A SECURE WEB BASED APPROACH IN MANAGING ELECTIONS IN KENYA: THE NATIONAL ONLINE ELECTORAL MANAGEMENT SYSTEM

By

CHURCHILL WINSTONE ODHIAMBO
17YAD102798

SUPERVISOR:
MR DAVID KIROP

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DATE
THURSDAY, 01 APRIL 2021

DECLARATION

I declare that this or any other University has not previously submitted this work for the awarding of the course marks. To the best of my knowledge and belief, this work contains no material previously published or written by another person except where due reference is made.

Student Name: Churchill Odhiambo Winstone

Signature:

Date: Thursday, April 01, 2021

APPROVAL

This project of **Churchill Winstone Odhiambo** was reviewed, and approved by the following:

Supervisor Name: ……..

Signature: ……
.

DEDICATION

The project is dedicated to my father, Mr Robert Onyango, a man in whose counsel I have learned the value of focus and self-motivation, in the same path I wish to acknowledge aunty Sandy for her generous encouragements and always being my wallet when I needed some monetary comforts.

Be blessed abundantly.

ACKNOWLEDGEMENT

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I would also like to express my appreciation to the Computer Science department at Riara University for allowing me to undertake my course and always guiding me through the entirety of the process.

I also do have much honor and gratitude to my friend and classmate Michael Se-Lunani who sacrificed his precious time to help me in the understanding of relevant requirement specifications. I owe you a lot for what you did.

ABSTRACT

The National Online Electoral Management System provides online voters registration forms for citizens where legally adult citizens are registered and allowed to log in as the voters. There is also a dashboard from which administrative privileges is exercised. Each registered user has a password for logging in as well as another One Time Pin layer for more security. The system allows preliminary voting, and the results graphically represented in varying types of charts, which is provided on a need basis. The system computes and gives the election results for all the positions and can be queried to provide a detailed report for the entirety of the election currently in place. The main objective of this system is therefore not limited to design, develop and implement an efficient; user friendly, interactive web based electoral management system. The methodology that will be used is the waterfall Model.

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DEFINITION OF TERMS

Mlolongo; literally translates to Queuing system used in the 1988 General elections of Kenya.

LIST OF ABBREVIATIONS AND ACRONYMS

NOEMS-National Online Electoral Management System.

KIEMS-Kenya Integrated Electoral Management System.

CCVS- Central Count Voting Systems.

ID –Identification Number.

MCA-Member of County Assembly

PHP-Hypertext Preprocessor

CSS-Cascading Stylesheet

OTP-One time Pin

WAMPP-Windows, Apache (A), MariaDB (M), PHP (P) and Perl (P)

XAMPP- Cross-Platform (X), Apache (A), MariaDB (M), PHP (P) and Perl (P)

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION:

In the recent past, electoral reforms have been a highly sensitive issue in Kenya cutting across all divides. The Independent Electoral Commission (IEBC), the State Organ tasked with the responsibility of demarcating political boundaries as well as conducting independent elections has been on the receiving end in almost all cases. The clarion call has been loud; that there is need for a free, fair and all-inclusive election done all across the country, one that is timely and effective. There is an urgent need to have a paradigm shift as to how elections are conducted in Kenya.

1.2 PROBLEM STATEMENT:

The current electoral system used in Kenya is manual, save for result transmission of results and relay of the same. On the Election Day, valid voters prepare to vote from as early as 6am and head to their respective polling stations from where they make queues with many such being very long, some spanning several few kilometers, in our hot tropical and/or equatorial climate. In this case, the voters do register using the KIEMS Kits and on the actual election day, the true identity of the supposed voter checked in the KIEMS Database after-which the next phase of voting goes fully manual, at the end of the election, the votes are counted manually then transmission of the same done electronically. The National Online Electoral Management System aims to alleviate this strenuous exercise into a seamless activity, which is very effective, efficient, and accurate. The electoral results currently in Kenya, takes up to 7 days for all the results to be computed and verified, something that can be done on the go with an online electoral management system.

1.3. OBJECTIVES:

1.3.1 GENERAL OBJECTIVES

i. To develop an independent Electoral Management System, one that is fault-tolerant.

1.3.2 SPECIFIC OBJECTIVES

i. To design and create a Database of Registered voters.
ii. To develop an online voting system that provides secure and trusted online voting experience.
iii. To analyze the trends in voting in Kenya to reach out to more Kenyans to vote.

1.4. JUSTIFICATION.

The success of this project will ensure the scalability of The National Online Electoral Management System to be used in other institutions of which voting is entailed. The concept can not only be applied to National elections, elections of higher levels learning institutions and even those of the basic level of education. It will ensure transparency and high integrity in the election process. The system will be user friendly and provide great efficiency in the election process. Its success can also be replicated in other spheres in which elections are involved, just like now that the world is experiencing an unprecedented public health crisis.

1.5 SCOPE

The NOEMS will use the digital ID of the valid electorate. This digital ID, which is the System-generated OTP, Voter National ID number and password, upon a successful login, only can the user transact.

CHAPTER 2: LITERATURE REVIEW

A society is defined by the kind of people that they choose to lead them. There is a clear distinction, between societies that choose good and responsible leaders, over the societies, which are reckless with the kind of leaders that they choose. Voting therefore is a tool that is used to decide the fate of such societies, through their institutional electoral processes.

2.1 HISTORICAL OVERVIEW OF ELECTIONS IN KENYA

Gibson and Long (2009) gives a view of the history of elections in Kenya and we all note how chaotic they have been. The first elections held in independent Kenya were done in 1963 under the stewardship of the British government, which were the former colonial masters of Kenya. The elections conducted in 1963, has often been hailed as one of the most free and fair elections ever done in the country aside from the 2002 General elections. After the 1963 elections, the next major General elections were conducted in 1988, using the *"mlolongo"* system of voting, in which voters queued behind the placard of the candidate, they wanted to elect. It was the only election done using that kind of strategy.

Following an outcry from the opposition candidates, the next general election carried out in 1992 used the secret ballot principal, in which the candidate with plurality of votes took to the helm of power. Other general elections were conducted in; 1997,2002,2007,2013 and lately 2017 with the next general election slated for the 2nd Tuesday of August 2022.

2.2 TYPES OF VOTING SYSTEMS

There exists several kind of voting systems, which are used around the globe with respect to elections. Hjálmarsson,Hreiðarsson,Hamdaqa and Hjálmtýsson(2018) in their July presentation at IEEE gives a preview of Blockchain technology based voting and one that was also used in Russian Municipal elections.

I Paper-Based Voting Systems.

They are used to record, count, and produce a tabulation of the vote count from votes that are cast on paper cards or sheets. Some PVSs may allow voters to make selections by means of electronic input devices. Voter selections are, however, not independently recorded, stored or tabulated by such input devices

II Direct-Recording Electronic Voting Systems
They record votes by means of a ballot display provided with mechanical or electronic optical components that could be activated by the voter. Such systems record voting data and ballot images in computer memory components. In addition, data processing is achieved by the use of computer programs.

III Public Network Direct-Recording Electronic Voting Systems
They make use of electronic ballots and transmit vote data from the polling stations to other locations over a public network. The votes may be transmitted as individual ballots as they are cast, or periodically as batches of ballots, or as one single batch, at the end of voting.

IV Precinct Count Voting Systems
These systems put the ballots in a tabular form at a particular place, say, a polling station. They provide mechanisms that store vote count electronically and transmit the results to a central location over public telecommunication networks.

V Central Count Voting Systems (CCVS):
Tabulate ballots from multiple precincts at a central location. Voted ballots are safely stored temporarily at the polling station. These ballots are then transported or transmitted to a central counting location. CCVSs may, in some cases, produce printed reports on the vote count.

2.3 CHARACTERISTICS OF A VOTING SYSTEM

(I). Trusted, all voting systems must be able to create an atmosphere of sincerity and honesty, this the voters full confidence that their votes count and that candidates would accept the outcomes from such processes

(II). Security, they must be fully secure to stop any form of malicious alteration of results.

(III). Transparency: They must be transparent and comprehensible enough so that both the voters and candidates would readily accept the results regardless of the choices they had made.

(IV). Precision: The entirety of an elections management should be tagged with the accuracy and precision exuded by the systems. The digital tallying of votes should be conflict-proof.

2.4 KIEMS SYSTEM USED IN KENYA

Gibson and Long (2009), after the disputed presidential elections of 2007, the parliament of Kenya, amended some of the clauses governing the elections in Kenya. Core to those legislations was a need to have centralized digital records of all voters, this resulted into having the registration and verification of voters to be done electronically, hence the IEBC procured an integrated electoral managements system.

The KIEMS kits are largely used in voter registration and verification of biometrics on the actual day of election. When a voter registers, personal information is recorded as well as biometric data (fingerprints and a profile picture) taken.

On the election date, the voter verification process takes place, where the voter presents their valid national ID and details counterchecked with those pre-existing in the KIEMS kits and then they head to vote through a secret ballot, manually.

2.5 SECURITY CONCERNS FOR ONLINE VOTING SYSTEMS

According to Yavuz, Cabuc and Dalkılıç (2018) E-voting on the other hand, is another trending, yet critical, topic related to the online services. The blockchain with the smart contracts emerges as a good candidate to use in developments of safer, cheaper, more secure, more transparent, and easier-to-use e-voting systems. Ethereum and its network is one of the most suitable ones, due to its consistency, widespread use, and provision of smart contracts logic. An e-voting system must be secure, as it should not allow duplicated votes and be fully transparent, while protecting the privacy of the attendees.

From the experience of elections conducted elsewhere on the globe, security issues often confront online voting systems head-on. Some of the security issues were not because of external saboteurs but also insider dealings, especially when system administrators are compromised. Some security issues arise because of inheriting bad code on given objects that are unsuitable and unsustainable. These errors caused the voting system to crash.

NOEMS will ensure security by applying strategies such as limiting the size of input that a user can send to the system.

2.6 ONLINE VOTING SYSTEM

The web-based approach in managing elections in Kenya through The National Online Electoral Management System provides a means by which any registered voter can exercise their voting rights regardless of location. The online voting opens up new possibilities and brings a unique experience to the Kenyan voting process. The benefits that will be reaped from this system in not limited to improving voter convenience and accessibility, improving accuracy and the security of the voting process and the timeous response of Election Results.

2.5.1 CHART FOR LEGISLATIVE UNITS IN KENYA

These are the legislative units of Kenya as shown in the figure1. These units are the basis for elections in Kenya.

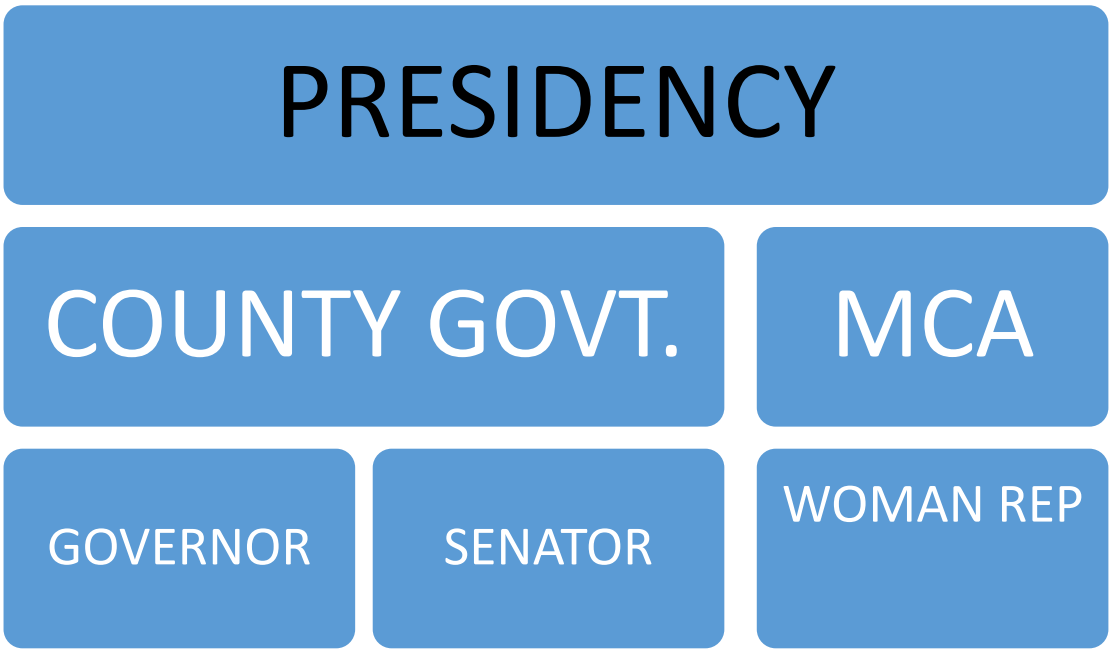


Figure 1 Legislative unit of Kenya

CHAPTER 3: METHODOLOGY AND DESIGN

3.1 SYSTEM DESIGN

System design phase of the software development life cycle is the phase where the proposed system prerequisite and the output design prerequisite are specified. These design requirements are specified in line with the user requirement, goals and objectives. The input to the system starts with routine on registration; this is done by allowing the admin to fill the voter registration form by giving the following data.

3.1.1 SOFTWARE PROCESS MODEL

Waterfall

The Waterfall Model was first Process Model to be introduced. In a Waterfall model, each phase must be completed before the next phase can begin and there is no overlapping in the phases. Waterfall model is the earliest SDLC approach that was used for software development.

In "The Waterfall" approach, the whole process of software development is divided into separate phases. The outcome of one phase acts as the input for the next phase sequentially. This means that any phase in the development process begins only if the previous phase is complete. The waterfall model is a sequential design process in which progress is seen as flowing steadily downwards (like a waterfall) through the phases of Conception, Initiation, Analysis, Design, Construction, Testing, Production/Implementation and Maintenance. As the Waterfall Model illustrates the software development process in a linear sequential flow, hence it is also referred to as a Linear-Sequential Life Cycle Model. Figure 2 shows the waterfall model.

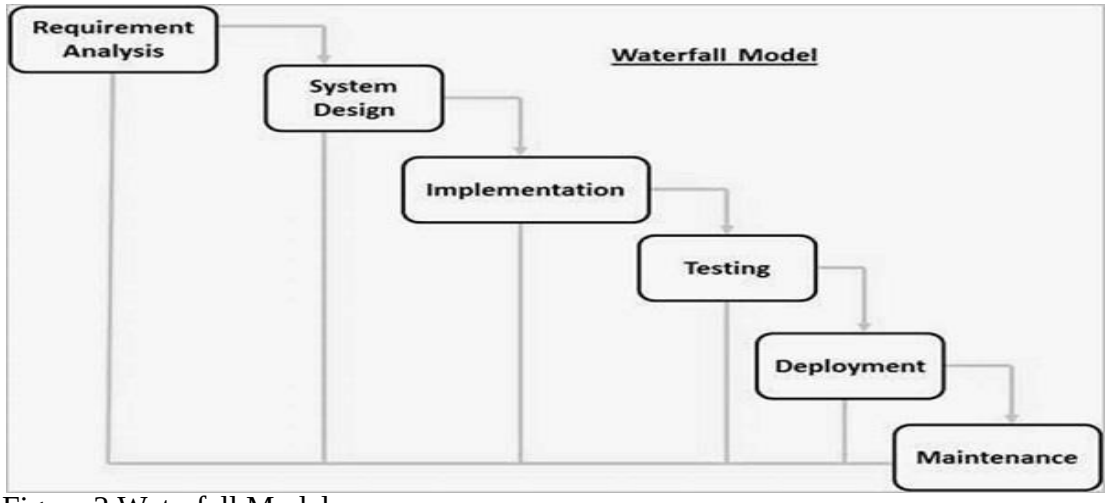


Figure 2 Waterfall Model

3.1.2 SYSTEM DEVELOPMENT LIFE CYCLE

The system development life cycle list all the process followed with an aim to enable a user to transform a newly developed project into an operational one. System analysis for the National Online Electoral Management System follows the following stages:

i. Planning
ii. System analysis and requirements
iii. System design
iv. Development
v. Integration and testing
vi. Implementation

3.1.2.1 SEQUENTIAL PHASES IN WATERFALL MODEL

1. **Requirements:** Involves understanding what needs to be designed and their function, purpose etc. Here, the specifications of the input and output or the final product are studied and marked.
2. **System Design:** The requirement specifications from first phase are studied in this phase and system design is prepared. System Design helps in specifying hardware and system requirements and helps in defining overall system architecture. The software code to be written in the next stage is created now.
3. **Implementation:** With inputs from system design, the system is first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing.
4. **Integration and Testing:** All the units developed in the implementation phase are integrated into a system after testing of each unit. The software designed, needs to go through constant software testing to find out if there are any flaw or errors.
5. **Deployment of System:** Once the functional and non-functional testing is done, the product is deployed in the customer environment or released into the market.
6. **Maintenance:** It involves making modifications to the system or an individual component to alter attributes or improve performance. These modifications arise either due to change requests initiated by the client, or due to defects uncovered during live use of the system. Client is provided with regular maintenance and support for the developed software.

3.1.3 CONCEPTUAL FRAMEWORK OF NOEMS

A conceptual framework is a written or visual representation of an expected relationship between variables, with the variables here being the characteristics of the study area of interest. The conceptual framework is developed based on a literature review of existing studies and theories about the topic.

Figure 3 shows a contextual framework diagram of NOEMS.

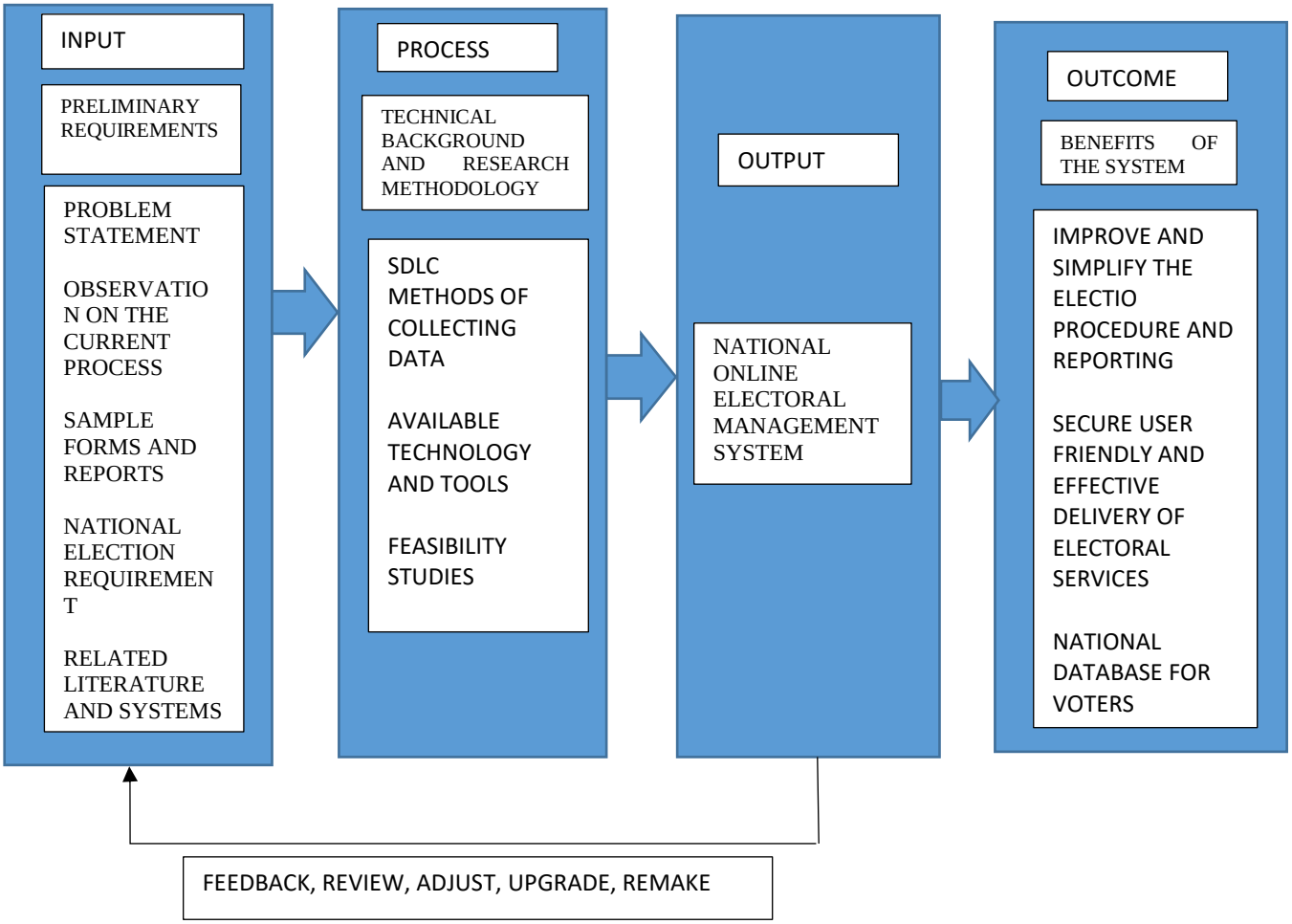


Figure 3 : Conceptual Framework

3.1.4 DATAFLOW DIAGRAM

A data flow diagram is a graphical representation of the flow of the data through an information system, modeling its process aspects. Figure 4 is a 0-level DFD that only shows the flow of data between the various parties and the system. In an online voting system, the Administrator is the controller of the system and all they have all the privileges on the system. The Administrator can handle the entire voter and their details, voting details etc. and view details of them and he can update that detail.

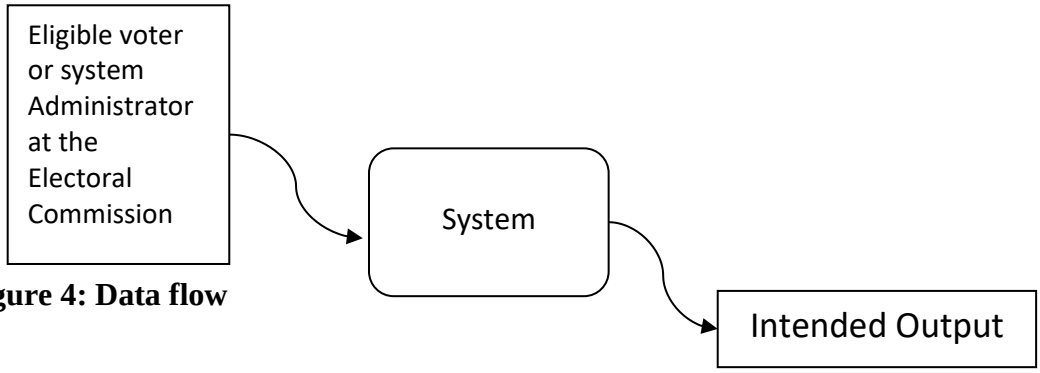


Figure 4: Data flow

DFD Level 1

Figure 5 is a 1-level DFD for the NOEMS. Following this diagram, voter login results into the culmination of other processes therein. The Administrator can register voter. The ELECTION COMMISION can register the voters and voter can use their voting rights. The voter can view the final report after giving vote..

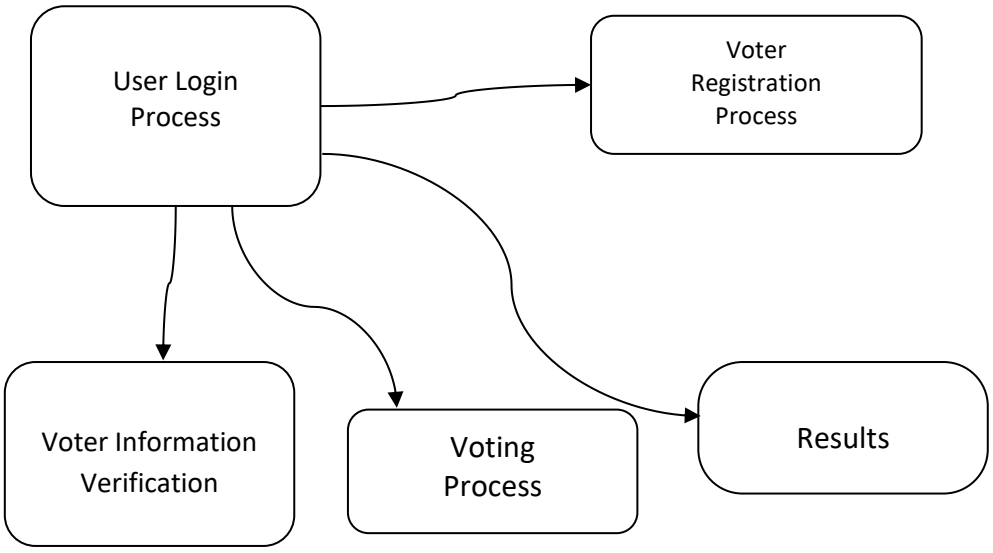


Figure 5 : Data Flow Level One

DFD: Level 2

Figure 6 is 2.1 level Data Flow Diagram for the Online voting system. According to this DFD. The Administrator can register the voter information. Administrator can allow or denies the voter. A voter can give vote if all the information filled by them are correct.

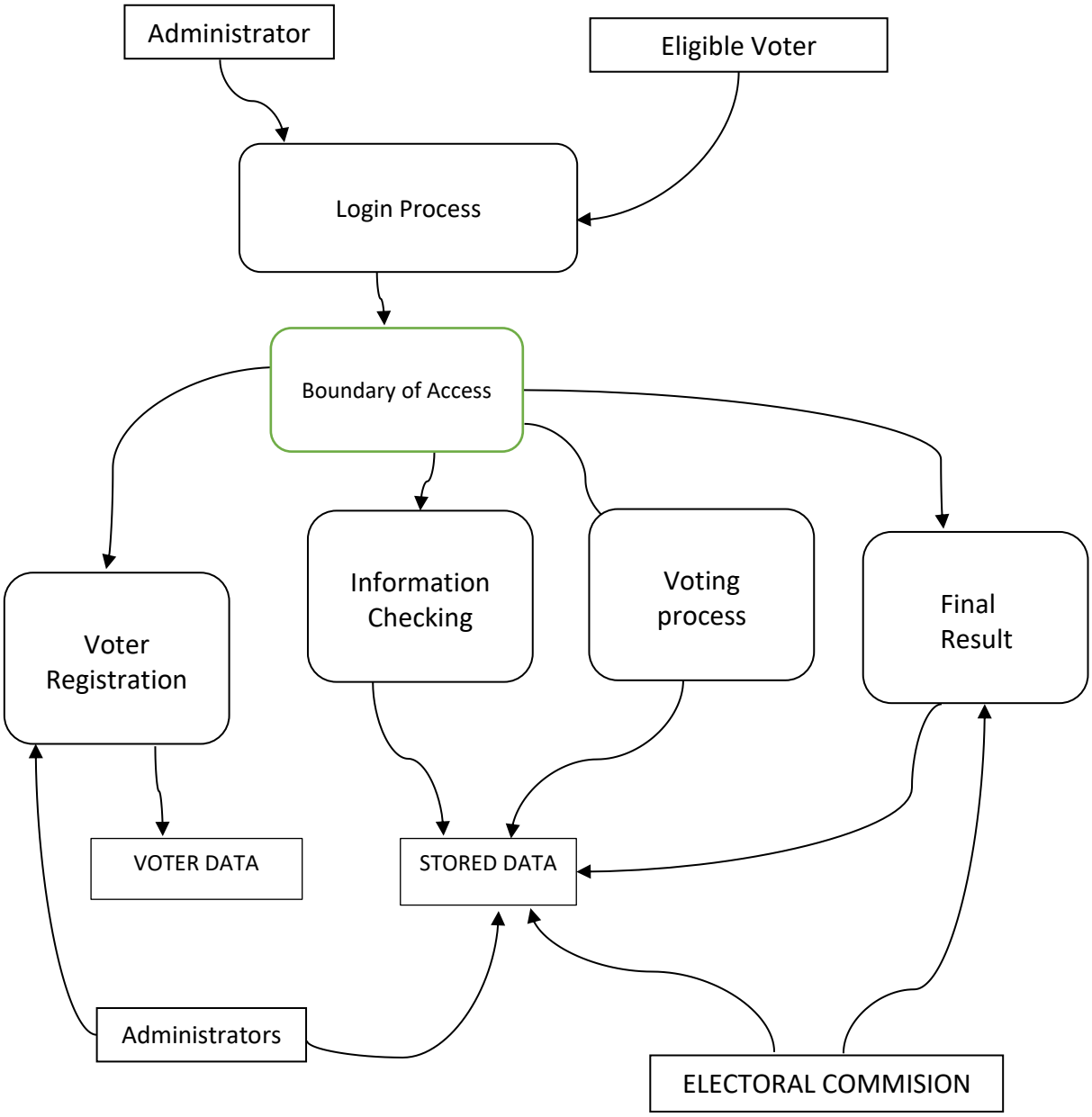


Figure 6: Data Flow Level 2

3.1.5 ENTITY RELATION DIAGRAM

The entity relationship diagram shows the relationship between the various users and their attributes. There is a relationship between the election commission and voter.

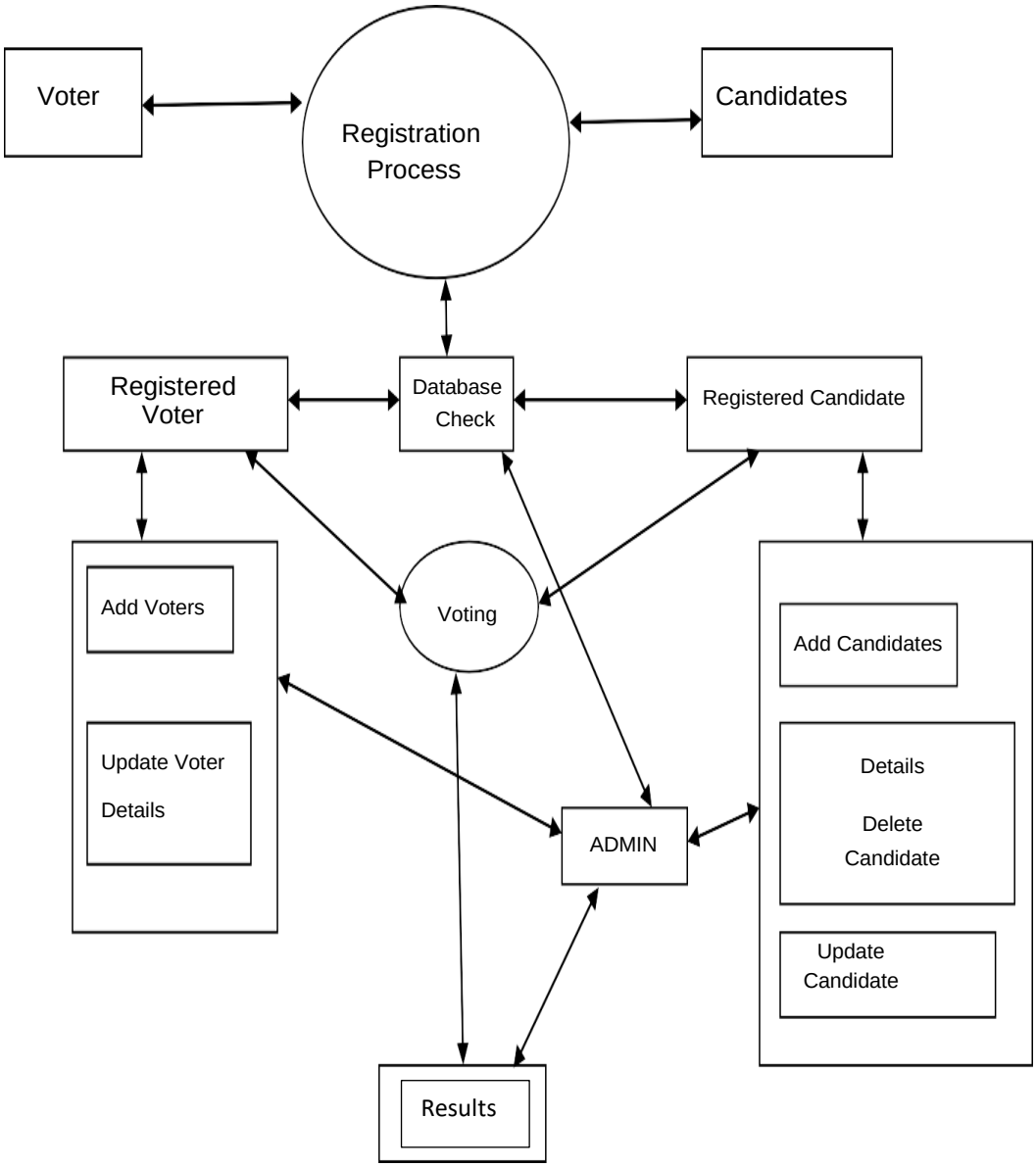


Figure 7 : Entity Relationship Diagram

3.1.6 CLASS DIAGRAM.

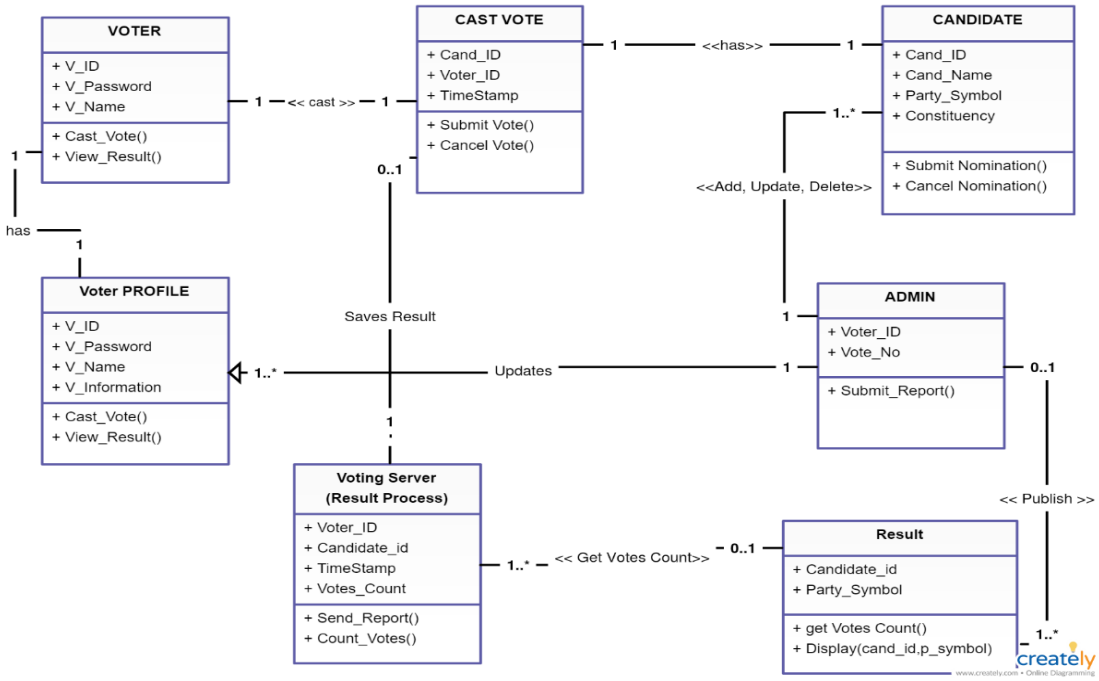


Figure 8: Class Diagram for the Noems system.

3.2 DATABASE DESIGN

A database is an organized collection of related data often designed to offer an organized mechanism for storing, managing and retrieving information. They do so using tables. Conventional databases are organized into records containing field. Each field contains specific information and is showing in the table below

Table 1: File Design Structure

FILE	DATA TYPE	FILE WIDTH
OTP	TEXT	12
EMAIL ADDRESS	TEXT	50
PASSWORD	TEXT	12

Table 2 : Voters Design

COLUMN NAME	DATA TYPE
VOTER NATIONAL ID	INT
VOTER ID	VARCHAR
COUNTY	VARCHAR
PASSWORD	VARCHAR
WARD	INT
CONSTITUENCY	TEXT

Table 3: Candidates

COLUMN NAME	DATA TYPE
CANDIDATE NAME	TEXT
CANDIDATE POSITION	TEXT
CANDIDATE PLATFORM	TEXT
CANDIDATE PHOTO	VARCHAR

3.3 DESIGN ALGORITHM

An algorithm is a procedure consisting of a finite set of unambiguous rules that specify a finite sequence of operations that provides solution to a given problem or to a specific class of problems for any allowable set of input quantity.

A Pseudo code as written below, presents the design algorithm for the project.

LOGIN

If login is successful

Check if the user is admin or voter

If Admin then display the Admin dashboard.

Select to check new registration form to verify their user's details

Select users that are qualified and move them to the eligible voters group

Select notification to notify the qualified voters and the disqualified users

Select vote

Select to create elections with different candidates

Select to determine voting duration

Select preview to preview all candidates

End

3.4 SYSTEM REQUIREMENTS

The existing voting system has so many problems such as; errors during data entry, time consuming, rigging, loss of registration form, delay in result publication and so many more even disable eligible voter cant exercise their right because of the inconveniences of queuing up to vote.

The current voting has all this problems mentioned above, and it is somewhat interesting to envision the proposal of devising a new method (online voting system) that will enable the citizens of The Republic of Kenya to carry out their civic duty, from any place.

3.5 METHOD OF DATA COLLECTION

In revealing the strength and weaknesses of the existing system, compilation of relevant facts proves to be of paramount significance. I did use the following methods.

3.5.1 OBSERVATION

As a Kenyan citizen and a registered voter, I have often observed the voting process and participated in the 2017 General Elections and have therefore seen from firsthand how the electoral process works.

3.5.2 SECONDARY DATA COLLECTION

Secondary data is one that has previously been gathered and can be accessed by researchers. I reviewed writings from online platforms such as GitHub, Research, and more online learning sites, PDFs files found online. Reliable news media outlets such as Citizen TV.

3.6 PROBLEMS WITH EXISTING SYSTEM

The problems of the existing manual system of voting include among others the following:

I. Expensive and Time Consuming

The process of collecting data and entering this data into the database takes too much time and is expensive to conduct. A lot of time and money is spent in printing data capture forms, in preparing registration/polling stations together with the required human resources, advertising the days set for registration process including sensitization of voters on the need for registration, as well as time spent on capturing all this data.

II. Too Much Paper Work:

The process involves too much paper work and paper storage that is difficult as papers become bulky with the population size. Several forms must be filled at each particular stage of vote tallying.

III. Errors during Data Entry:

They say to err is human; There is a high chance of inefficient in data entry and when this happens especially during thumb printing this makes the vote invalid.

IV. Time Constraints during Voter Registration.

Since voters must register at given places, there is a high likelihood for some to miss the registration due to the logistical challenges poised.

3.7 BENEFITS OF THE NEW SYSTEM

I. Security and Integrity:

NOEMS is well designed and implemented into a secure server that also stores the database of eligible voters. Security of process is ensured by requiring voters to provide valid authentication details before gaining access to the system. The system will be able to create an (OTP), which shall be used as the third layer of login into the system. The higher the levels of authentication, the greater the security of the voting system. Typically, two or three levels of authentication are used.

II. Accessibility:

Eligible voters can vote using any Internet/Online enabled computer and mobile phones, anywhere and there is no need for any special software or browsers. The accessibility of this system will increase the voter turnout, since voters do not have to present themselves to a voting station.

III. Simplicity:

Eligible voter only needs to Login to the secured voting web-app located on the server, key in their authentication details and access is granted to the voter panel.

Once a voter makes their selections, by checking inside a box beside their chosen candidate, a screen will appear confirming the voter's selection(s). Either at this stage, a voter is able to confirm and submit their selection by simply looking at the "Confirmation Screen", or they may amend their ballot by "clicking" on the "Reset" button. Once their vote is cast and submitted, a "Thank You" screen appears completing the voting process.

NOEMS provides the distinct advantage of the voter being able to visualize every step in the voting process, as well as having the flexibility and capacity to amend their vote, prior to its final submission.

IV. Timely Tabulations:

Practically, the results are instantaneously available; there is no waiting for the conduct of potentially inaccurate manual counts, or for the data keying or electronic scanning of Ballots. As soon as our standard internal checking processes are completed, the results are broadcast for all to see and could as well be live-fed to the media and other third party. Most elections are based on the concept of plurality, in which case there might be the variants of preferential or "first past the post" systems; NOEMS is designed to deliver accurate count outcomes and output reports, again virtually instantaneously.

V. Cutting on Costs

The price of democracy is a high one and as such there is a significant cost of running elections and do not seem to be going down any soon since the population of Kenya is ever growing. With the current electoral system, there is need to print ballots, hire more human resources and get more KIEMS KITS all having a direct cost implication. With NOEMS, once the relevant web screens have been developed, essentially there are few other costs. There is no need to hire more human resource to conduct the electoral process, cost will substantially reduce.

3.7.1 CHALLENGES FACED DURING DEVELOPMENT

i. Breakdown of the Xampp Server and loss of all data.
ii. Linking php to the database to perform given set of complex queries.
iii. Unable to print the data from my local host.
iv. Need to buy premium third party APIS to get access to given functionalities of NOEMS.

3.8 FEASIBILITY STUDY

A feasibility study is an analysis used in measuring the ability and likelihood to complete a project successfully including all relevant factors. It must account for factors that affect it such as economic, technological, legal and scheduling factors.

3.8.1 TECHNICAL FEASIBILITY

It lays out details on how a good or service will be delivered, which includes transportation, business location, technology needed, materials and labor.

With the technical feasibility carried out, it is clear that Kenya is at par with the minimum requirements of adopting a completely online voting experience.

3.8.2 SCHEDULE FEASIBILITY

The process of assessing the degree to which the potential time frame and completion dates for all major activities within a project meet organizational deadlines and constraints for affecting change.(Iamgylak Feb, 2013).The schedule feasibility of NOEMS is as shown in table 1,highlighting the weekly schedules.

Table 4 Schedule Feasibility

WEEKS	1	2	3	4	5	6	7	8	9	10	11
PLANNING											
RESEARCH											
DESINGING											
IMPLEMENTATION											
TESTING											
DOCUMENTATION											

3.8.3 ECONOMIC FEASIBILITY

Generally, it means whether a business or a project feasible cost wise and logistically. Economics calculate economic feasibility by analyzing the costs and revenues a business would incur by undertaking a certain project (Taylor. M, 2018)

The table below highlights the cost to be incurred.

Table 5 Economic Feasibility

RESOURCES	COST
Training Resources	KES 40,000
WEB HOSTING during electioneering period	KES 100000.00
Amazon Cloud Storage annually	KES 200000.00
Total	KSH 340000

3.8.4 RESOURCE FEASIBILITY

This studies focus is if the company has enough resources, the type of resources that will be required, and what facilities will be required for the project. Since the system is computer based it requires both hardware and software components. Therefore, the software requirements include Operating System: Windows (10), Linux, Mac-Os; web Browser: IE 10 or above, Mozilla FF 31 and above or Google Chrome, Drivers: Java Runtime Environment.

3.8.4.1 HARDWARE AND SOFTWARE REQUIREMENTS

The following are the hardware and software specifications required to build NOEMS:

Hardware Components

i. Any Intel Processor Core i3 and above.

ii. 400MB of free hard-drive space.

iii. 4 GB of Random Access Memory

Software Interface:

i. Operating System: Windows (7) and above, Mac OSx

ii. Web Browser: Mozilla FF 31 and above or Google Chrome

iii. Integrated Development Environment: MySQL, Apache,

iv. WAMP OR XAMPP Server for a local server environment.

v. An antivirus with updated definitions of malwares.

CHAPTER FOUR: IMPLEMENTATION, TESTING AND ANALYSIS

4.1 SYSTEM IMPLEMENTATION

For system implementation, we define how information needs to be built, involving the actual physical system design. Therefore, we do ensure that the information system is operational and usable, in additions to that we ensure maintenance of the software quality assurance, controls and standards.

NOEMS was developed using VsCode, PHP, MYSQL database, HTML, CSS, JAVA SCRIPT, and Bootstrap 4.Since NOEMS is an online web application, it has the advantage of easy development, flexibility, and it has the capacity of providing the developer and eventually the user a graphical user interface.

4.1.1 INSTALLATION

i. Export the project folder to your (W) XAMPP SERVER.
ii. Launch (W) Xampp Server and ensure the Apache and MYSQL are running.
iii. Import the NOEMS file to your htdocs folder and then import the database to your server.
iv. Launch NOEMS from your browser.

4.1.2 TOOLS AND ENVIRONMENT.

I chose to develop the system are open Source frameworks among which are the following languages PHP, Bootstrap 4, JavaScript, MySQL, HTML and CSS3.

I settled for those languages because I am conversant in them and they are available in many online web applications. They are also flexible to use.

4.1.2.1 VSCODE

I used the community edition of VsCode, which is an IDE that supports many languages and has many useful extensions for debugging the codes that we write.

4.1.2.2 PHP

This scripting language seamlessly connects with the localhost environment that I was using as my server. PHP is also easy to use and easily connects my databases for additional querying.

4.1.2.3 JAVASCRIPT

JavaScript is a simple to use language for adding additional functionality to web elements in addition to verification of form data input.

4.1.2.4 BOOTSTRAP 4

This consists of easy to use HTML and CSS styling that are pre-defined.

The framework allows for additional code expansion.

4.1.2.5 MYSQL

This is a database creation tool and language.

It allows for CRUD Operations (create, read, update, and delete), meanwhile it also gives room for database manipulation and other relevant querying operation.

4.2 SYSTEM TESTING

4.2.1 TYPES OF SYSTEM TESTING

Several testing techniques and tools are available. For NOEMS, I used the following types of tests.

i. Integration testing
ii. Browser compatibility testing
iii. Back-end testing
iv. Unit Testing
v. Functionality Testing

4.2.1.1 INTEGRATION TESTING

Integration testing is the phase in software testing in which individual software modules are combined and then tested. This kind of test is performed to evaluate the compliance of a system or component with specified functional requirements. It occurs after unit testing and before validation testing.

I was able to test all components of NOEMS. The test I conducted was registering a user (voter) as a normal user and an administrator, thereafter I logged in into the system. Once a registration was made it reflected in the database and in the back-end, where the administrator can add or remove a user or upgrade a user. Besides, the individual buttons worked in harmony.

4.2.1.2 BROWSER COMPATIBILITY TESTING

This test is performed for web applications as it ensures that the application can run with the combination of different web browsers and operating system. It also validates whether web application run on all versions of all browsers or not.

I tested the system with Microsoft edge, Chrome, Mozilla Firefox and opera. In all the instances, NOEMS was operational, however on other browser the system was slower to launch such as Opera, which took 16s as opposed to the rest, which ranged from 4s to 8s.

4.2.1.3 BACK-END TESTING

Here, we aim at testing the functionality and workability of the back-end system of any given application. The back-end is the core and driver of other components of the system. Whenever an input data is passed through the user interface, the data and their interaction are stored in the database. There are different databases like SQL Server, MySQL, and Oracle etc. Database testing involves testing of table structure, schema, stored procedure, data structure and so on.

I was able to test all the tables in database and all the tables and no issues were identified that is no data loss, no deadlock or data corruption.

4.2.1.4 UNIT TESTING

Since I have a proper understanding of the internal structures of my project, I easily undertook the unit test as I majored on fractions of code that I wanted to do given tasks. I did check and verify the roles that each of the buttons as espoused by the requirements should do. There was no aforementioned errors in that, each sample unit worked well.

4.2.1.5 FUNCTIONAL TEST.

I carried out this test in line with the objectives and contents of requirement specification for my project. I tested the main functions of NOEMS, which is from registration to login and voting process. At the same time, I checked for basic usability and navigation on the given pages either as an admin or as a voter, which proved to be seamless. I also checked on the accessibility of the system to the user and in deed at any point one wants to can access the system.

4.3 TEST PLAN

The test plan as part of analysis and design of NOEM, defines the various set of activities and operations, which are carried out by the System Administrator.

4.3.1 EXPECTED VERSUS ACTUAL RESULT

Figure 6 lists the set of procedures involved in testing and the actual result obtained.

Table 6 : Test Plan

EVENT	INTENDED RESULT	ACTUAL OUTCOME
Click on the local site project folder	The home page of the voting site should display containing the candidates overview, the login and registration of new voters	The home page containing the overview of candidates to vote for and a login and registration section for new users was displayed on the screen
Log-in with Admin. privilege	The Admin page should load and immediately taken to the dashboard	The page loaded all the information about the voting exercise.
Click icons on the dashboard to input, edit, or give privilege to any information needed	The dashboard should show all records about the voting exercise and control panel of the voting section	This page contains the control area of the voting process.
Login with voters privilege	A page load to welcome you to the voting page.	The welcome page with the go to vote instruction appears.
Click to register at the homepage	The voter registration form will appear containing, entry space for personal information, email, and password, confirm password, and submit button.	The registration page contains registration form where users will input their details waiting to be approved by the Admin
Click vote button	The voting page will appear containing candidates in a	This page is the main page for voting for candidates.

	certain locality to choose.	

4.4 EVALUATING PERFOMANCE AND RESULTS

With a completed NOEMS in place, carrying out performance evaluation and finding out the results is just the surest way of knowing what the system does.

4.4.1 OPERATING NOEMS

i. Login

From figure 9, the System admin Logs-in with the right credentials and are granted access.

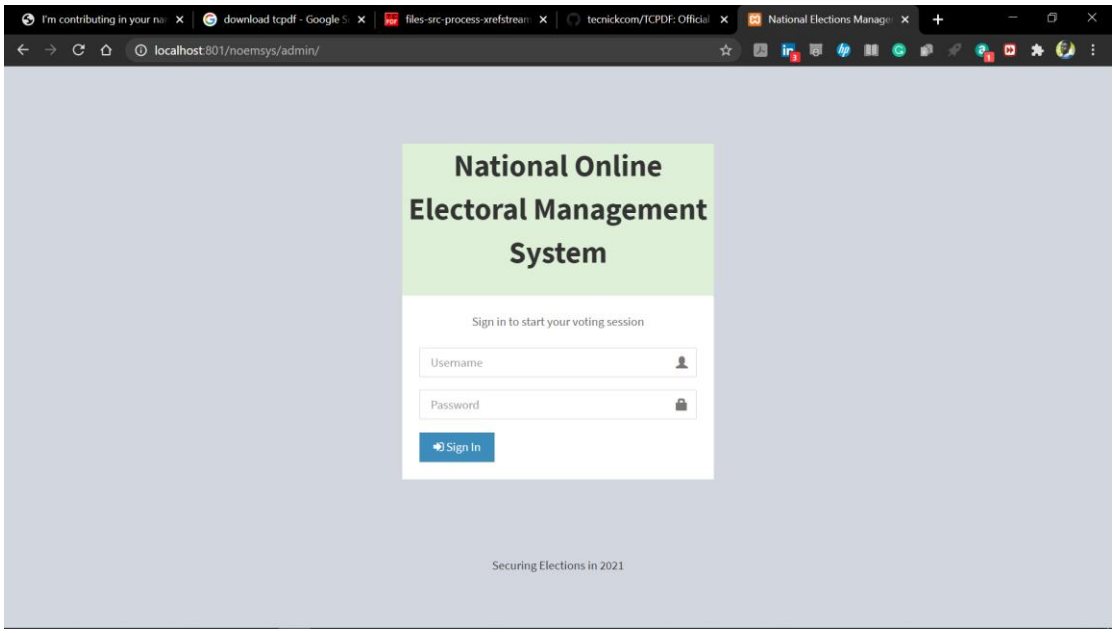


Figure 9 Login Panel

iii. Registration/Adding of New Voter by Admin.

Upon successful login, as shown in figure 10 system admin has full control of the system and can do several tasks. The figure below shows the process of adding a new voter.

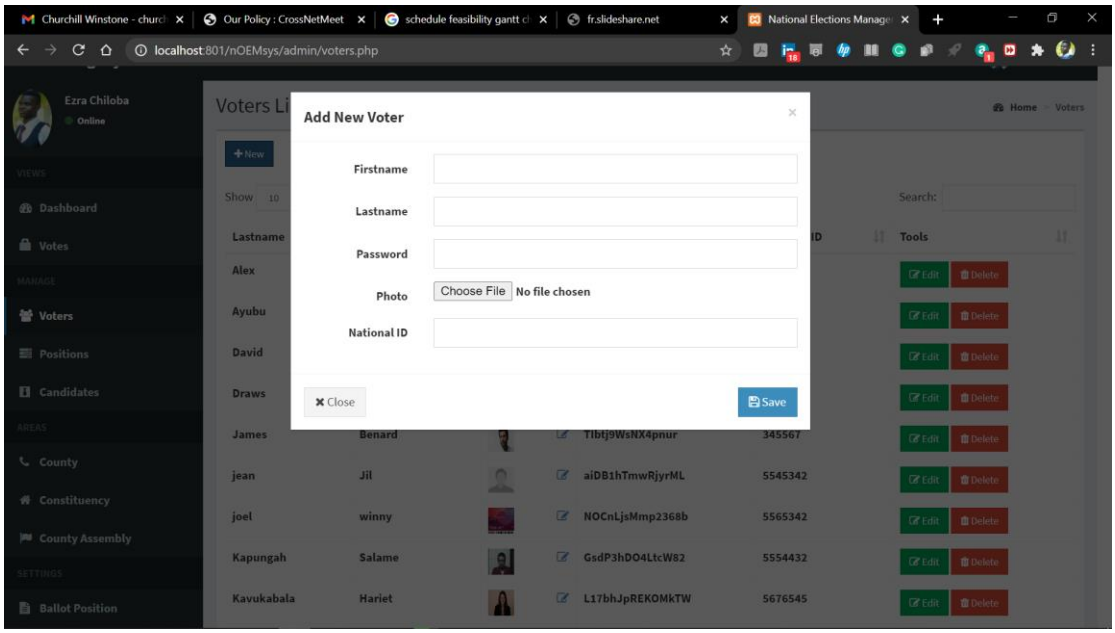
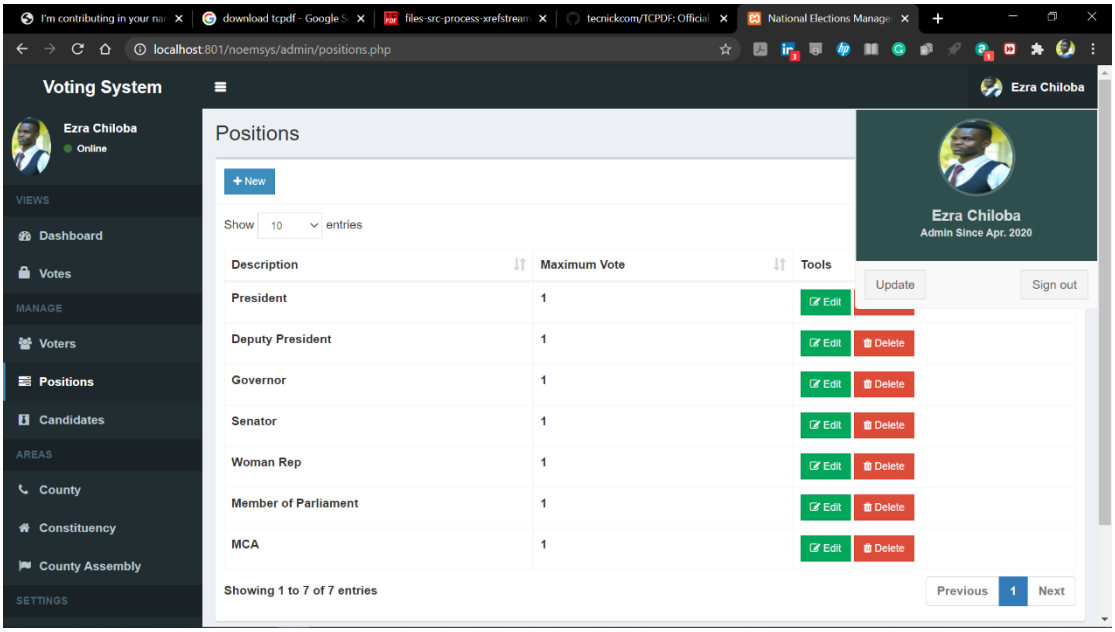


Figure 10 Voter Registration

iv. Log-out

Figure 11 shows how the users of NOEMS can log out of the system successfully



upon completion

Figure 11 Log out

vi. Voting

Figure 12 reveals that after a successful voter login, they are redirected to the voting page, which has a list of candidates they would vote in.

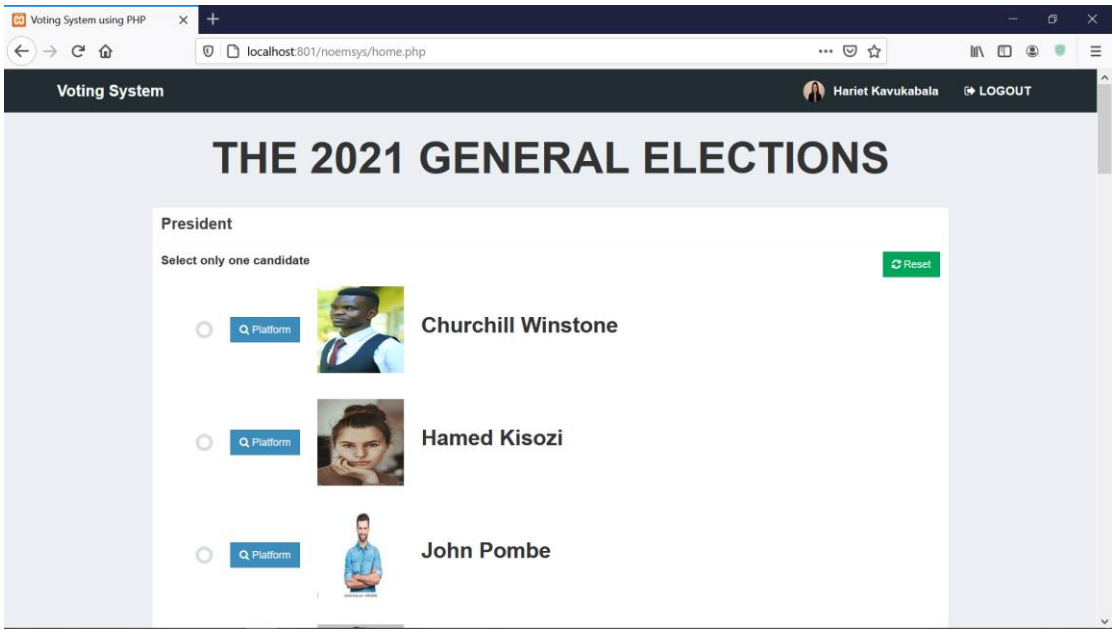


Figure 12 Voting panel

vii. Preview Votes

Figure 13 shows how voters can preview the choice of candidates that they have made before they submit the outcomes.

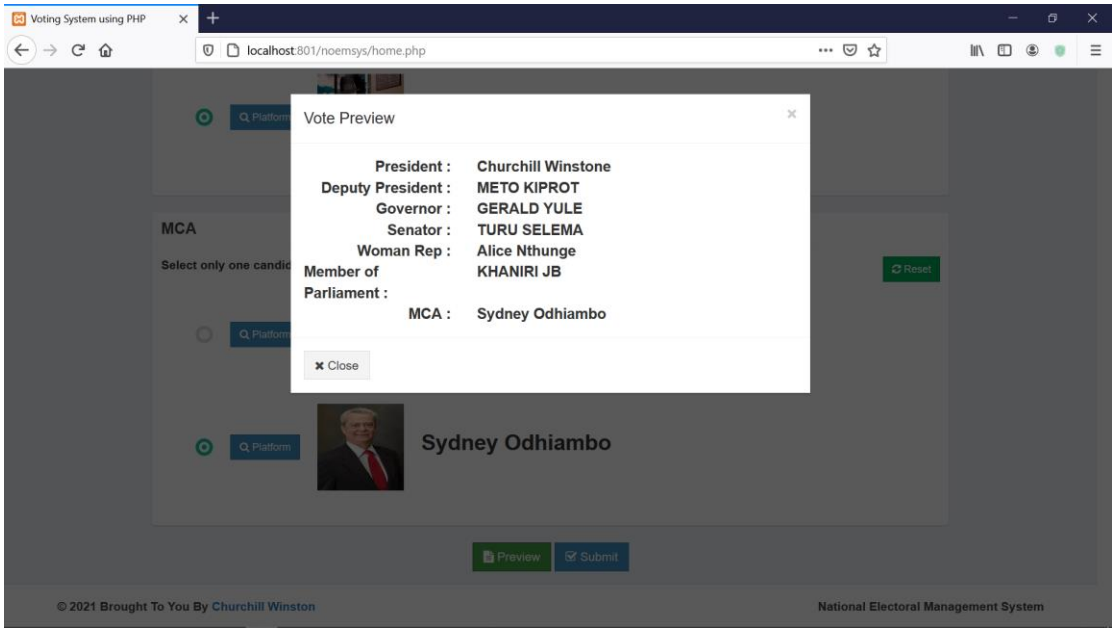


Figure 13 Preview votes

ix. Viewing Results

The system admin can view the results instantaneously as they stream into the system during a live voting process.as shown in figure 14.

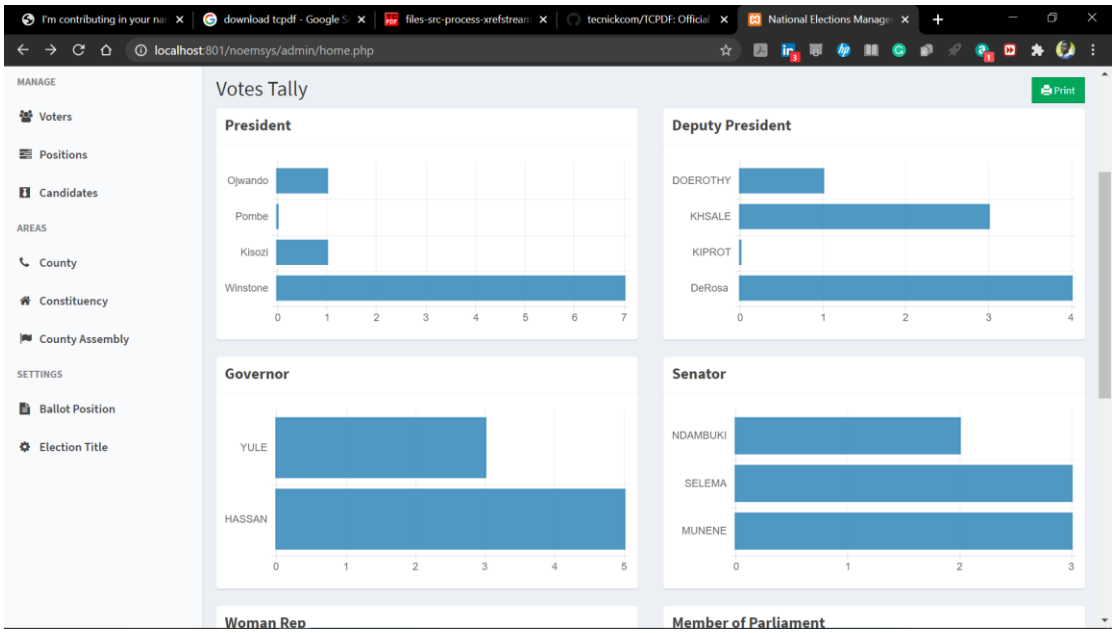
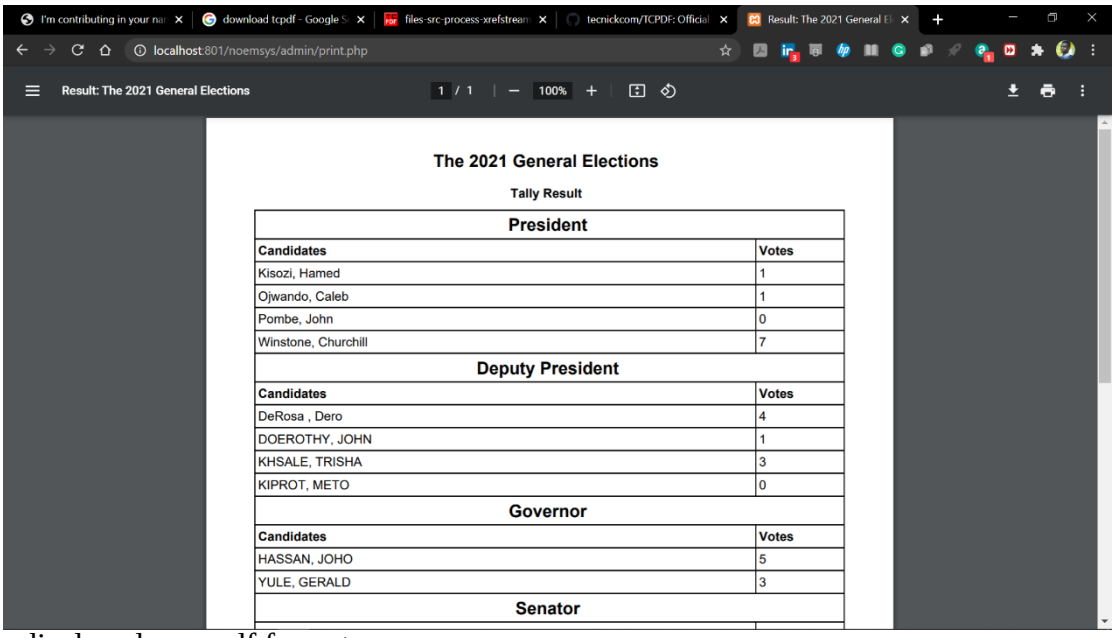


Figure 14 Results View

x. Reports

In figure 15, we see how reports can be generated upon querying and the result



displayed on a pdf format.

Figure 15 Reports

xii. Dashboard

Figure 16 shows the Dashboard. The Administrator can fully view all the details pertaining a given election and control all features of an election from the dashboard.

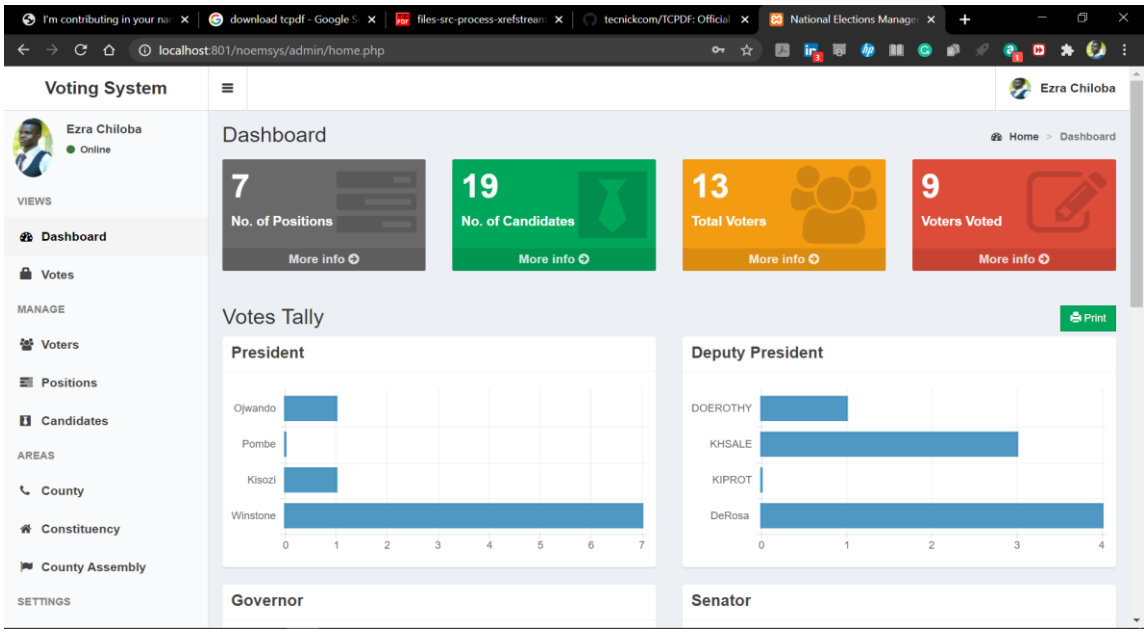


Figure 16 Admin Dashboard

xiii. Voters' List

Figure 17 highlights that the system Admin Can Perform CRUD operations on a given voter.

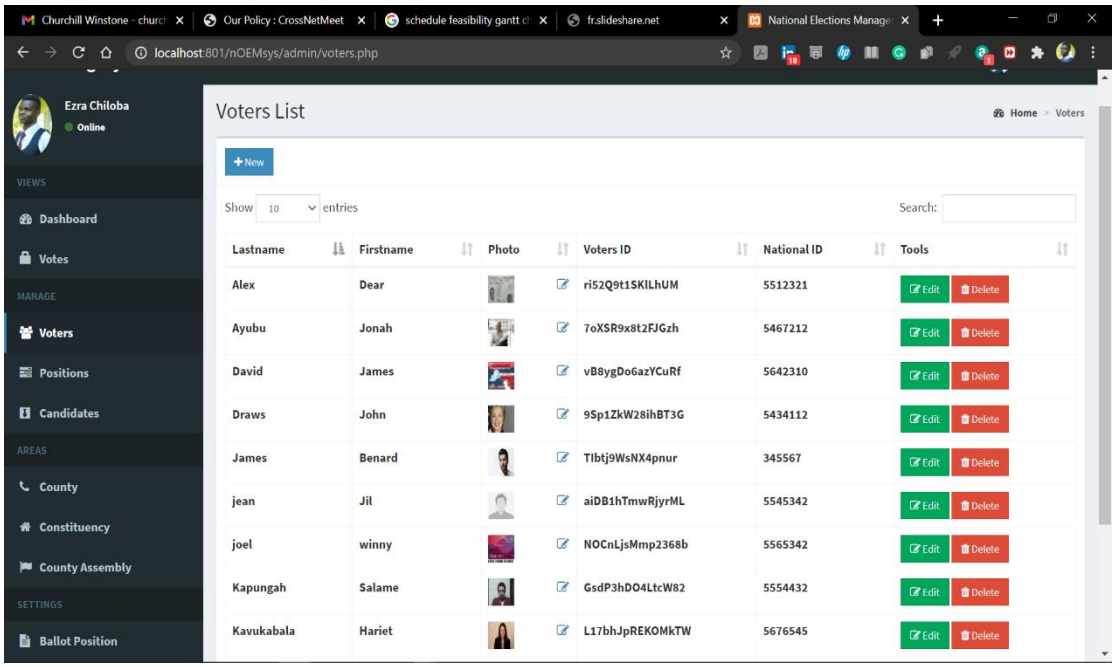


Figure 17: Voters List

xiv. Candidates List

From figure 18, the System admin will create and therefore add a list of qualified candidates.

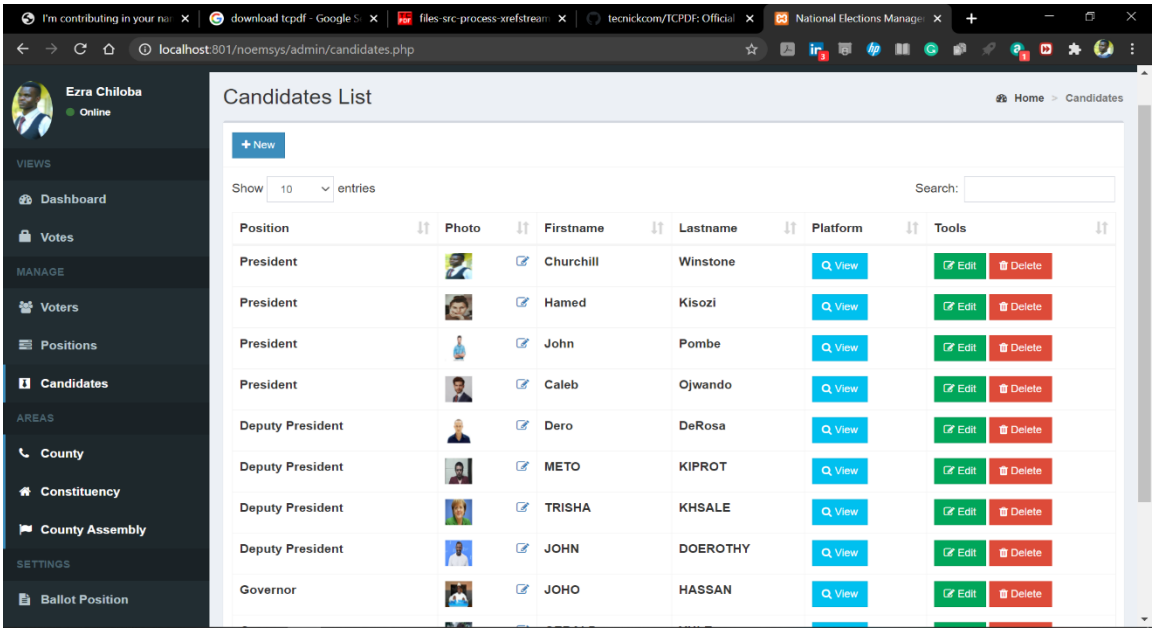


Figure 18 Candidate List

xv. Elective Positions

The system admin can create, update, delete and modify details of given elective positions as shown in figure 19.

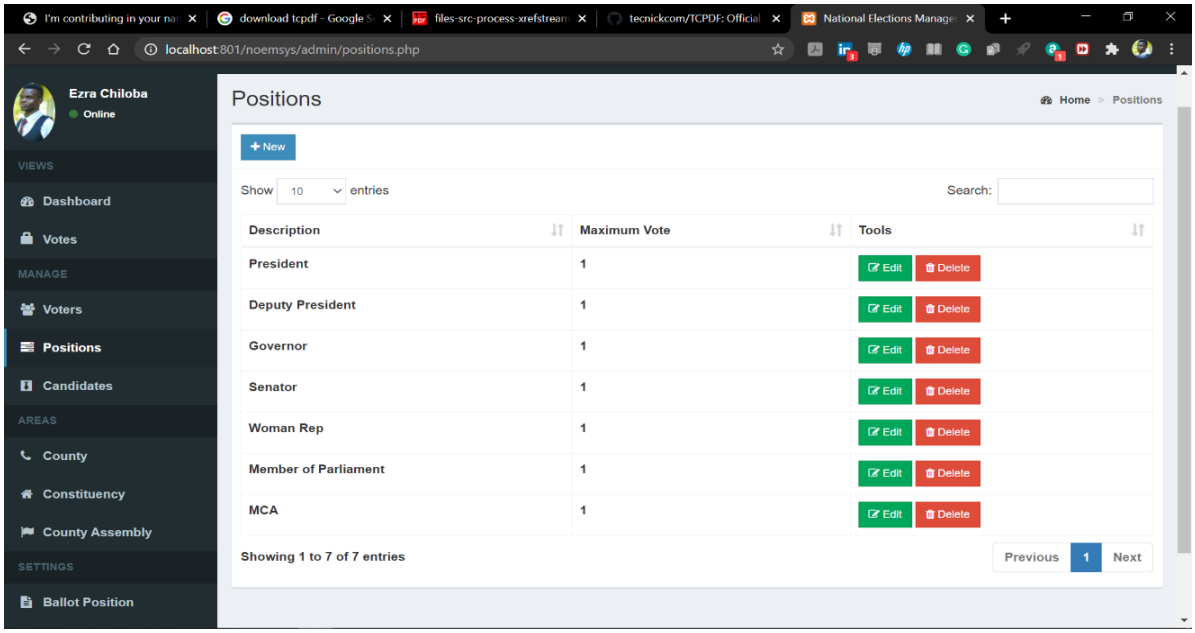


Figure 19 Elective Positions

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

With a renewed level of exposure, during this project, I was able to recognize that the consistent problem in elections held not just in Kenya, but also elsewhere; was integrity. Introduction of NOEMS will eradicate human errors and voters will now have self-belief in carrying out this exercise with full confidence that their votes count.

5.2 CONCLUSION

I was set on a mission to accomplish several objectives, as listed above from the beginning of my project. I am hopeful that someday we shall transition to using NOEMS in defining the future of our democracy. In addition to that, it will be able to serve its intended purpose and meet its objectives to the satisfaction of the voters, administrators and any other third party of interest.

Online voting offers convenience to the voter and considerable ease to election administrators as they can get election results out more quickly than conventional methods of manual voting and to sum up the discussion above, this project clarifies the requirements and key elements of online voting system, and the implementation.

In this study, I have shown how online voting system offers a number of advantages over the conventional manual paper-based voting system and this project portal is still open for further studies and modifications to increase its security.
I have come up with a database of registered voters in Kenya, and provided secure voter registration and voting pages.

5.3 FURTHER RECOMMENDATION

NOEMS can be optimized by having the following set of tasks included.

1) Enhance User Interface by adding more user interactive features.
2) Create an option to allow voters to print their soft voter's card.
3) Lock voting time, automatically rather than through code configuration
4) Automation of tasks such as Voter registration.

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APPENDICES

Appendix One

Sample code for the login page.

```php
<?php
    session_start();
    include 'includes/conn.php';

    if(isset($_POST['login'])){
        $voter = $_POST['voter'];

        $password = $_POST['password'];


        $sql = "SELECT * FROM voters WHERE voters_id = '$voter'";
        $query = $conn->query($sql);

        if($query->num_rows < 1){
            $_SESSION['error'] = 'Cannot find voter with the ID';
        }

        else{
            $row = $query->fetch_assoc();
            if(password_verify($password, $row['password'])){
                $_SESSION['voter'] = $row['id'];
            }
            else{
                $_SESSION['error'] = 'Incorrect password';
            }
        }
    }
    else{
        $_SESSION['error'] = 'Input voter credentials first';
    }

    header('location: index.php');

?>
```

Figure 20 Sample code for login page

Appendix Two
VSCODE sample outlook

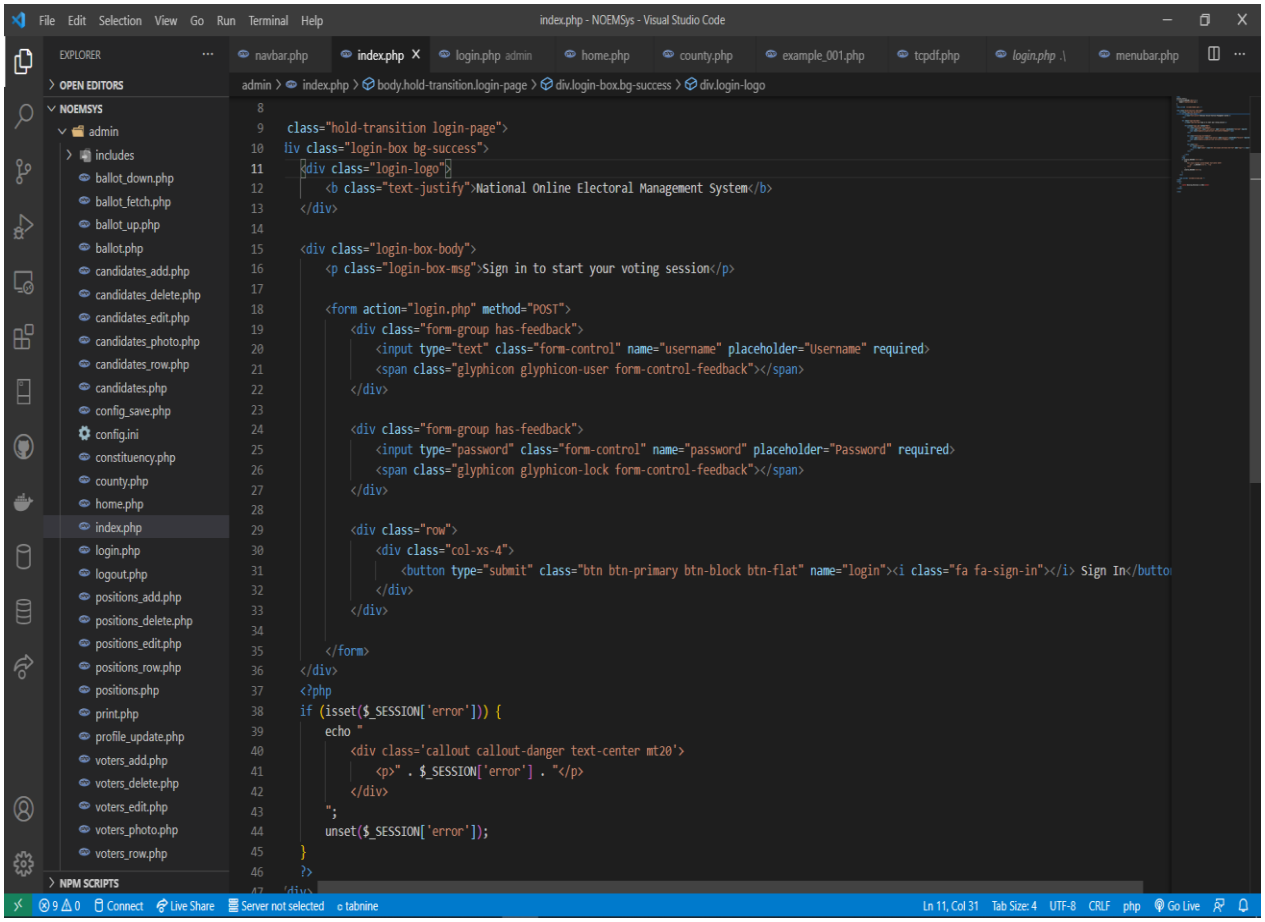

Figure 21 VsCode Outlook

Curiginal

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