. For back-end speech recognition (or deferred speech recognition), the provider dictates into a digital dictation system, then the voice routes through a speech-recognition machine. The editor compares the recognized draft document and the original voice file, and finalizes the output. Deferred speech recognition is being widely used in the industry today [48].

The Hidden Markov models (HMM) are the dominating approach in speech recognition. [49] “The Hidden Markov Model is a finite set of states, each of which is associated with a (generally multidimensional) probability distribution.”[48] Normally, ASR problem can be approached from two sides: speech generation side and speech perception side. The HMM is a result of the attempt to model the speech generation statistically and thus belongs to the first side: speech generation. In the past several years, HMM has become the most successful speech model used in ASR. The HMM is popularly used both in isolated recognition and continuous recognition. “Isolated recognition” generally means the speech recognition based on any kind of isolated speech unit. The speech unit can be any one of words, such as a word, a sub word or a concatenation of words. Isolated word recognition has direct practical applications only when the isolated recognition is based on other two types of units has basically a theoretical value. Especially the sub word recognition in isolated mode can give good indication about the continuous recognition based on the same techniques. This study used one HMM for each of the speech unit in the isolated mode. But this is not possible because a sequence of connected speech units in the



continuous case (called a sentence) is to be recognized and hence the number of possible sentences may be prohibitively large even for a small vocabulary. In addition to this, there are two other fundamental problems associated with continuous recognition: not knowing the end points of the speech units in the sentence and not knowing the number of speech units that are contained in the sentence. Because of these problems continuous recognition is more complicated than the isolated recognition. HMM provides a good framework for continuous mode of speech recognition. In this case we connect the HMM for each speech unit in a particular sentence to form a large HMM for the sentence. The HMM is obtained by connecting all the speech units in the vocabulary. The transitions between speech units are determined using the so called language model. [48]

In recent years, ASR has been used in the customer service departments of large corporations. It is also used by some government agencies and organizations. “Basic ASR systems only recognize the single-word entries, such as yes-or-no responses and spoken numerals. This makes it possible for people to work using automated menus without having to enter dozens of numerals manually with no tolerance for error. Sometimes, a customer might hit the wrong key after having entered 20 or 30 numerals at intervals previously in the menu, and give up rather than call again and start over. ASR virtually eliminates this problem [26].”

The technology of speech recognition has been around for some time. Even with constant improvement, some problems still exist. For example, the ASR system cannot always correctly recognize the input from a person who speaks with a heavy accent or dialect. The ASR also has major problems with people who combine words from two languages by force of habit [26].

### **2.3.3 Nuance 8.0**

Nuance is the world leader in natural speech interface software for telecommunications, enterprise, and web-based systems. Examples of successfully deployed applications include a package tracking system deployed by United Parcel Service (UPS), a flight information system deployed by American Airlines,

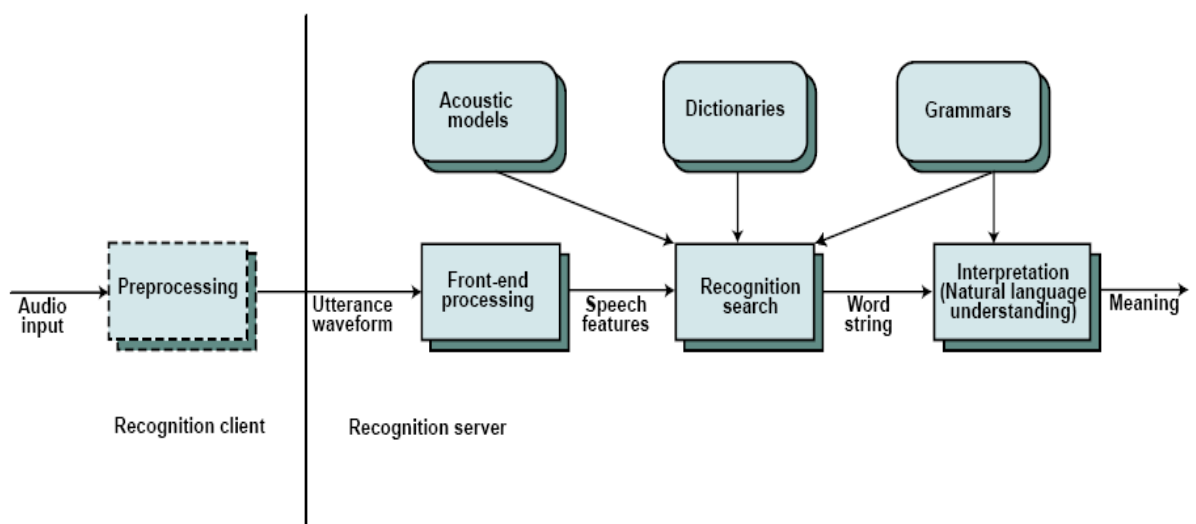


and Charles Schwab’s VoiceBroker System, which provides voice access to sock portfolios and quotes [50].

When we say “speech recognition”, we think of products that allow users to interact with their computers using voice instead of keyboard and mouse. These systems’ main function is transcribing speech or performing dictation. In contrast, the Nuance System provides the following capabilities to automate over-the-phone transactions [50]:

- Speech Recognition ----- Recognizes callers’ utterances
- Speech Verification and Identification ----- Identifies which speaker said the utterance and authenticates the caller
- Natural Language understanding ----- Interprets the meaning of the utterance. Nuance language understanding allows dialog flexibility and more human-like interaction.

The Nuance recognition process can be broken into several phases, as shown in the following figure.



**Figure 2.9 Nuance Recognition Processes [50]**

As part of the process, the recognition server receives the speech signal as input and uses the following three components to perform recognition:

- Acoustic models: Acoustic models are provided by the Nuance System and used for phonetic recognition.
- Dictionary files: Dictionary files contain description of the phonetic pronunciations for the words in the grammar. The Nuance System includes extensive system dictionaries for each language that it supports. You can optionally add dictionaries containing special technical terms or uncommon proper names.
- Recognition grammar: The recognition grammar defines the set of utterances that can be recognized and the interpretations for these utterances.

The Nuance Verifier is a voice authentication server that integrates with the Nuance Speech Recognition System [51]. The Nuance SpeechChannel interface defines methods you can implement to enable access to the Nuance recognition engine on the specific platform, including access to dynamic grammar and speaker verification functionality. The Nuance implementation of the SpeechChannel interface, NuanceSpeechChannel, can be used with any audio provide and includes telephony control methods [52].

NuanceSpeechChannel API is Java classes that access recognizer, verifier and speech synthesizer. The NuanceSpeechChannel framework includes the following interfaces: [53]

CoreSpeechChannel: speech recognition and parameter access interface. The NuanceSpeechChannel class is an implementation of this interface for the Nuance platform [53].

- ❖ CoreTelephonyControl: telephony control interface [53].
- ❖ CorePromptPlayer: prompt playback and speech synthesizer interface [53].

- ❖ CoreDynamicGrammarControl: external dynamic grammar interface [53].
- ❖ CoreSpeakerVerificationcontrol: speaker verification interface [53].
- ❖ CoreSubscriberControl: subscriber profile interface [53].

All function calls are blocking, except for the CoreSpeechChannel.abort method. The speech channel allows multiple simultaneous function calls and executes them in parallel, as long as these calls can be performed simultaneously by the underlying engine.

## **2.4 Literature Review Summary**

This chapter has provided an overview of the development of the e-voting systems, Election Markup Language and the EML voting processes. It has presented the advantages and disadvantages of each of the following systems: Punch Card, Optical scan system, DRE and Internet voting. Some of these are semi-electronic voting systems such as the Punch card voting and optical scan system. Both of them use machines to automatically count the paper based ballots. Some of the voting methods are much easier to use such as DRE voting machine, the Internet voting and the telephone voting. They clarify and simplify the application of the e-voting. However, the usability of DRE and Internet voting has some limitations based on voter's background. The telephone via voice voting doesn't have these limitations. The Automatic Speech Recognition and Text-to-Speech technologies as well as the ASR and TTS engines that we employed in our system have been elaborated on.

## **Chapter 3**

# **METHODOLOGY**

The focus of this research is the development of a telephone/voice based voting system based on the new Election Markup Language (EML) standard. The research utilizes a hybrid quantitative and qualitative approach. In pre- and post-trials, questionnaires were used to collect usability feedback based on users experience with the voting system. Feedbacks from initial trial were incorporated into the voting systems redesign, and subsequent trials thereof. Two qualitative techniques were implemented. Questionnaires were taken from both the operators and voters. This quantitative and qualitative crossbreed method attempts to compensate for any result analysis limitations.

### **3.1 Research Question**

The voting system can be modeled as a standard call center. The voting system server should correctly understand the user responses and act as a bridge that transfers information between the speaking user and the database.

In this system we use the Automatic Speech Recognition (ASR) [26] and Text-to-Speech (TTS) [43] technologies to pass on the information between user and the voting system.

The aim of this research study is to build and run a real-time communication voting system between speaking user and e-voting system based on EML. The system should meet the following requirements, which are considered as the basic foundations of a voting system [23]:

1. Provide authentication, privacy, integrity and non-repudiation
2. Keep each voter's choice a secret

3. Allow each eligible voter to vote only once
4. Avoid tampering with voting system
5. Report all votes accurately
6. Keep it operable throughout the election
7. Keep an audit trail to detect any breach of 3 and 5 but without violating 2

Voters will cast their vote on the e-paper verbally. Also the system should make the voting and counting processes independent. In other words, the ability to make an easy and simple real-time communication between two points is a requirement. Of importance are questions how the information is transmitted and how can we convert data between different formats and maintain the voting XML database?

In this system, the TTS and ASR technologies were used to translate the data between voice and text [50]. With limited voice recognition hardware and software, for the purpose of this research we simulated the telephone network by using a telephone connected to a server via the telephone card. A small election process was set up, and carried out using trials with a hybrid quantitative and qualitative approach to data collection [54].

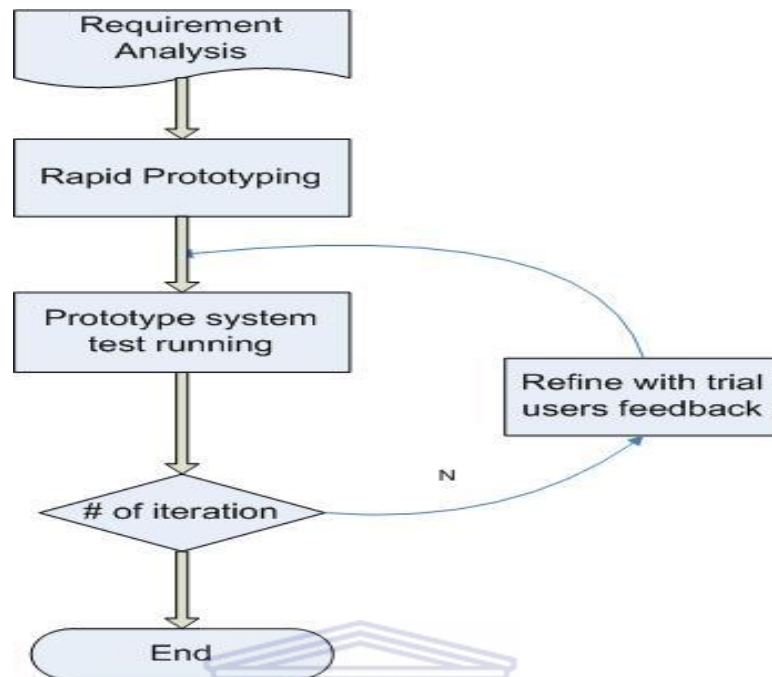
### **3.2 Research Approach**

We encapsulated and adopted a hybrid quantitative and qualitative approach for this research. Qualitative approaches deal with how people understand their experiences. Quantitative approaches deal with numerical measurements (i.e. quantities or amounts) [55]. Mixed research is a general type of research in which quantitative and qualitative methods, techniques, or other paradigm characteristics are mixed in one overall study [54]. It will also discover something that would have been missed if only a quantitative or a qualitative approach had been used [54]. In our study, experiment (quantitative) and a questionnaire study were used. The participants (qualitative) were given a questionnaire to establish how they viewed the experiment. Quantitative instances of voting system usage were noted

with the times of smooth process existing. In addition, pre and post Caregiver Self-Assessment Questionnaires (CSAQ) [56] were used to collate users' usability and usage feedback based on their experience with the voting process and software. The Pre-trial questionnaire captured participants' voting background knowledge. Feedback from the initial trial was incorporated into the voting system redesign and running of the second trial. The post-trial questionnaire provided feedback on the voting system and process. This quantitative and qualitative crossbreed method should compensate for result analysis limitations.

### **3.2.1 Research Steps**

Kock illustrates four major types of research approaches: Experimental, Survey, Case study and Action Research (AR) [57]. In Babbie and Mouton's book: "The Practice of Social Research" [56], they proposed six design types: Experiments, Surveys Research (SR), Qualitative, Participatory Action Research (PAR), Evaluation research and Unobtrusive research [54]. Kock [57] presented a method that factored iterating any of the main research methods (especially AR). Action Research can be simply called "learning from doing" [58]. We find the problem, the design a plan to solve it. If the plan is not the right way, we try again. During this process, we use iterations. The figure 3.1 presents conceptualized Iteration Research (IR). [59] IR enables quick prototyping, testing, refinement and sufficient to validate the research hypothesis. Iteration is well established in solving numerical computation problems and is capable of converging to a root solution. In this thesis, we set the iteration level for software refinements and users' trials to two by following this approach.



**Figure 3.1 Two-level Iteration**

In this cycle, we use questionnaires as the feedback. All the feedbacks will be used for the next level software design and trial to improve the system. The iteration depends on the feedback, showing whether or not the system acted according to our expectations on the voting system.

### 3.2.2 Software Development

An operator interface was used to monitor the system processes. It could show the points where and the reasons why the voting process had stopped. The operator was able to collect the data needed for the system redesign. Detailed design of the system and the interface will be explained in Chapter 4. In line with IR, the users' feedbacks from the first trial were incorporated into a second level of software development for the second trial.

The feedback was in the form of close-ended and open-ended questionnaires about the users themselves, and the e-voting system. Before the final trial, the system was redesigned taking into account all collected information.

### 3.3 Experimental Design

Experiments are conducted to establish the following goals [60]:

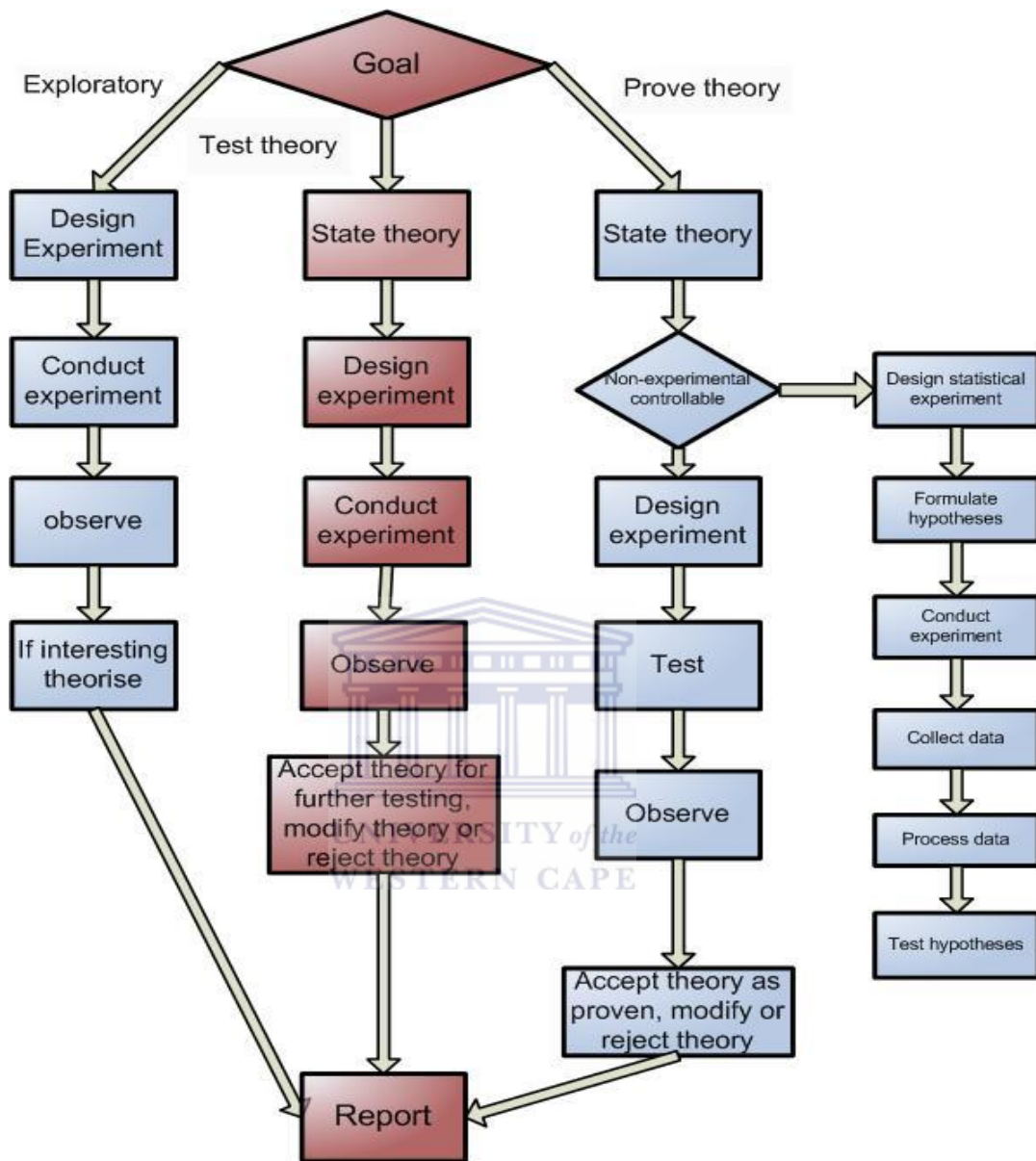
Exploratory experiment

- To “test” a theory
- To prove a theory

Figure 3.2 schematically depicts the major milestone on the route followed to complete our experiment. In this thesis, we test the system usability for all voters keeping in mind disabled people. The experiment may consist of writing the necessary software (system design), deploying it in one or two locations in the “field”, observing that no major problems exist and learning what we can from this exercise.

For the purpose of this research we employ questionnaires (pre-trial and post-trial including a general overall comment session at the end), short unstructured interview sessions with focus groups and observation of participants in the two trial sessions. Each form of data collection is discussed in depth below.





*Figure 3.2 Goal versus experiment approach [60]*

### 3.3.1 Questionnaire

The questionnaires are used as a research instrument. As defined in the dictionary, “Questionnaire is a form containing a set of questions, especially one addressed to a statistically significant number of subjects as a way of gathering information for a survey [61]”. Questionnaires have advantages because they are cheap, do not

require as much effort from the questioner as the survey is conducted verbally, and often have standardized answers that can help in making data processing simpler. Questionnaires may be designed to gather either qualitative or quantitative data. We can get information such as users' background, how the client feels about the system, whether the process was problematic and what the highlights and positives were. Such information would help us to analyze and improve the system as well as the process.

The questions were adapted in the pre- and post-study questionnaire to elicit feedback on the usability, control and functionality of the voting system. One of the aims was to compare e-voting with the standard voting methods. The questionnaires were given to both operator and users.

### **Pre-Trial Questionnaire**

The pre-trial survey questionnaire elicited background information on voting and e-voting in general. Some questions captured whether or not responders had taken part in voting or e-voting before. How many times and which kind of voting did they participate in? How did they think about the televoting? Did they have any problem during voting before? Other questions addressed the features as to whether televoting would be suitable for disabled people. An introduction to the voting system and process were presented to which they rated in terms of relevance or necessity. (See Appendix A for the pre-trial questionnaire.)

Like [62], the pre-trial questionnaire provided an understanding and experiences of the participants, in this case, their exposure and experience of using electronic voting methods and whether they have been introduced to e-voting before. This baseline helped to draw conclusions on their experience from using the enhanced feedback introduced in the trial sessions.

### **Post-Trial Questionnaire**

The post-trial questionnaire examines participants' experience with using voice based telephone voting. It also provides feedback on the process and system introduced in last trial.

The questionnaire concludes with the usability and vote count correctness. Unlike [62] that used a concluding discussion with a focus group, the optional ending question was included in the post-study questionnaire to solicit overall experience and general feedback on the voting system. The final post-study questionnaire is in Appendix B.

### **3.3.2 Logging – Server and Client Side**

The voters communicated with the voting system, verbally over the telephone with no additional visual guidance. All the information about the system and the voting process were given to the user by voice. Clients logged in by verbally giving the ID and password. On the server side, the operator monitored the system functioning using a GUI. In addition, the operator could stop the process if an error had occurred. A questionnaire was given to see how the system responds during the voting. (See Appendix C)

### **3.3.3 Focus Group**

Short unstructured review sessions with focus groups helped to triangulate findings from logs and questionnaires as well as observation during trials. In the initial trial, test trial participants were closely observed. Afterwards, a short discussion session allowed further aligning pre-trial questionnaire data and trial feedback with the respondents. Bugs were reported and suggestions made on software improvements. Participants were loosely observed in the final structured trial. A short informal discussion was carried out to elicit feedback on system foundation and process steps.

### **3.3.4 Trial**

Two trials ensured an exhaustive testing of the voting system features by study groups. Having the trials in two phases also provided for lessons learnt and feedback from the initial trial to be incorporated into the final trial.

### **Initial Trial Session**

The purpose of the initial trial sessions was to simulate voting process with participants, draw from the pre-trial survey, and test the system and basic

foundations including the basic processes. The trial was conducted with people from various backgrounds, technological level to computer literate level. In this trial we wanted to see if this system could be used by all groups, even the non-educated. We selected ten non-computer science students from the University of The Western Cape who comprised of a sector of technologically and previously disadvantaged group: three male and seven females. Eight of them were unfamiliar with the voting process. Two were 'au fait' with the traditional paper voting, stating that they had experienced this type of voting a few times. But none of them had experiences in the electronic voting. They were also asked to input wrong information to the system to test if the system could acknowledge the correct information and rectify the wrong one. After the trial, the group was required to fill in the post-trial questionnaire. A short discussion session allowed for further aligning pre-trial questionnaire data and trial feedback with respondent. This also addressed reported bugs in the software. Both the system set up and experimental setup is described in Chapter 5.

### **Structured Trial Session**

The structured trial was the second phase of the initial trial run to test the functionality of the system. With experience from the first attempt, it aimed to proof-test the system modifying feedback. This time, the participants were asked to carry out more extensive usage of the voting system. Participants in this trial all had some more or less experience of the e-voting (some of them attended last trial). The task includes generating technical problems to test the system response. The Appendices D and E show the examples of smooth and problematic voting processes.

## **3.4 Methodology Summary**

We are going to build and run a real-time communication voting system between speaking user and e-voting system based on the new standard, EML. The system should have some basic foundation like providing authentication, keep each voter's choice a secret, allow each eligible voter to voter only once, report all votes accurately, keep it operable throughout the election and so on. It combines the ASR/TTS technologies with the EML voting system to develop a voice based

voting system. To provide an answer, the ASR and TTS technologies were implemented for the communication purposes. The EML was used as the data format.

A two-level iteration approach provided the quick prototyping, testing, and improvement of the voting system. One benefit of this approach is to refine and make informed decisions and changes in the software development cycle and architectural design. Moreover, test trials were conducted in two iterations in line with one group pre-test-post-test experimental study.

Data collected from multiple sources and incorporated both qualitative and quantitative data to triangulate the voting study group results. The quantitative and qualitative crossbreed method compensated sufficiently for any methodological limitations. The triangulation of results was essential to align pre- and post-trial questionnaire feedback with the other data sources.



## **Chapter 4**

# **SYSTEM DESIGN**

This chapter describes the overall system design, high-level design and the software implementation. The system should support four activities of the voting process: the candidate's nomination process, voter's registration, the voting and the auditing.

### **4.1 User Requirements and Requirements Analysis**

The requirement can be divided into two types, foundation and non-foundation requirements. [63] In this research, the voters are the final user of the system. So, what the voters want the system to do will be the goals of our system design. Martin Maguire comments: "Understanding user requirements is an integral part of information systems design and is critical to the success of interactive systems." [64] Complete and correct understanding of users' requirements can increase productivity, enhance quality of work, reduce support and training costs and improve user satisfaction. In this section, we will discuss two types of requirements: user requirements and requirements analysis.

#### **4.1.1 User Requirement (UR)**

Users normally have an abstract idea of what they want as an output, but not how software processes and what the software does. Users' requirements are the fundamental structures for the software design. This section describes the requirements from the users for the EML Based Televoting System. The users' requirements are as following:

- The system accepts voter's ID and the password (voter identification is verbal).
- The system will guide the voter during the whole voting process by voice.

- The system should read out all the information about the voting process.
- Voters should be allowed to progress easily through the system when casting a vote, as well as to recant on their previous actions.
- Voters should be allowed to reconsider the final vote.
- Users should not be allowed to vote more than once.
- The Voters should be counted and easy to recount.
- The system should not accept any “write-in” (say-in) type of vote.
- The system should be reliable and easy to use.

#### **4.1.2 Requirement Analysis**

Once the general requirements are gleaned from the user, an analysis of the scope of development should be determined and clearly stated. The user’ requirements should be recognized and translated into technical requirements or foundations for the software. According to the above UR, the EML based televoting system should have the following basic functions:

- Establish a voice communication with a voter.
- Maintain the EML database correctly and give the right information to a voter.
- Verbally guide the voter throughout the voting process.
- Count the vote and keep a copy of the vote for recounting purposes.
- Allowed voters to cancel the foregoing choice and make a new one before they cast their vote
- Reliable conversion of voice to text and vice versa.
- Prevent multiple voting

- Reliable votes registration and counting, including recounting.

## 4.2 High Level Design

OASIS defined a high-level voting process design based on EML in an approved international standard in 2002. In this section, we will look at this process and discuss our own high-level design based on it.

### 4.2.1 High Level Design Overview

The EML described its own voting process. In this process, voters were able to use a choice of physical channels such as postal or paper ballot (the 'physical access methods'), or 'electronic access methods' to cast their votes.

Each channel may have a gateway acting as the translator between the voter terminal and the voting system. Typically, these gateways are in proprietary environments. The EML messages schemas 410, 420, 430, 440 and 450 can be used as interfaces to such gateways. These schemas function irrespective of the application or the supplier's choice of technology.

To create balloting information, some input data describing the election are needed. EML message 230, 110 and 120 are used for exchanging information about options/candidates and eligible voters between e-systems.

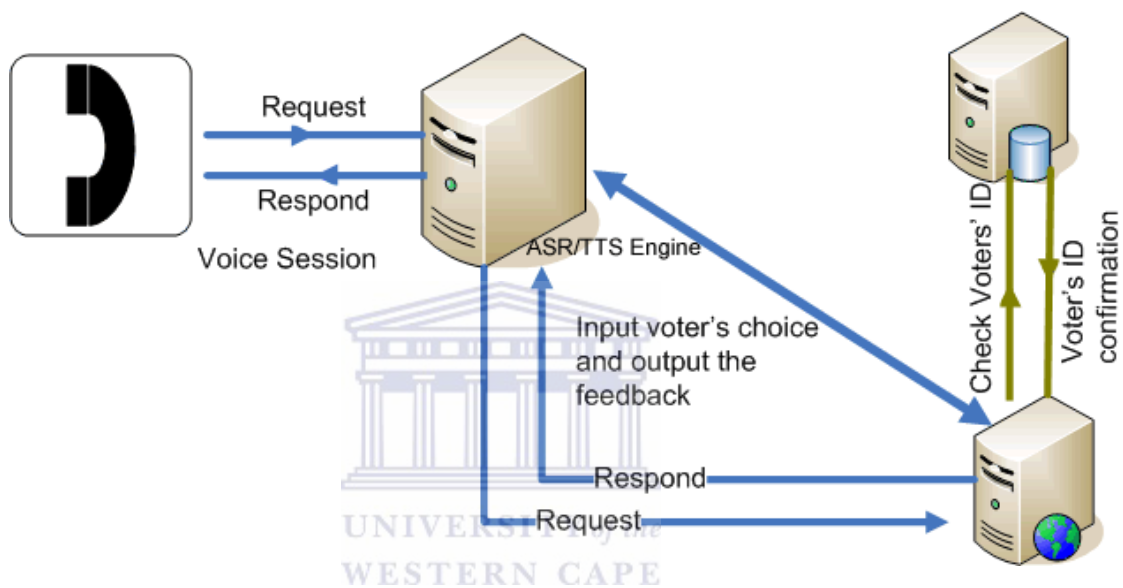
The EML voting process also includes the parts like qualified voter, vote casting and votes counting. According to the EML voting process, we designed our voting system. In our voting system showed in figure 4.1, we use documents to simulate the voter database.

In the telephone voting, two endpoints are speaking users and IP based voting system. Voters can use Public Switched Telephone Network (PSTN) or mobile telephone to cast their votes. We use the Nuance Speech Channel as the gateway to allow verbal communication with the ELM based voting system. The Nuance Speech Channel used for this project includes Automatic Speech Recognition (ASR) and Text-To-Speech (TTS) engine. The ASR is technology that allows a



computer to identify words that a person speaks into a microphone or telephone. The TTS system converts normal language text into speech.

The voting system uses EML as interaction standard. The voting system in this study uses the following EML schemas: 440, 450, and 460, for casting the vote; schemas 230 for candidates list, and schemas 510,520 for votes counting.



*Figure 4.1 Our Voting Process.*

#### **4.2.2 Software Development Overview**

In this system, we employ Nuance TTS and ASR Engine to get the voters' voice command and Java Speech channel as the Nuance Application APIs.

The figure 4.2 shows the voting flow chart. The Nuance listener server is waiting for the telephone call. After answering the call, the voting system says a welcome message and asks for the voter's ID and the password. After voter has responded, the ASR engine converts the voter voice to text and compares the information with the voters list. If the voter passes the authentication, the system will allow her/him to cast the vote. The system will read out the candidates list and ask the voter to make their choice. After the voter has confirmed the selection, the voting

is completed and the result will be displayed on the operator's user interface to indicate that the vote was counted. The system marks voter as "voted" to ensure one voter can only cast one vote, once. The vote is kept in an EML document for archiving and recounting purposes.

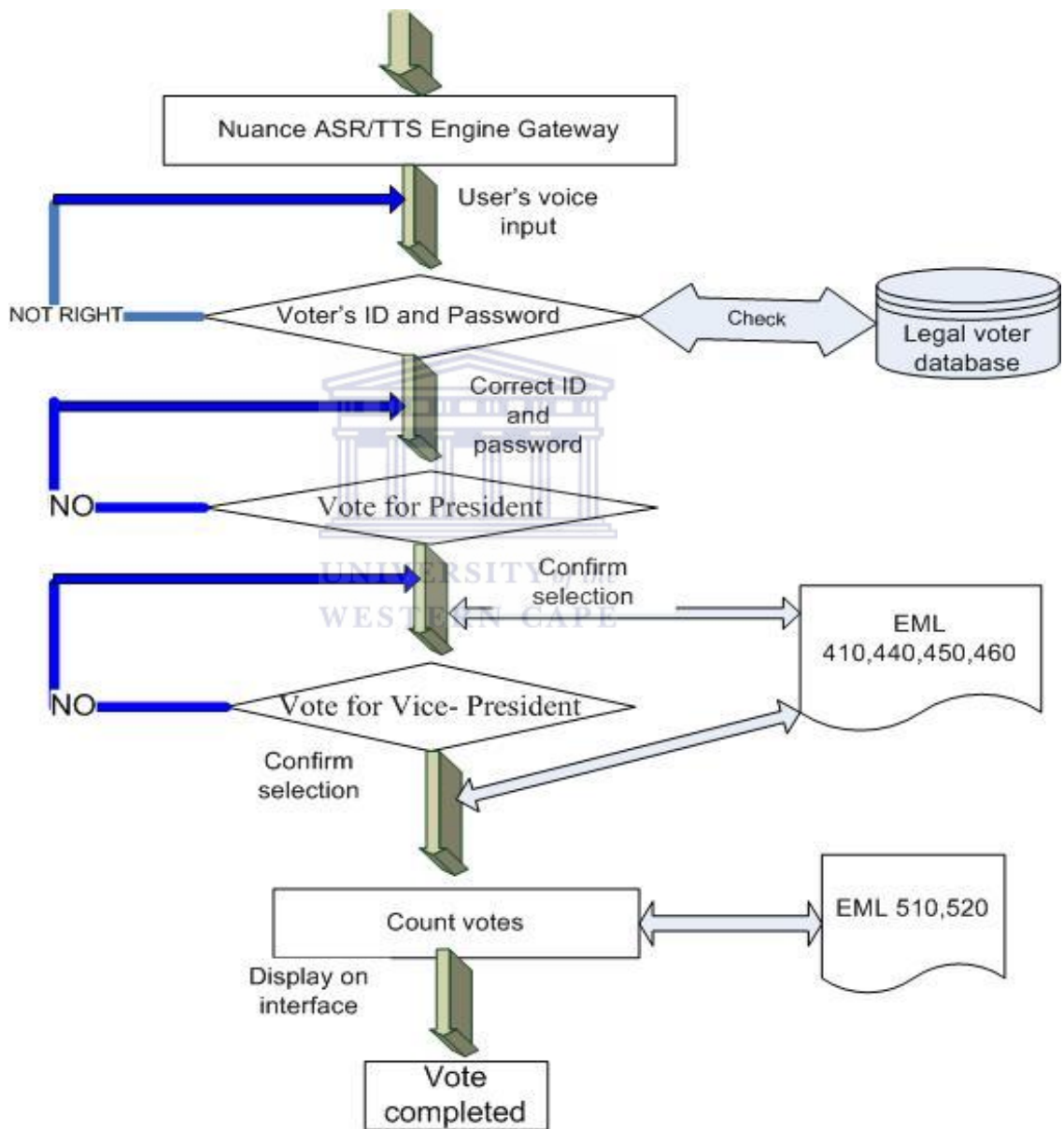


Figure 4.2 Flow Chart

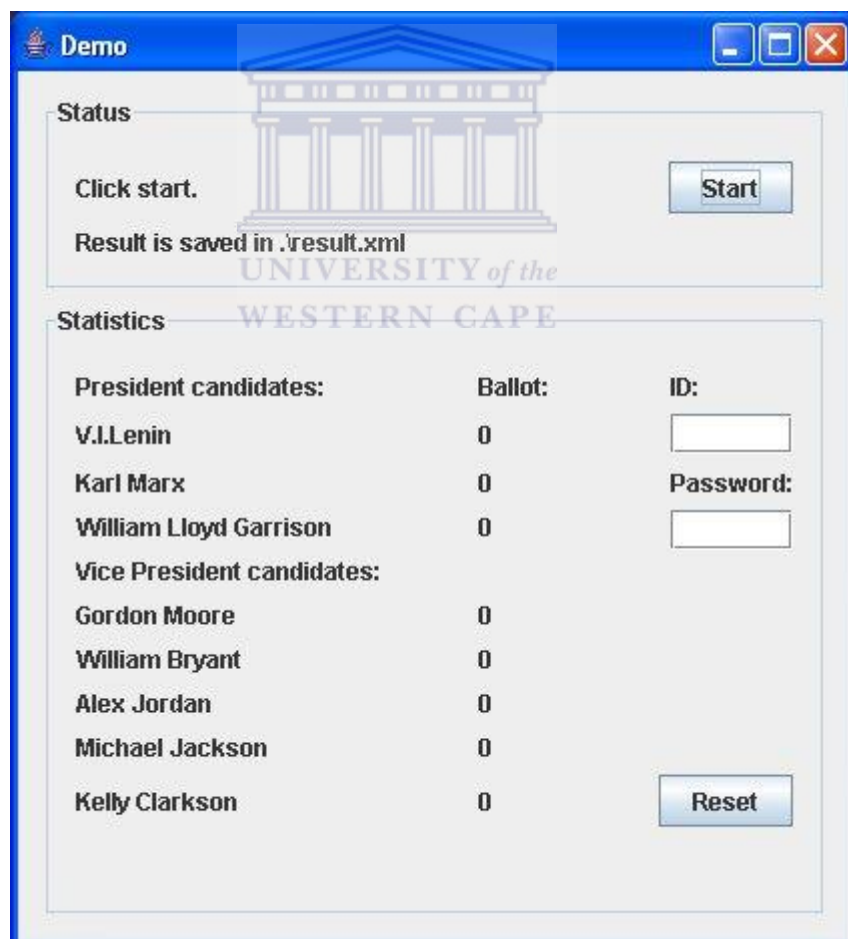
## 4.3 User Interface Specification

### 4.3.1 Users' Interface

The interface for the client side is a voice interface. The system asks for information from the user and reads out the choice options to the user. The voting process is a dialogue between the system and user. Appendix A shows a complete voting dialogue as viewed from a user's side.

### 4.3.2 Operator Interface

Operator is presented a graphical user interface. Figure 4.3 shows the operator's screen.



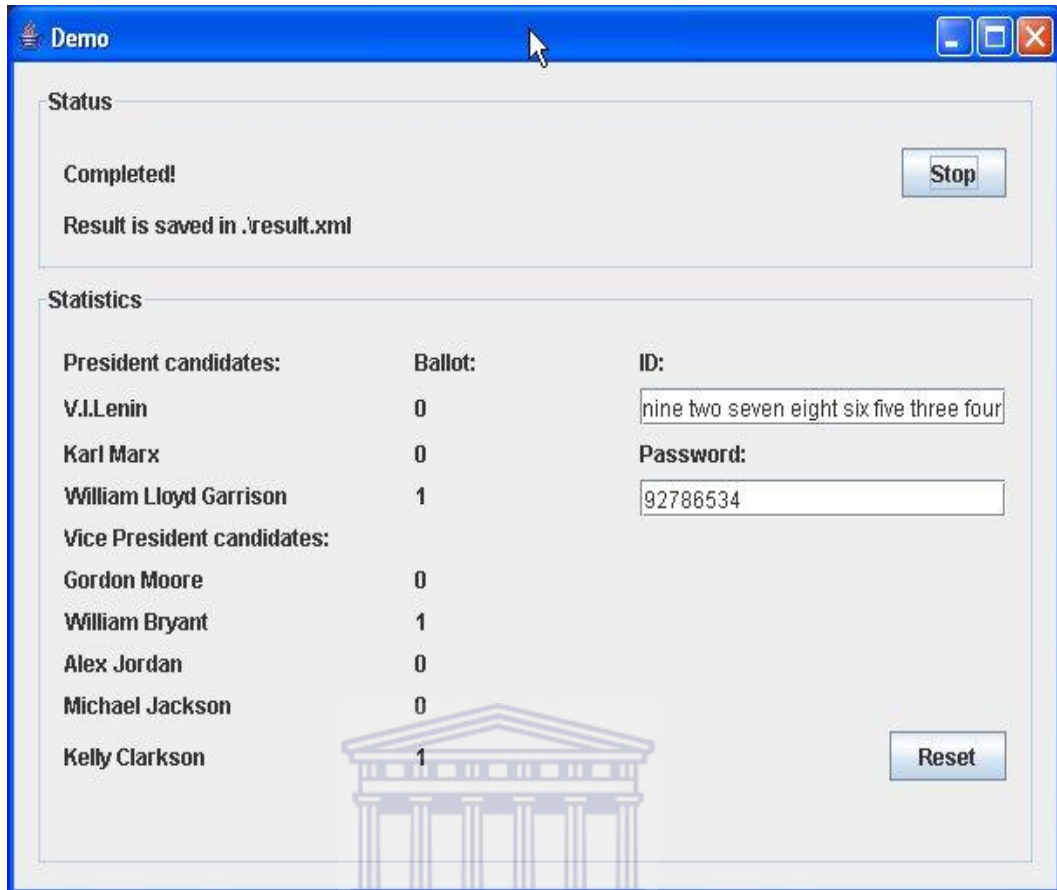
*Figure 4.3 Operator's Interface*

From this interface, the operator can monitor, recognize and attend to possible problems. The operator monitors the system by watching status options:

- ❖ Click start: Before system is started.
- ❖ Failed: when the Nuance cannot start, this will be displayed.
- ❖ Verifying: when the system is getting the voters' information.
- ❖ Voting: during the voter vote.
- ❖ Completed: display when voter confirms all the choices.

Figure 4.3 shows the interface's initialization. After clicking on the Start button, the system will start to listen to the voter telephone calls. Calls are answered and the voting process begins. When the voter completes the voting the display will be updated showing current results indicating whether or not the voting was successful and if the result was counted. Figure 4.5 shows the display after a voter has cast a vote. The figure 4.4 shows the voter's ID is "92786534". He chooses "William Lloyd Garrison" as the president, "William Bryant" and "Kelly Clarkson" as vice presidents. His vote was successfully cast and counted. The result is saved.

On the interface, the user's ID is displayed during the test in writing and numbers, thus allowing the operator to check if the problems come from the ASR. In the real voting situation, to keep the vote secret, this information will be displayed as row of asterisks.



*Figure 4.4 Successful Voting*

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## 4.4 Software Implementation

Typically, the election process includes the pre-election, election and post election stages. In our study, we only discuss the election and post election stage that includes the vote casting and counting.

### 4.4.1 EML Messages

In the EML's standard high-level process model, the voting process can be divided into three major areas, pre election, election, post election. Each area involves one or more election processes. One or more XML schemas are specified to support each process; this ensures consistency with all the figures and schemas required. [2]

- ❖ Pre election
- ❖ Election
  - Voting
- ❖ Post election

In our system, we use election and post election areas represented by the following EML schemas.

Election processes: [1]

- Cast vote (440) ----- we used this message to represent a cast vote, which comprises of an optional voting token to ensure a legal vote, information about the election event, each election within the event and the vote or votes being cast in each election.
- Vote confirmation (450) -----This show whether a vote has been accepted and provides a reference number in case of future queries. If the vote is rejected, the remark element will show a reason.
- Votes (460) ----- This schema defines a message comprising a set of votes being transferred for counting. It is a set of CastVote elements from schema 440 with the addition of the ProposedRejecion and ProposedUncounted elements and audit information for the voting system.

Post election processes:

- Count (510) ----- It is used to communicate the results of one or more contests that mark up one or more elections within an election event. It may also be used to communicate the count of a single reporting unit for amalgamation into a complete count.
- Result (520) ----- messages described by this schema can be used to communicate the results of simple election types. The main part of the schema is held within the Selection element. This allows the choice of

candidate, affiliation or referendum option identifiers to be defined with the position that choice achieved.

**Table 4.1 Cast Vote Elements**

Element	Attribute	Type	Use	Comment
CastVote	Spoilt	xs:token	optional	
Contest	Spoilt	xs:token	optional	
Selection	Value	VotingValueType	optional	
	ShortCode	ShortCodeType	optional	
Candidate	Value	VotingValueType	optional	

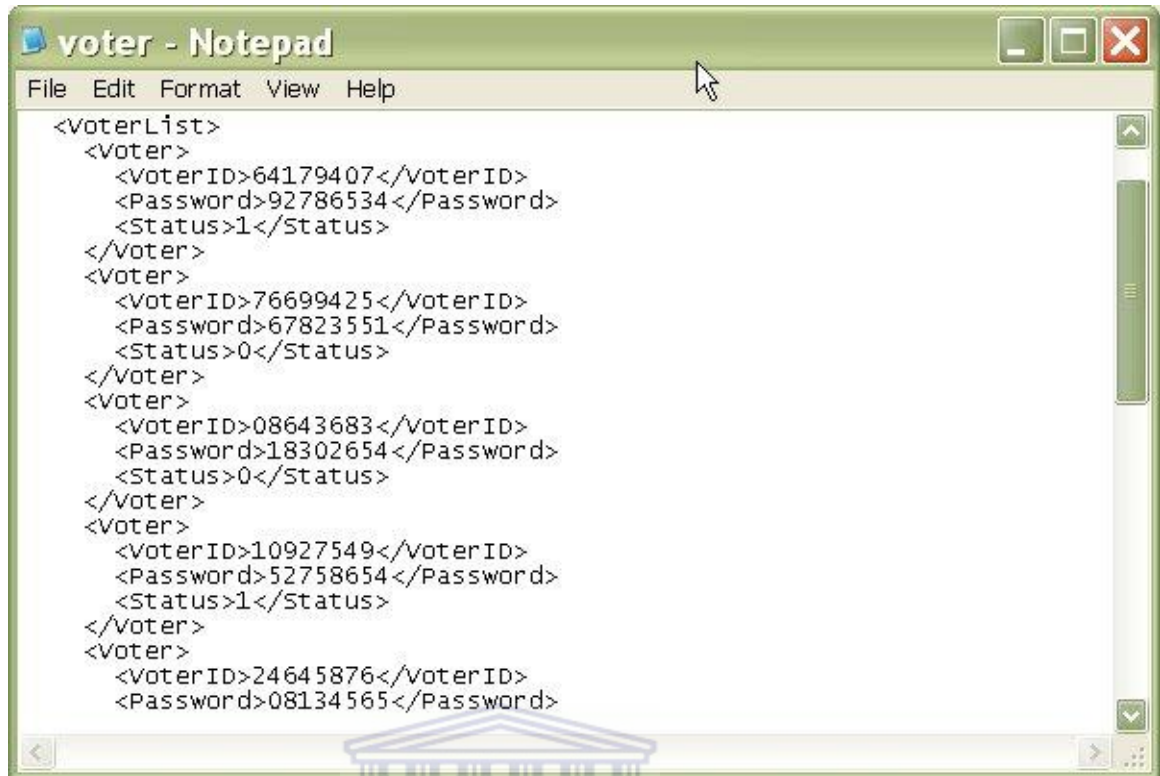
**Table 4.2 Count Elements**

Element	Attribute	Type	Use	Comment
Selection	Value	VotingValueType	optional	
RejectedVotes	Reason	xs:token	optional	
	ReasonCode	xs:token	required	
UncountedVotes	Reason	xs:token	optional	
	ReasonCode	xs:token	required	

Table 4.1 and 4.2 show the elements of the schema of 440 and 510 respectively.

#### 4.4.2 System Files

Figure 4.5 shows the voter record in the XML database. The users' IDs and passwords are represented by numbers. When the voter has input his details into the system regarding the ID, the system will search through database for checking the Voter ID. When found, the same will be repeated for the password. When the voter's ID and password have been confirmed, and after the voting, the Status value will be changed to "1", meaning that the voter had cast his vote and cannot vote again. As the figure shows, the first and fourth voter had cast their votes. The system keeps a backup copy of the database for the recount or double check of the election results.

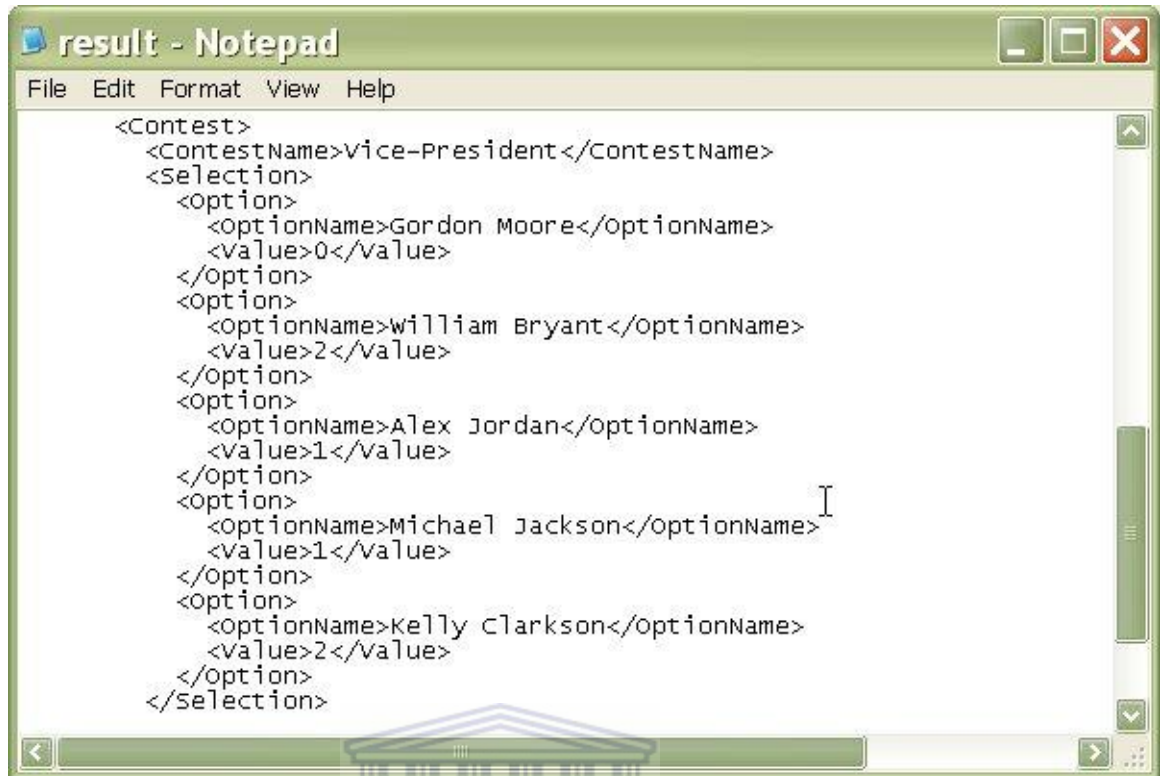


```
<voterList>
  <voter>
    <voterID>64179407</voterID>
    <Password>92786534</Password>
    <Status>1</Status>
  </voter>
  <voter>
    <voterID>76699425</voterID>
    <Password>67823551</Password>
    <Status>0</Status>
  </voter>
  <voter>
    <voterID>08643683</voterID>
    <Password>18302654</Password>
    <Status>0</Status>
  </voter>
  <voter>
    <voterID>10927549</voterID>
    <Password>52758654</Password>
    <Status>1</Status>
  </voter>
  <voter>
    <voterID>24645876</voterID>
    <Password>08134565</Password>
  </voter>
</voterList>
```

*Figure 4.5 Voter Data in This System*

The figure 4.6 shows the results after some voters cast their vote. The *optionname* mentions the candidate. For the vice-president, the voter could choose two from five candidates. As this result shows, three voters had cast their vote. The value *option* shows how many votes each of the candidates has got.





```
<Contest>
  <ContestName>vice-President</ContestName>
  <Selection>
    <option>
      <optionName>Gordon Moore</optionName>
      <value>0</value>
    </option>
    <option>
      <optionName>William Bryant</optionName>
      <value>2</value>
    </option>
    <option>
      <optionName>Alex Jordan</optionName>
      <value>1</value>
    </option>
    <option>
      <optionName>Michael Jackson</optionName>
      <value>1</value>
    </option>
    <option>
      <optionName>Kelly Clarkson</optionName>
      <value>2</value>
    </option>
  </selection>
</Contest>
```

*Figure 4.6 EML 530 Message In This System*

### 4.4.3 High Lever Classes

#### DemoJFrame Interface

This is an interface for the operator, which audits the voting process. The operator also audits and monitors votes counting. It comprises of the following methods that provide functionality to other classes and act as interface to the main class----

DemoJFrame

Void actionPerformed (ActionEvent);

Boolean NuanceInit ();

Boolean Confirm ();

Void display ();

Vector go ();

Void init ();

Void initComponents ();

Void terminate ();

Boolean verify (RecResult r, init i);

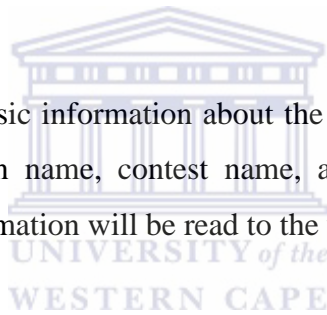
Void main (string args []);

## **DemoJFrame**

This is the main class, which implements the DemoJFrame interface. It is the starting point for the voting process. It employs the Nuance and voice interface to the user. It also handles the EML messages by calling other classes. The system is initially started by the operator and the user can hear the welcome message and carry on the voting process.

## **Election**

This class handles all basic information about the election. It will get all election information like election name, contest name, and various options by calling EMLIO class. This information will be read to the user.



## **EMLIO**

This class handles all the EML message reading and writing. It has readEml () and writeEml () methods. It reads the EML message, puts out to DemoJFrame class and reads it to the user. WriteEml method will write the voter's information into the EML files.

## **FFilter**

This class handles files manipulation, creation, reading and writing. It keeps every voter's choices as a separate file. That means every voter has written (cast) a file (vote) like the paper voting's vote. When the choice was confirmed by the voter, the file will be saved.

## **Voter**

This class handles the information about the voter. It will get the ID and password from the voter, and perform the authentication by comparing the information with one stored in the database. If the voter is an illegal voter, it will return the main class to stop the voting process. If the voter is authenticated, system will continue with the voting process. Also, this class will tag this voter as having “voted” after the completion of the voting process.

## **Deployment**

The EML based Televoting system was packaged with a Demo using NetBeans IDE 5.0 and deployment tool.

## **4.5 System Design Summary**

This chapter described the design and implementation of the EML based Televoting system. An ideal environment for testing this Televoting system would be to use handhelds running on a LAN network that connects to the PSTN. This Televoting system enables the blind and illiterate people to vote by talking on the telephone instead of pressing the buttons. This system runs on the IP based network and on Windows or UNIX platforms.

## **Chapter 5**

# **EXPERIMENTAL IMPLEMENTATION**

This chapter presents a detailed experimental implementation based on the methodology discussed in Chapter 3. We selected two-level iteration research method based on trial questionnaires collected from users (voters) and operators. As described in Chapter 4, the system is an EML based televoting system. The system has two interfaces. The interface to the voter is completely voice based. Operator uses a Graphical user Interface (GUI) for the monitoring and debugging purposes.

Experimental trials took place in October 2006 with participants drawn from diverse sectors of the University of the Western Cape. The selected candidates were asked to act as voters and comment on the voting process afterwards by filling in the questionnaire. The aim of the project is to provide convenient access to the majority of voters, and more importantly a better voting method for blind, disabled and illiterate citizens.

For the testing purposes a database of 20 registered participants (voters), was created and an election for a “chairperson” and his/her assistants was simulated. In the voting process, the voter could make a single choice from three candidates for the chairperson and select two assistants from five candidates. The system would not allow voter to choose more or less than the required candidates, and write-in candidate was not allowed also.

### **5.1 The Initial Trials**

The initial trial was conducted in October 2006 with two groups of participants classified as non-technical and technical. The final trial was carried out in April 2007. As an addendum to this experiment we added a group of some non-technical participants. The participants for both trials were drawn from the general

population of the University of the Western Cape and University of Setenllenbosh. We also had two operators to control and audit the voting system and to look out for possible problems on the voting server side.

The first part of this trial was a usability trial, which introduced the EML-based voting system and experimental voting rules to the non-technical group. Most of them did not take any kind of electronic based voting prior to this experiment. The next trial consolidated on the experiences learnt from this previous trial. This late-adopter's trial made the technical testing available for the televoting system in the early-adopter trial.

### **5.1.1 First Trial Run – Late Adopter**

#### **Overview of Purpose Trial**

This trial was the initial step to expose the experimental system to the users. The aim was to determine the impact and user response to the system as well as a test of the voting system's basic functions.

#### **Participant Selection/Grouping**

The trial election participants were drawn from respondents from the pre-trial survey. We emailed the pre-trial questionnaire to fifty students and got twenty-eight replies. We selected ten non-computer science students as the non-techies (representing late adopters), three male and seven females. Eight of them were unfamiliar with the voting process. Two of them had participated a few times in the traditional paper voting, but none of them attended the electronic voting.

#### **Experimental Environment: Network, Equipment and Software**

A server was set up in the so called "Icebox Lab" (this name did not affect the experiment - the name was lovingly given by the students to describe the air conditioning system) of the computer science building at UWC. The non-techies were placed in the "Icebox Lab" to cast their vote. The voting system was installed on an hp desktop computer whereby the voter communicated with the server by using headsets.

The computer was setup as follows:

Hp dx2000 MT Intel®

Pentium® 4 CPU 2.80GHz

512 MB of RAM

Microsoft Windows XP professional version 2002

Nuance 8.0

### **Task**

To demonstrate the voting process and the system used, a brief introduction was given to the participants. Each one of them was given a voter ID and a password. Then they were encouraged to try out the system by themselves.

Finally, they were asked to vote for a “lab election”. They had to use their user ID and password to access the system. Some of them were asked to make wrong choices, to vote for more or less people than needed and to make a “write-in” vote. Two participants were asked to make a multi-vote. They were asked to do make incorrect procedural steps during the voting process. We also had an operator monitoring the whole process at the server side through the operator interface. The participants and operator were given the trial questionnaire to fill-in after the voting.

### **Data Collection**

Data collection was multifold. Each of the participants and operator filled out the post-trial questionnaire and we also had a short discussion after the voting. Because all of them were the first time users of the electrical voting machine, most of them did not go through the voting process smoothly. Only one voter was able to go through the process without any problems.

## **Results**

The trial proved inconclusive. Participants were excited by using the system. They were intrigued by the interesting technology and were willing to try it. The system could implement the basic voting functions without problems. However, it still had some inconvenience for the voter. The operator found that the setting of the ASR cache time period was too short. The system forced people to speak fast but it could not interpret their responses correctly. Some voters were stopped because of misinterpreting the system voice guidance. The operator found the cases when the system could not continue with the process when the voter gave an incorrect answer. It was because the systems response to the incorrect information was long. However, the system worked well for the positively identified voter. Only legal voters were allowed to cast the vote. Also, the system prevented multiple voting. After confirmation of the vote, the voter could not vote again. The first phase was an eye opener on how to conduct further trials.

The feedback from the short discussion held with the group after the trial session revealed some of the inconveniences as noted above. One of the participants suggested the system should give more guidance when using a multiple choice method like repeating candidates' names.

### **5.1.2 Second Trial Run – Early Adopter**

#### **Overview of Purpose Trial**

The second phase of the initial trial was to run a system functionality test. With the experience from the first attempt, it aimed to proof-test the system modifying the feedback.

#### **Participant Selection/Grouping**

Trial participants were drawn from the respondents of the pre-trial survey. Six of the first trial participants continued in the experiment. Another four referred to as 'early adopters' were drawn from UWC. All new participants had the experience of e-voting. Two of them had the experience of SMS voting. Three of them had taken part in elections by using voting machines or online voting.

## **Experimental Environment: Network, Equipment and Software**

The voting server and the “voting poll” were set up in the “Icebox lab” at the Computer Science building at UWC. The hardware and software setup was similar to the first group trial outlined above.

### **Task**

A brief introduction was given to the participants to demonstrate the voting process and the system functionality. They were each given a voter ID and password and were asked to vote in a “lab election”. As before, some of them were asked to make wrong choices, to vote for more or less people as needed and to make a “write-in” vote. Two participants were asked to make a multi-vote. They were asked to make incorrect procedural steps during the voting process. We also had an operator monitoring the whole process at the server side through the operator interface. The participants who attended the last trial were asked to pay attention to the changes of the system. After the voting was over, the participants and operator were given the trial questionnaire.

### **Data Collection**

The data collection for this group was multifold as for the first group. All the participants and operator were asked to complete a post trial questionnaire. They also had a short informal discussion after the voting. They were asked to compare this trial with the last one. In the process some technical and non-technical problems were discovered. These reported problems and bugs were fixed for the next iteration, the final trial.

### **Discussion of Trial**

In this trial, the system worked smoothly. All the voters received the necessary guidance during the process and none of them were stopped because of misunderstanding the voice guidance of the system. In this trial, we changed the method of the multiple-choice vote confirmation. User had to confirm them one by one. Most of participants thought it was more convenient than confirming all at the same time. The system gave the users more time to make their choice by prolonging the ASR waiting time. Also, the system could continue the process and



give the user right guidance when the information received was wrong. The votes were counted correctly and reported to the system immediately which was observed at the operator interface.

The early adopters group discussed this system. Three of them pointed out that it would be better if the system could accept just the candidate name or surname, rather than the full name only. However, this would cause trouble when more than one candidate uses the same name or surname.

## **5.2 The Test Bed – Final Trial**

### **5.2.1 Overview of Purpose Trial**

The main experimental trial drew from the experience of the initial trials, both the early and late adopter. The purpose of this trial was to test the re-designed system. We want to test the functionality, accessibility and usability of the system. A completed voting dialogue was shown to introduce users to the system (see Appendix E).

### **5.2.2 Participant Selection/Grouping**

This time we were able to obtain more participants than in the previous two trials. We accepted all participants willing to take part in the experiment, twenty of them in total. Most of them were the participants who attended the initial trials. This group comprised of twelve males and eight females: Masters or Honors students from Education department, Science Faculty, and Economics Faculty. Five of them took both early and late adopter. They were chosen because of their experience with the system. They were offered some snacks and drinks during the experiment and everybody was given a cell phone ornament.

### **5.2.3 Experimental Environment: Network, Equipment and Software**

Experimental setup for the final trial followed an approach similar to the initial trial set up. Feedback from the initial trial was analyzed and incorporated into the re-design of the EML Based Televoting System. A server and the polling station

were set up in the ‘Icebox Lab’ in the Computer Science building. The voting system was installed on an HP computer of the following configurations:

Genuine Intel® CPU 2160@1.80GHz

1GB of RAM

Microsoft Windows XP professional version 2002

Nuance 8.0

### **5.2.4 Task**

Unlike in the initial trials, participants were introduced to the system formally. We explained all the steps to the users. This time some of them were asked to do some unconventional voting as part of their election process. Some of them were asked to do the following:

- To give a wrong user ID or password
- To cancel the first choice and choose another one
- To make a write-in vote
- To select less or more candidates than required
- To mispronounce some words

An operator audited the voting process and made sure that all votes were counted. After the voting was done all of the system’s responses were checked and documented manually to find out if the system could control the voting system logically and correctly. All the participants were asked to fill in the post-trial questionnaire.

### **5.2.5 Data Collection**

Data collection was multifold as in the initial trial groups. After the voting, all participants and operator had a meeting to discuss the voting process. All the

participants filled in the post-trial questionnaires. The operator also filled in a questionnaire to establish the problems from the server side.

### **5.2.6 Discussion of Trial**

Like in the previous trials, participants had an informal discussion after they completed the post-trial questionnaire. They discussed the system's response during the voting process, especially when they made deliberate mistakes during the voting process. It was found out that the system guided them to correct the mistakes. The participants who joined the second initial trial were asked to compare this trial with the last one.

Feedback from the participants and operator were analyzed, which will be discussed in the next chapter of results and analysis.

## **5.3 Experimental Implementation Summary**

This chapter presented a detailed description of the experiment for the initial and final trial. The trials took place in same location-----the university computer science ice-box laboratory. Lessons learnt from the initial trials were incorporated into the final trial. More than twenty participants came forward to extensively try out this system.

The two trials were observed and data collected via operator questionnaire, pre- and post-trial questionnaires and feedback sessions with groups. The results are presented and analyzed in the next chapter.

## **Chapter 6**

# **TELEVOTING SYSTEM RESULTS**

In this chapter, we discuss results based on the data that incorporates both qualitative and quantitative data collected as described in Chapter 5. In each test the participants gave feedback which helped the researcher to devise appropriate intervention measures and to draw meaningful conclusions from it. Some important hints that were highlighted by the participants are presented in this chapter. The chapter also discusses the effectiveness of omit televoting with regards to reducing the number of spoiled votes and boosting or enhancing voter participation.

### **6.1 Questionnaire Results**

During the system testing phase, multiple data gathering techniques were used namely, questionnaires and group discussions. Complete results from the test and control samples that summarize the views of both the proposed system operators and ordinary system users are presented in Appendix A, B and Appendix C, respectively.

#### **6.1.1 Base Lining**

This research set out to explore the design and implementation of a real-time oral voting system. Questionnaires were designed to identify the experience and views of our participants with regards to e-voting system.

Respondents were asked if they had the experience of voting and if so, which voting methods or system they were familiar with. Table 6.1 shows that most respondents have been subjected to the traditional paper-based voting. On the contrary, the majority of respondents to our questionnaire had never used an electronic voting system. However, judging from the group discussions with the participants, almost everyone expressed interest in using an electronic voting

system. They were excited about the idea of using a new system. Based on the analysis of collected data on people’s voting experiences, it is possible that the respondents’ inexperience might have influenced their interpretation of the questions asked in the questionnaire.

**Table 6.1 The Experience of Voting**

Pre-Trial Questionnaire	Trial (n=28)
Have you taken part in voting process before? (Yes)	82.14%
Did you know e-voting before televoting? (Yes)	28.58%
Which kind of voting did you attend if you did attend before?	
Traditional paper-based voting	71.43%
E-voting at the voting station	21.43%
Remote electronic voting (phone keyboard voting)	7.14%

Post-Trial Questionnaire * not asked	Trial 1 (n=10)	Trial 2 (n=10)	Final Trial (n=20)
Did you attend any voting process before? Yes	20.00%	100.00%	70.00%
Which kind of voting method did you use before if you did?			
Traditional paper voting	100.00%	0	28.58%
E-voting at voting station	0	80.00%	35.71%
Remote voting (online or phone voting)	0	20.00%	35.71%

\*\* “n” is the number of the feedback we got.

### 6.1.2 Usability

An e-voting system is most likely going to encourage more people to participate in the election process. As explained in Chapter 2, some people do not vote simply because they do not want to go to the polling station. Is it because they are not interested in voting or it is because they dislike the voting method used in such elections? During the course of our research, we also captured the respondents’ views on the deployment of a centralized electronic voting system

that spans over remote geographical locations. The pre-trial feedbacks showed the main reasons why some voters decide not to vote.

**Table 6.2 Usability of E-voting in Pre-Trial**

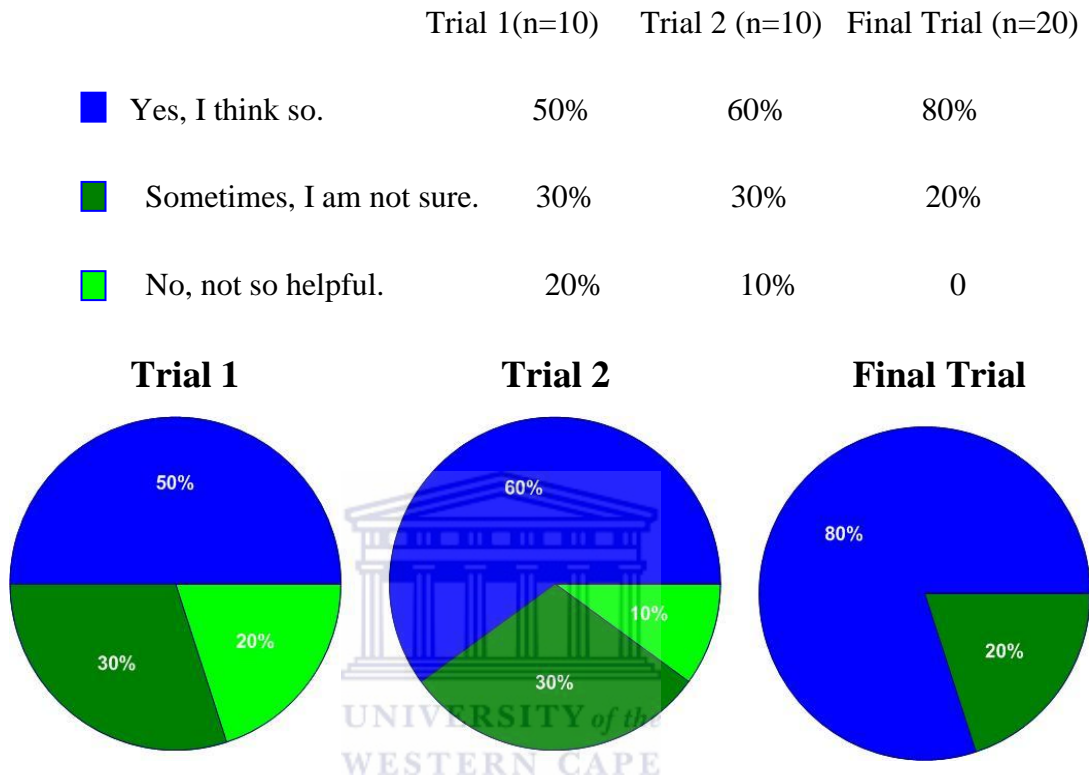
<b>Why you choose this voting method?</b>	
Was the only choice available	57.15%
It's fair and easy	35.71%
<b>What is the reason when you gave up on voting?</b>	
There is nothing interesting about voting	21.43%
There are often long queues and I don't have time	57.14%
<b>Which kind of voting method would you prefer?</b>	
Paper Ballot	7.14%
Voting machine at voting station	28.57%
Remote voting(online or televoting)	64.29%

In the initial trial/pre-trial questionnaire 57.14% of the respondents indicated the long queues as the reason why they do not vote (see table 6.2). 92.86% of them indicated that they would prefer using an electronic voting system. If a remote electronic voting was available, 64.29% the respondents would have participated in the voting process. This signals the possibility of a great improvement in voter participation. Generally, respondents found the prospect of using a voice based voting system a fascinating experience.

Figure 6.1 shows that the participants' positive attitude towards the voiced-based televoting system had increased during the trials. After using the final version of our test system, 100% of the respondents indicated that they were interested in an e-voting system. The following factors could have contributed to this interesting observation. Firstly, most of the participants had used the initial versions of the system; hence they were now very familiar about the strength and weakness of our previous system design. Their experience with our trial version might have influenced their attitude towards our final version. Secondly, almost all

participants who tested the final version of our system volunteered on their own to test the system.

Q: Do you think voting by voice like this is helpful and more interesting to you?



*Figure 6.1 the Participant's Attitude towards a Voiced-based Voting*

### 6.1.3 System Foundations

Each time we obtained feedback from the users; we incorporated some of their suggestions into our system and made it better and more voter-friendly. In general, a good voting system should clearly present all basic information to voters prior to voting and give them necessary guidance during the voting process. A voter using an e-voting system should go through the voting process effortlessly and without being exposed to the technical complexities of the system.

**Table 6.3 The System is Correct and Responsive**

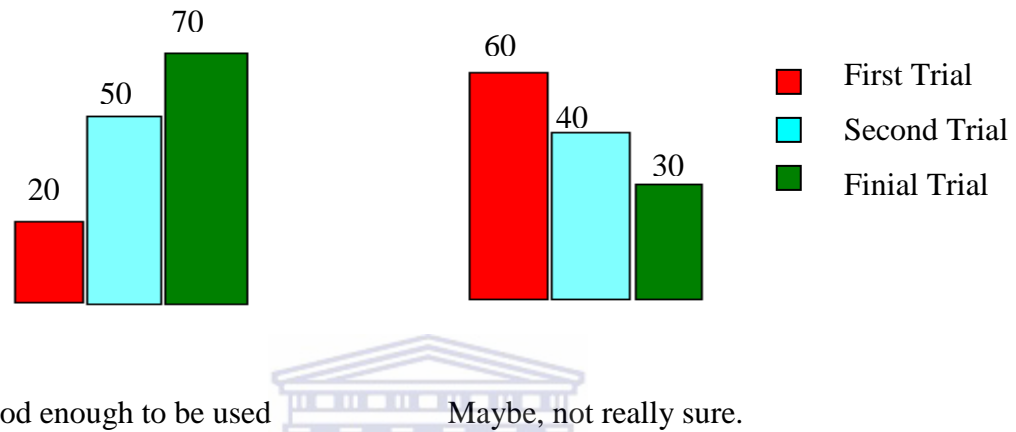
Post Trial Questionnaire	Trial 1	Trial 2	Final Trial
<b>Did the voting process go smoothly?</b>			
Yes, very well	10.00%	60.00%	80.00%
Not completely	70.00%	30.00%	20.00%
No	20.00%	10.00%	0
<b>Was the system guide easy to follow and did it help you to complete voting?</b>			
Yes, all of that is fine	60.00%	70.00%	90.00%
Sometimes got problem	30.00%	20.00%	10.00%
No, not at all	10.00%	10.00%	0
<b>How many times were you interrupted by the system before you finished voting?</b>			
No interruptions	10.00%	40.00%	50.00%
Less than 3 times	20.00%	30.00%	30.00%
Less than 6 times	50.00%	20.00%	10.00%
More than 6times	20.00%	10.00%	10.00%
<b>Did you get clear guidance on what to do whenever the system interrupted you?</b>			
Yes, it was clear	50.00%	80.00%	*
Sometimes	40.00%	20.00%	*
No, the guide was not clear	10.00%	0	*
<b>Did the system correctly distinguish between the different voting processes?</b>			
Yes, very correctly	10.00%	40.00%	60.00%
Sometimes needed repeat	70.00%	50.00%	30.00%
Not so well	20.00%	10.00%	10.00%

According to Table 6.3, approximately 80% of the participants went through the voting process without any difficulties. They correctly used all the available system functions.

Each time a new user started using the system, the system asked for and verified the user's identity number and password. If this information was not correctly supplied; the system gave voice guidance. More than 90% of participants thought



the system's guidance was easy to understand. Table 6.3 also shows that there were a fewer problems as the participants gained more and more experience. Views obtained from the trial version, indicate that even though our televoting system has its own shortfalls, it has all the basic functions required by a voting system.



**Figure 6.2** *Satisfactions of the System and Process*

Figure 6.2 shows the users levels of satisfaction with the system and voting process in general. The level of satisfaction and trust increased with each new version released.

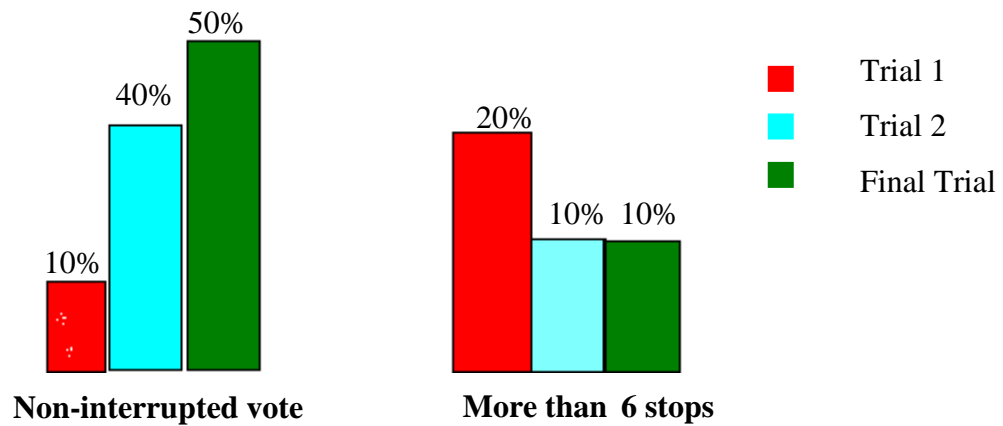
**Table 6.4** *Operator Questionnaire*

Operator Questionnaire	Trial 1	Trial 2	Final Trial
<b>How much information was correctly understood by the system?</b>			
Less than 60%	70.00%	23.00%	12.00%
Less than 85%	30.00%	60.00%	68.00%
More than 85%	0	17.00%	20.00%
<b>Did the software count the vote correctly?</b> (Yes)	80.00%	100.00%	100.00%
<b>Why users were stopped during the voting?</b>			
System's technical problem	47.15%	29.36%	23.45%
User did not responded in the right way	42.53%	52.75%	49.7%
Other problem	10.32%	17.89%	26.85%

Table 6.4 shows that more than 40% of the interruptions were due to non-technical problems that originated from the operator's side. This implies these interruptions could be avoided if the users were trained before the voting. Table 6.4 also shows the system correctly understood about 60% of the information that was provided by the voters, and the voting-processing was almost 100% correct. Thus the robustness of the system design was proved.

## **6.2 Focus Group Feedback**

After each trial session discussions were held with the participants. Most participants indicated that they expected the voting process to be made simpler and easier so the voting could be completed without difficulties. In the initial test version, one of the participants suggested that the system should provide all candidates' name whenever the voter wants to vote for more than one candidate – voters should not be compelled to remember all the candidates' names. Some participants also suggested that the system should provide more information. These recommendations were incorporated with each progressively newer version of the system and they proved to be very useful. As part of the system testing, some participants were asked to make mistakes in order to verify how the system responded to wrong procedures. Any inadequate responses which required some additional attention were redressed in each new software version. In the final version the application was able to give all the necessary guidance to the voters during the voting process. Figure 6.3 shows that the number of non-interrupted voting processes increased by 40% compared to the first trial version. This means that the system was getting more and more user-friendly. The users' stops (the user is asked to redo the same step) were reduced from 20% to 10%.



*Figure 6.3 Smoothes of the Voting Process*

The final version of the televoting system was more stable than the earlier versions and it was positively received by the participants. In the final version, 80% of the participants indicated that they found the voice-based televoting process more interesting and useful. During the trials, the number of people who volunteered to participate increased by 30%. The other reason why people preferred the voice-based televoting system was that it was easy to access. Simply said, the system allows voting to effect from work or home and makes the voter more comfortable about the voting. The conclusion that real-time voice-based televoting system would encourage more people getting involved in the voting was apparent.

### **6.3 Trial Observation**

In the first trial version, participants with no technical background faced a myriad of difficulties while using the system. However, those participants were encouraged to keep on trying. They were particularly encouraged to follow the guidance provided by the system rather than asking for help from the system operator. They were even encouraged to discuss problems amongst themselves and try to find solutions for the problems they encountered. In a case a participant was lost to the extent that he/she could no longer make any headway; the operator gave him/her the necessary hints that enabled him/her to proceed with the voting. Some of the problems voters faced have been highlighted in Chapter 5.

In the second trial, the participants were enthusiastic to try a new version. All the voters received the necessary guidance during the process whenever they encountered problems. This time, voters were not interrupted so many times like in the previous trial because they had gotten used to this system. Also the system had been adjusted according to the comments from the previous trial, for example, the system allowed the voter more time to make his choice.

In this trial, we also changed the way of multi-choice confirmation. The voter could confirm chosen names one by one. Most of participants thought it was more convenient than confirming all names as a group.

For the final trial, observations were compared to the initial trial. It was noted that some of the participants were able to go through the whole process smoothly. Others were interrupted much less comparing to the case in the first two trials. Generally, it was concluded that the system was more accommodating to the voters.

## **6.4 Discussion**

The televoting system was found more interesting and convenient than paper based voting. After each trial discussions were held with the participants and operators. The outputs from the first and second discussions were incorporated in the final trial. Some technical bugs and problems were pointed out. The ASR response time was adjusted to avoid interruption. The system repeated the candidates' name every time for user whenever they were asked to make the choice. This system has proved that it can go through a whole voting process smoothly.

## **6.5 Televoting System Results Summary**

In this chapter, we discussed in detail the data we collected from the multiple trials, multiple questionnaires and discussion sessions. The televoting system developed has been proven to be not only feasible but easily implementable in the real election.

## **Chapter 7**

# **CONCLUSION AND FUTURE WORK**

### **7.1 Overview**

This thesis presented a telephonic voting system which uses the EML as a standard. Easy to use, more effective than traditional paper-based voting, the electronic voting system has been designed in such a way as to encourage people to participate in elections. In addition, the system can easily be reconfigured in line with technological progress and advancement of EML standard.

### **7.2 General Remarks**

Electronic voting systems are getting more popular in developed countries. The Internet, SMS, ATMs and some other e-systems are now part of our daily life. Despite their shortcomings, people find e-systems more convenient, easier to use and less time demanding. In addition, many e-systems are easier to use by, the old, the illiterate and/or other disabled people.

In most countries, national elections hardly attract 50% of the eligible voters. Such low turnouts show that people are somehow dissatisfied with the voting process. Democratic elections must reflect the wishes of the majority of people and this can only be achieved if most of the voter constituent participates in the voting process. It is envisaged that a telephonic voting system will attract a bigger voter turnout, as well as reduce the numbers of electoral frauds and spoiled ballots.

This system controls the number of candidates that each voter can vote for. This is done in order to limit the number of spoiled votes. The paper-based voting systems do not have provision for implementing such restrictions. When a voter singles out a wrong candidate, the paper-based voting systems have no provision for reversing the cast vote.

Also, a voting system should have some basic functions that may help to identify the users, process the cast votes, and to recount votes when necessary. It should be user-friendly to the extent that the whole voting process should be easy to complete. Furthermore an effective e-voting system should be able to connect to multiple terminals.

An e-voting system developed in this research using open source tools and which is based on global standards can easily be adapted for different application domains. A voice-based televoting system uses the EML standard and the ASR and TTS technologies in order to achieve the voice and text conversions. EML based systems can provide the voter with comprehensive guidance during the voting process.

During our trials, participants were asked to make wrong choices, like to vote for more or less people as needed and to make a “write-in” vote or make incorrect procedural steps during the voting. During all these an operator was monitoring the whole process at the server side through the operator interface. In the first trial, the operator found that the setting of the ASR cache time period was too short. The system forced people to speak fast and could not interpret their responses correctly. One of the participants suggested the system should give more guidance when using a multiple choice method like repeating candidates’ names. All of this was useful information for the next software release when the system asked user to confirm the multi-choice one by one. Participants of the second trial were much more satisfied with the improvement. This system was simple, easy to use and suitable for almost all the users.

### **7.3 Conclusion**

Telecommunication and network technologies are rapidly improving almost on the daily basis. Implementing the current and new technologies will make the voting process even simpler, more reliable and accessible to everybody.

The aim of this research study was to build and test a real-time communication EML based voting system that meets the following requirements:

1. Provides authentication, privacy, integrity and non-repudiation
2. Keep each voter's choice a secret
3. Allow each eligible voter to vote only once
4. Do not permit tampering with voting system
5. Report all votes accurately
6. Keep it operable throughout the election
7. Keep an audit trail to detect any breach of 3 and 5 but without violating 2

Research questions that guided this study were positively answered:

- ASR, TTS and EML technologies were successfully integrated and the usable real-time telephone based voting system was built.
- Experiments have shown that communication and conversion between voice, data streams and EML messages is possible in real time.
- A series of trials has shown that this study had succeeded in building a usable, reliable; voter friendly telephone based voting system.

The televoting system was not under a manual control. It was able to independently positively identify all voters, allow only eligible voters to cast a vote and prevent multiple voting. The voter database was maintained correctly and the system was able to make backup copies of files necessary for auditing and possible recounting purposes. Most importantly, voters found the system easy to use and more convenient than the traditional paper based voting.

## **7.4 Future Work**

Is televoting safe for voting? Is there a possibility for manipulating it? Is the data safe to send through the network? Can the televoting be integrated with existing e-voting systems? The goal of the future work will be to solve all these problems and to develop a better, more reliable, fair, and easy to use voting system.

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## Appendix A Pre Trial Questionnaire

Pre-Trial Questionnaire	Trial (n=28)
<b>Have you taken part in voting process before?</b> Yes	82.14%
<b>Did you know e-voting before (televoting)?</b> Yes	28.58%
<b>Did you have or saw any problem during voting?</b> Yes	32.14%
<b>Which kind of voting did you attend if you did attend before?</b>	
Traditional Paper vote	71.43%
E-voting at the voting station	21.43%
Remote electronic voting (phone keyboard voting)	7.14%
<b>Why you choose this voting method?</b>	
The only choice	57.15%
Fair and easy	35.71%
<b>What is the reason when you gave up to vote?</b>	
Not interesting	21.43%
Long Queue there, don't have time	57.14%
<b>Which kind of voting method would you prefer or more interesting if you vote?</b>	
Paper Ballot	7.14%
Voting machine at voting station	28.57%
Remote voting(online or televoting)	64.29%
<b>Would you think voting verbally using a telephone device will get more people involved (like blind and some disable people)?</b>	
Definitely be helpful	57.15%
Probably might be of assistance	25.00%
No, I don't think so	17.85%

*Pre-Trial Questionnaire Result Percentage of some response does not add up to 100%, as they are selected results.*



## Appendix B Post Trial Questionnaire

Post-Trial Questionnaire * not asked	Trial 1 (n=10)	Trial 2 (n=10)	Final Trial (n=20)
<b>Did you attend any voting process before?</b>			
Yes	20.00%	100.00%	70.00%
<b>Which kind of voting method did you use before if you did?</b>			
Traditional paper voting	100.00%	0	28.58%
E-voting at voting station	0	80.00%	35.71%
Remote voting (online or phone voting)	0	20.00%	35.71%
<b>Did the voting process go smoothly?</b>			
Yes, very well	10.00%	60.00%	80.00%
Not completely	70.00%	30.00%	20.00%
No	20.00%	10.00%	0
<b>Can you understand the system guide and complete the voting?</b>			
Yes, all of that is fine	60.00%	70.00%	90.00%
Sometimes got problem	30.00%	20.00%	10.00%
No, not at all	10.00%	10.00%	0
<b>How many times did the system stop before the voting was finished?</b>			
Did not stop	10.00%	40.00%	50.00%
Less than 3 times	20.00%	30.00%	30.00%
Less than 6 times	50.00%	20.00%	10.00%
More than 6times	20.00%	10.00%	10.00%
<b>Did you get a clearly guide what to do when you were stopped?</b>			
Yes, it is clear	50.00%	80.00%	*
Sometimes	40.00%	20.00%	*
No, the guide is not clear	10.00%	0	*
<b>Do you think this system and the process is good enough to be used in election?</b>			
Yes	20.00%	50.00%	70.00%

No	20.00%	10.00%	0
Maybe, not sure	60.00%	40.00%	30.00%
<b>Do you find the televoting easier and more convenient than paper based?</b>			
Yes, definitely helpful	60.00%	*	80.00%
No, not at all, too complex	20.00%	*	0
I am not sure	20.00%	*	20.00%
Post-Trial Questionnaire	Trial 1 (10)	Trial 2 (10)	Final Trial (20)
<b>Do you think the remote voting security enough?</b>			
Yes, I think so.	20.00%	35.00%	50.00%
Maybe, the technology is developing.	60.00%	65.00%	50.00%
No, not at all.	20.00%	0	0
<b>Do you think voting by voice like this is helpful and more interesting for you?</b>			
Yes, I think so	50.00%	60.00%	80.00%
Maybe sometimes, not sure	30.00%	30.00%	20.00%
No, not so helpful	20.00%	10.00%	0
<b>The nature of problems you noticed:</b>			
There were no problems for me	10.00%	50.00%	60.00%
Problems were mainly of technical nature	60.00%	40.00%	30.00%
Problems were more procedural nature (I was not sure what to answer; question was not clearly defined etc...)	30.00%	10.00%	10.00%
<b>Was the system applicable to identify the voting process correctly?</b>			
Yes, very correctly	10.00%	40.00%	60.00%
Sometimes needed repeat	70.00%	50.00%	30.00%
Not so well	20.00%	10.00%	10.00%
<b>Do you think the problems you had last time has been improved?</b>			
Yes, it is much better now.	*	50.00%	60.00%
Some of them	*	40.00%	40.00%
No, not at all	*	10.00%	0

*NB: the “n” is the number of the feedback we got.*

## Appendix C Operator Questionnaire

Operator Questionnaire * not asked	Trial 1	Trial 2	Final Trial
<b>Do you think this interface is friendly and easy to understand?</b> Yes	100.00%	100.00%	*
<b>Did the ASR get the user's information correctly?</b> Yes	60.00%	*	*
<b>How many percent can the system get correctly?</b>			
Less than 60%	70.00%	23.00%	12.00%
Less than 85%	30.00%	60.00%	68.00%
More than 85%	0	17.00%	20.00%
<b>Did you attend any e-voting process before?</b> Yes	50.00%	100.00%	*
<b>Did the software count the vote correctly?</b> Yes	80.00%	100.00%	100.00%
<b>Can you know the problem from the interface?</b> Yes	72.00%	85.00%	88.75%
<b>Why users were stopped during the voting?</b>			
System's technical problem	47.15%	29.36%	23.45%
User did not responded in the right way	42.53%	52.75%	49.7%
Other problem	10.32%	17.89%	26.85%
<b>Do you think this system will be applicable for real voting?</b>			
Yes, it will.	*	75.00%	90.00%
I am not sure.	*	25.00%	10.00%
Not really.	*	0	0

## Appendix D Smooth Voting Process Dialogue

System (S): Welcome to the televoting system. Your ID please!

Voter (V): 92786534

S: Your password please!

V: 64179407

S: You are a legal voter. Choose one from the candidates as president please!  
The candidates are V.I.Lenin, Karl Marx and William Loyd Garrison.

V: William Loyd Garrison.

S: Are you sure you choose William Loyd Garrison?

V: Yes.

S: Please choose two from the five candidates as the vice president. The  
candidates are Gordon Moore, William Bryant, Alex Jordan, Michael Jackson and  
Kelly Clarkson.

V: William Bryant.

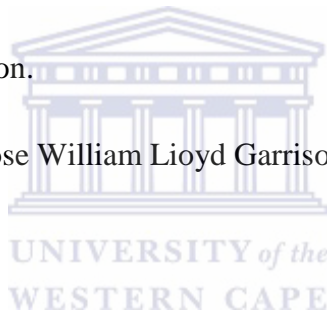
S: Are you sure you choose William Bryant?

V: Yes.

S: The candidates are Gordon Moore, William Bryant, Alex Jordan, Michael  
Jackson and Kelly Clarkson.

V: Kelly Clarkson

S: Are you sure you choose Kelly Clarkson?



V: Yes.

S: Vote completed. Your vote was counted. Thanks for your vote!

(See the interface figure in chapter 4)



## Appendix E Problematic Voting Dialogue

System (S): Welcome to the televoting system. Your ID please!

Voter (V): 92786534

S: Sorry, you voted already. Your ID please!

V: 64179407

S: Sorry, you are not in the voter list. You have no right to vote. Your ID please!

V: 18302654

S: Your password please!

V: 08643683

S: You are a legal voter. Choose one from the candidates as president please!  
The candidates are V.I.Lenin, Karl Marx and William Lioyd Garrison.

V: William Lioyd Garrison.

S: Are you sure you choose William Lioyd Garrison?

V: No.

S: Choose one from the candidates as president please! The candidates are  
V.I.Lenin, Karl Marx and William Lioyd Garrison.

V: Karl Marx.

S: Are you sure you choose Karl Marx?

V: Yes.



S: Please choose two from the five candidates as the vice president. The candidates are Gordon Moore, William Bryant, Alex Jordan, Michael Jackson and Kelly Clarkson.

V: William Bryant.

S: Are you sure you choose William Bryant?

V: Yes.

S: The candidates are Gordon Moore, William Bryant, Alex Jordan, Michael Jackson and Kelly Clarkson.

V: Kelly Clarkson

S: Are you sure you choose Kelly Clarkson?

V: No.

S: The candidates are Gordon Moore, William Bryant, Alex Jordan, Michael Jackson and Kelly Clarkson.



V: Alex Jordan.

S: Are you sure you choose Alex Jordan?

V: Yes.

S: Vote completed. Your vote was counted. Thanks for your vote!