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DESIGN AND IMPLEMENTATION OF ONLINE VOTING SYSTEM

CASE STUDY: The National Elections Commission (NEC) Liberia

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Declaration

"This dissertation titled DESIGN AND IMPLEMENTATION OF ONLINE VOTING SYSTEM is my original work, it has never been submitted before for any other degree award to any other University ".

Student's name: Shadrach Barkolea Tokpah

Signature: ……..

Date: ……..

Approval

This dissertation titled **"DESIGN AND IMPLEMENTATION OF ONLINE VOTING SYSTEM"** has been done under my supervision and submitted for examination with my approval.

Supervisor's name: Mr. Kwizera Jean Pierre

Signature: ……

Date: …….

Dedication

This dissertation is dedicated to the people of Liberia, whose resilience and pursuit of democratic governance inspire hope for a brighter future. To the voters who believe in the power of their voices and the value of their participation in the electoral process, this work is for you.

To my family, whose unwavering support and encouragement have been the foundation of my academic journey, thank you for always believing in me. Your love and sacrifices have made this achievement possible.

Lastly, this dissertation is dedicated to all the pioneers of digital democracy and the advocates of fair and transparent elections around the world. May this work contribute to the ongoing efforts to harness technology in strengthening democratic processes and promoting inclusive participation.

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Shadrach Barkolea Tokpah

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Abbreviations and Acronyms

- **AJAX** - Asynchronous JavaScript and XML
- **API** - Application Programming Interface
- **CSS** - Cascading Style Sheets
- **DBMS** - Database Management System
- **HTML** - Hypertext Markup Language
- **HTTP** - Hypertext Transfer Protocol
- **HTTPS** - Hypertext Transfer Protocol Secure
- **ID** - Identification
- **IP** - Internet Protocol
- **IT** - Information Technology
- **JS** - JavaScript
- **JSON** - JavaScript Object Notation
- **MAMP** - Mac, Apache, MySQL, PHP (Local development environment)
- **NEC** - National Elections Commission (Liberia)
- **OS** - Operating System
- **PHP** - Hypertext Preprocessor
- **SQL** - Structured Query Language
- **SSL** - Secure Sockets Layer
- **TCP/IP** - Transmission Control Protocol/Internet Protocol
- **UNDP** - United Nations Development Programme
- **UI** - User Interface
- **UX** - User Experience
- **XML** - Extensible Markup Language
- **VPN** - Virtual Private Network
- **OTP** - One-Time Password
- **OTP** - Online Transaction Processing
- **2FA** - Two-Factor Authentication

Abstract

This thesis explores the feasibility and potential implementation of an online voting system in Liberia. With advancements in technology and the increasing need for more efficient and accessible electoral processes, online voting presents a compelling alternative to traditional voting methods. However, the successful adoption of such a system requires careful consideration of various factors, including technological infrastructure, social acceptance, legal frameworks, and security measures.

The study employs a mixed-methods research design, integrating both qualitative and quantitative approaches to gather comprehensive data. Qualitative methods include interviews and focus group discussions with key stakeholders, such as government officials, electoral commission members, IT experts, and civil society representatives. Quantitative data is collected through surveys administered to a diverse sample of the Liberian population, capturing their perceptions, trust levels, and readiness for online voting.

The findings of this research highlight the critical role of technological readiness, including reliable digital infrastructure and robust cybersecurity measures, in the successful implementation of online voting. Social factors, such as public trust, digital literacy, and cultural attitudes towards technology, also play a significant role in shaping acceptance and usage. Furthermore, the study identifies the need for comprehensive legal and regulatory frameworks that address data privacy, electoral integrity, and transparency to ensure the credibility of online voting.

Based on these findings, the study provides practical recommendations for policymakers, electoral bodies, and stakeholders to consider in the implementation of an online voting system in Liberia. These recommendations include enhancing digital infrastructure, conducting public awareness campaigns, strengthening cybersecurity protocols, and developing clear legal guidelines.

This research contributes to the ongoing discourse on digital democracy and aims to provide a roadmap for countries like Liberia that are exploring the integration of technology into their electoral processes. The adoption of online voting, if effectively managed, has the potential to enhance voter participation, reduce electoral costs, and increase trust in the democratic process.

Key word: Technological infrastructure, Legal framework, Security , Electoral Integrity

CHAPTER ONE: GENERAL INTRODUCTION

1.1. Introduction to the study

The introduction of an online voting system aims to provide a more convenient and efficient way for citizens to participate in elections. With paper-based voting systems, it can be difficult to locate specific candidates and ensure voter eligibility. It also made hectic and rush for voters to visit the centers and vote the candidate. An online voting system addresses these issues by providing secure authentication and verification mechanisms, making the voting process more automated and streamlined. It made easy for authorized person to login in from its own device and vote. Furthermore, online voting systems can also increase transparency and provide faster results. While there are concerns regarding security and privacy, the benefits of an online voting system cannot be denied. In this context, the purpose and scope of the system are to ensure that every citizen can participate in the democratic process in a secure and hassle-free manner. As countries around the world explore the feasibility of online voting, it is crucial to study the potential impact, benefits, and challenges of such systems, particularly in regions with unique socio-political and technological landscapes.

Liberia, a West African nation with a history of political instability and civil conflict, has made significant strides towards democratic governance in recent years. The introduction of an online voting system could be a pivotal step in strengthening the country's electoral process, enhancing voter participation, and ensuring the integrity of elections. However, given Liberia's infrastructural limitations, cybersecurity concerns, and varying levels of digital literacy, the implementation of online voting poses a set of unique challenges.

1.2 Background of the project

The concept of online voting, often referred to as e-voting or Internet voting, has gained considerable attention globally due to its potential to streamline electoral processes, enhance accessibility, and improve voter turnout. As more countries seek to modernize their electoral systems, the adoption of online voting has emerged as a promising solution to some of the limitations associated with traditional, paper-based voting methods. However, the

implementation of online voting systems varies significantly depending on the country's technological infrastructure, cybersecurity preparedness, socio-political environment, and public trust in the electoral process Simons, B., & Jones, D. W. (2018).

Liberia, a country located on the west coast of Africa, presents a unique case for examining the feasibility of online voting. With a population of approximately 5 million people, Liberia has undergone significant political and social transformations since the end of its civil war in 2003. The country has made substantial progress in rebuilding its democratic institutions and conducting elections that are generally considered free and fair. However, Liberia still faces considerable challenges in terms of infrastructure, economic development, and technological capacity Aggelos Kiayias, et al. (2018).

Despite these challenges, the government of Liberia and various stakeholders have shown interest in exploring digital solutions to improve governance and enhance civic participation. The introduction of an online voting system is viewed as a potential means to modernize the electoral process, reduce the logistical complexities associated with traditional voting, and provide a more inclusive platform for all eligible voters, including those in remote areas and the diaspora community Alvarez, R. M., Hall, T. E., & Trechsel, A. (2022).

1.3 Problem Statement

In Liberia, the National Elections Commissions (NEC)'s traditional paper-based election systems face numerous challenges, including logistical complexities, high costs, potential for human error, and security vulnerabilities. These issues can lead to inefficiencies, delays in results, and reduced voter participation due to the inconvenience of in-person voting. There is a growing need for a secure, efficient, and user-friendly online election system that can manage all aspects of the electoral process, from voter registration to the final vote count. Despite the potential benefits of online voting, there are considerable challenges and concerns that need to be addressed to ensure its successful adoption. In Liberia, these challenges include issues related to cybersecurity, voter authentication, infrastructure readiness, digital literacy, and public trust in the electoral process. Understanding these issues are essentials for the development of a secure, reliable, and widely accepted online voting system.

1.4 Objectives of the project

1.4.1 General objective

The primary objective is to design and implement a comprehensive online election system that ensures the integrity, security, and efficiency of the election process that will allow users to participate from anywhere and at any time.

1.4.2 Specific objectives

The specific objectives of this research are:

i. To Evaluate the Technological Readiness for Online Voting in Liberia:
ii. To Identify and Analyze Cybersecurity Risks:
iii. To Assess the Level of Digital Literacy and Accessibility Among Voters:
iv. To Understand Public Perceptions and Trust in Online Voting:
v. To Examine the Legal and Regulatory Framework for Online Voting:
vi. To Evaluate the Potential Impact of Online Voting on Electoral Participation and Integrity:
vii. To Develop Recommendations for the Design and Implementation of an Online Voting System:

1.5 Research Questions

To address the research problem and achieve the specific objectives outlined, this study will focus on the following research questions:

i. What is the current state of technological infrastructure in Liberia, and is it sufficient to support an online voting system?
ii. What are the primary cybersecurity risks associated with implementing an online voting system in Liberia?
iii. What is the level of digital literacy among the Liberian population, and how might it impact the adoption of online voting?
iv. What are the perceptions and attitudes of Liberian citizens towards online voting?
v. What legal and regulatory changes are needed to support the implementation of online voting in Liberia?

vi. How would the introduction of online voting impact voter turnout and electoral participation in Liberia?
vii. How can we design and implement an online voting system?

1.6 Scope of the project

The scope of this research project on the feasibility and implications of implementing an online voting system in Liberia encompasses several key areas to ensure a comprehensive understanding of the topic. These areas are defined as follows:

1.6.1 Geographical Scope:

The study will focus on Liberia, covering both urban and rural areas across the country. It will include an analysis of the infrastructure and socio-political context in different regions to understand how these factors may affect the implementation and success of an online voting system.

Consideration will also be given to the Liberian diaspora, examining how online voting could facilitate their participation in elections.

1.6.2 Theoretical Scope

The theoretical scope of this research focuses on the frameworks, theories, and models that will guide the analysis and understanding of online voting systems in the context of Liberia. By defining the theoretical parameters, the study can systematically explore the key issues related to technology adoption, cybersecurity, public trust, and electoral participation. This scope will help in formulating hypotheses, analyzing data, and interpreting findings within a structured conceptual framework.

1.6.3 Technological Scope:

The research will assess the existing technological infrastructure in Liberia, including internet penetration, availability of digital devices (such as smartphones, computers, and tablets), and the reliability of telecommunications networks.

It will examine the technical requirements for implementing a secure and efficient online voting system, including software, hardware, and cybersecurity protocols.

1.6.4 Cybersecurity Scope:

The study will explore the cybersecurity threats specific to online voting, such as hacking, data breaches, and vote manipulation. It will investigate best practices for securing online voting systems and propose measures to protect voter data and ensure the integrity of the election process.

1.6.5 Socio-Demographic Scope:

The research will consider the digital literacy levels of different demographic groups in Liberia, including urban and rural populations, various age groups, and socio-economic classes.

It will explore the barriers to digital access and participation in online voting, such as literacy levels, access to technology, and familiarity with digital tools.

1.6.6 Public Perception and Trust Scope:

The study will examine the attitudes and perceptions of the Liberian public towards online voting. It will explore concerns related to security, privacy, reliability, and fairness of online voting systems.

Surveys, interviews, and focus groups may be conducted to gather qualitative and quantitative data on public trust and acceptance.

1.6.7 Legal and Regulatory Scope:

The research will review the existing legal and regulatory framework governing elections in Liberia to determine its adequacy for supporting online voting.

1.7 Significance of the project / Interest

The implementation of an online voting system in Liberia represents a significant step towards modernizing the electoral process, improving accessibility, and enhancing the integrity of

democratic governance. This research project is critical for several reasons, as it seeks to address key challenges and capitalize on opportunities associated with online voting.

1.7.1 Personal interest

My personal interest in researching the feasibility and implications of implementing an online voting system in Liberia stems from a deep commitment to democratic values, technological innovation, and the empowerment of communities through accessible governance. Several factors motivate my interest in this project: passion for technology and innovation, commitment to democratic participation, interest in public policy and governance

1.7.2 Institutional interest

The institutional interest in researching the feasibility and implications of implementing an online voting system in Liberia is rooted in the desire to advance the institution's goals of promoting democratic governance, technological innovation, and public policy development. This research aligns with several strategic objectives of academic, governmental, and non-governmental institutions focused on democracy, technology, and social impact.

1.7.3 Public interest

The public interest in researching the feasibility and implications of implementing an online voting system in Liberia is significant and multifaceted. The project holds substantial value for various segments of the public, as it addresses key concerns related to electoral participation, security, accessibility, and democratic engagement. Here's an overview of why this research is of broad public interest: Increased voter participation, **e**nhanced convenience and efficiency, security and trust in elections**.**

1.8 Project methodology

The system development methodology outlines the approach taken to design, develop, and implement the online voting system for Liberia. Given the critical nature of voting systems, which require high levels of security, reliability, and user accessibility, the choice of development methodology is crucial. This project adopts the **Agile Software Development** methodology, which is widely recognized for its flexibility, iterative nature, and ability to incorporate stakeholder feedback throughout the development process.

Agile development is characterized by iterative cycles known as sprints, each aimed at producing a working version of the software. This methodology is chosen because it allows for continuous testing and improvement, facilitating the rapid identification and resolution of issues. Key principles of Agile applied in this project include:

Iterative Development: Breaking the development process into small, manageable sprints, typically lasting 2-4 weeks. Each sprint focuses on specific features or components of the online voting system, allowing for incremental development and continuous integration.

User-Centric Design: Involving end-users and stakeholders throughout the development process to ensure that the system meets their needs and expectations. This involves regular feedback sessions, usability testing, and adjustments based on user input.

Continuous Improvement: Using feedback from each sprint to refine and enhance the system. This iterative approach ensures that the final product is robust, secure, and user-friendly.

1.9 Limitations of the project

While researching the feasibility and implications of implementing an online voting system in Liberia offers many potential benefits, it is important to acknowledge and address the limitations and challenges that may arise. Understanding these limitations helps to set realistic expectations and provides a basis for developing strategies to overcome them.

Infrastructure Limitations: Liberia's technological infrastructure may not be uniformly developed across all regions. Limited internet connectivity, intermittent power supply, and inadequate digital infrastructure in remote areas can hinder the implementation and effectiveness of an online voting system.

Device Availability: Variations in access to digital devices, such as computers and smartphones, among different segments of the population may affect the ability of all citizens to participate in online voting. Addressing device accessibility is crucial for ensuring inclusivity.

1.10 Organization of the project

This study is structured and articulated into four chapters sequentially:

Chapter 1: Introduction to the study

This chapter gives an introduction and background of this research. It introduces the main research purpose including, the statement of the problem, Research objectives, research questions, scope and the limitations.

Chapter 2: Literature review

The main purpose of this chapter is to describe the key terms or concepts used in our study, to review the existing related systems and how previous researchers addressed data exchange problems.

Chapter 3: System analysis and design

This chapter will present the analysis of the system Vs the new system to be implemented along with research methodologies used and the system design and overview.

Chapter 4: System implementation

In this chapter will describe the tools and technologies used for implementation and system implementation flow and Specifications.

Conclusion and recommendations

This offers the conclusion of the study and suggestions to call institutions to adhere on the importance and advantages of using machine learning algorithms in Organization.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The literature review provides a comprehensive understanding of existing research, theories, and practices related to online voting systems, focusing on their feasibility, benefits, challenges, and implications. It aims to contextualize the study of implementing an online voting system in Liberia by examining global experiences, technological and social factors, and potential impacts on democracy and governance.

2.2 Definition of the Concepts Online Voting

2.2.1 Online Voting: Also known as electronic voting or e-voting, online voting refers to the process of casting and counting votes electronically, typically via the internet. This system allows voters to participate in elections using digital devices, such as computers, smartphones, or tablets, rather than traditional paper ballots or physical polling stations (Goodman & Pyman, 2016).

2.2.2. Security Implementation of Online voting

i. **Security:** Ensuring the security of online voting systems is crucial to prevent unauthorized access, fraud, and tampering with election results. Security involves implementing measures such as encryption, secure authentication, and intrusion detection systems Pran, K. (2019).

ii. **Privacy:** Voter privacy is a fundamental principle in any voting system. Online voting must guarantee that voters' choices remain confidential and that their personal information is protected from unauthorized access (Vinkel, 2018).

iii. **Accessibility:** Online voting systems should be accessible to all eligible voters, including those with disabilities, limited digital literacy, or inadequate access to technology. Ensuring accessibility involves designing user-friendly interfaces and providing alternative voting methods for those unable to use online systems.

iv. **Transparency:** Transparency in online voting refers to the openness and clarity of the voting process, enabling voters and stakeholders to verify that the election is

conducted fairly and accurately. Transparent systems build trust and confidence in the electoral process Research by Serdült et al. (2019).

v. **Usability:** The ease with which voters can interact with the online voting system is critical. Usability affects voter participation rates and satisfaction. A system must be intuitive, easy to navigate, and require minimal technical expertise Krimmer et al. (2020).

2.2.3. Theoretical Frameworks Related to Online Voting

i. **Technology Acceptance Model (TAM):** The TAM is used to understand how users come to accept and use technology. It posits that perceived usefulness and perceived ease of use are primary factors influencing the adoption of new technologies. In the context of online voting, TAM can help assess how voters perceive the system's benefits and ease of use, which in turn impacts their willingness to adopt online voting. Krimmer et al. (2020).

ii. **Diffusion of Innovations Theory:** This theory, developed by Everett Rogers, explains how, why, and at what rate new technologies spread through cultures. It identifies factors such as relative advantage, compatibility, complexity, trialability, and observability as key to the adoption process. The diffusion of online voting would depend on how these factors are perceived by the population and stakeholders in Liberia.

iii. **Trust Theory:** Trust is a critical element in the adoption of online voting systems. Theoretical models of trust highlight the importance of perceived integrity, reliability, and security of the system. Building trust involves demonstrating the system’s ability to handle votes accurately, securely, and confidentially.

2.2.4. Contextual Considerations for Liberia

i. **Technological Infrastructure:** Liberia’s technological infrastructure, including internet penetration and digital literacy, is a critical factor in assessing the feasibility of online voting. A robust infrastructure is necessary to support the deployment and operation of online voting systems.

ii. **Political and Social Environment:** The political stability and social dynamics in Liberia can influence the acceptance and success of online voting. Ensuring that the system aligns with the country's political and social context is essential for its adoption and effectiveness.

2.3. Related Literature of the project

The implementation of online voting systems has been studied extensively across different contexts, focusing on various aspects such as technological feasibility, security, user acceptance, and regulatory frameworks. This review synthesizes key findings from existing literature and identifies the gaps that this research aims to address. The review is structured around four main themes: technological readiness, security concerns, social and behavioral factors, and regulatory frameworks.

2.3.1 Global Adoption and Experiences of Online Voting

2.3.1. System which exist

Numerous countries have experimented with online voting systems to varying degrees of success, each offering valuable insights into the practical challenges and benefits associated with their implementation

i. **Estonia:** Estonia is frequently cited as a pioneer in online voting. Since its introduction of internet voting in 2021, Estonia has consistently utilized this method in national and local elections. Research highlights Estonia’s success factors, including a robust digital infrastructure, a high level of public trust in electronic systems, and stringent security measures. The country’s use of a digital ID system and strong cryptographic protocols has ensured both the security and anonymity of voters (Vinkel, 2023).
ii. **Switzerland:** Switzerland has conducted several online voting trials, particularly targeting expatriates and specific cantonal referenda. Research by Serdült et al. (2024) reveals that public acceptance in Switzerland is influenced by the transparent design of the system and pilot testing. Switzerland’s cautious, incremental approach and extensive use of feedback from these trials have helped refine the system’s usability and security.

iii. **Canada:** Certain provinces in Canada, such as Ontario and Nova Scotia, have utilized online voting in municipal elections. Studies have shown that online voting in Canada led to increased voter turnout, particularly among younger demographics and voters who would otherwise have difficulty accessing polling stations (Goodman & Pyman, 2020).

iv. **United States:** Online voting in the United States has been limited and primarily targeted at overseas and military voters. Research underscores significant security concerns, including vulnerability to cyberattacks, data breaches, and the challenge of ensuring voter anonymity. The U.S. experience highlights the importance of cybersecurity resilience and the need for rigorous testing and certification standards (Hall, 2020).

v. **Existing Research**: Several studies have assessed the technological readiness for online voting in various countries. For example, Alvarez, Hall, and Trechsel (2021) discussed the infrastructure requirements for online voting, emphasizing the need for reliable internet connectivity, secure servers, and robust software applications. Similarly, Benaloh (2021) examined the technical standards required to ensure the reliability and accuracy of online voting systems.

vi. **Gaps Identified**: While these studies highlight the technical requirements, they often assume a baseline level of digital infrastructure that may not be present in developing countries like Liberia. There is limited research on adapting online voting systems to environments with less reliable internet access and varying levels of technological sophistication.

vii. **How This Work Addresses the Gap**: This study focuses specifically on Liberia's technological landscape, evaluating the current infrastructure capabilities and identifying realistic solutions for implementing online voting in a context where internet penetration and digital literacy may be limited. By conducting a thorough assessment of Liberia's existing technology, this research will propose tailored technological solutions that address local constraints.

2.3.2 Old Methods of Voting

i. Paper-based voting: The voter gets a blank ballot and use a pen or a marker to indicate he want to vote for which candidate. Hand-counted ballots is a time and labor consuming process, but it is easy to manufacture paper ballots and the ballots can be retained for verifying, this type is still the most common way to vote, Benaloh (2021).

viii. Lever voting machine: Lever machine is peculiar equipment, and each lever is assigned for a corresponding candidate. The voter pulls the lever to poll for his favorite candidate. This kind of voting machine can count up the ballots automatically. Because its interface is not user-friendly enough, giving some training to voters is necessary (Hall, 2020).

ii. Direct recording electronic voting machine: This type, which is abbreviated to DRE, integrates with keyboard; touch screen, or buttons for the voter press to poll. Some of them lay in voting records and counting the votes is very quickly. But the other DRE without keep voting records are doubted about its accuracy Alvarez, Hall, and Trechsel (2021).

iii. Punch card: The voter uses metallic hole-punch to punch a hole on the blank ballot. It can count votes automatically, but if the voter's perforation is incomplete, the result is probably determined wrongfully Benaloh (2021).

iv. Optical voting machine: After each voter fills a circle correspond to their favorite candidate on the blank ballot, this machine selects the darkest mark on each ballot for the vote then computes the total result. This kind of machine counts ballots rapidly. However, if the voter fills over the circle, it will lead to the error result of optical scan(Hall, 2020).

2.3.3 Security Concerns

i. **Existing Research**: Security is a primary concern in online voting. Research by Adida (2021) and Neumann (2020) explored cryptographic methods and security protocols to protect against threats like hacking, data tampering, and unauthorized access. Moreover, Mercuri and Camp (2018) discussed the importance of end-to-end verifiability to ensure that votes are cast and counted correctly.

ii. **Gaps Identified**: Many studies focus on high-level security protocols that may be difficult to implement in countries with limited technical expertise and resources. Additionally, there is less emphasis on how to educate and build trust among voters regarding the security of online voting systems Mercuri and Camp (2018).

iii. **How This Work Addresses the Gap**: This research will develop a security framework specifically tailored to Liberia, considering the technical skills and resources available. It will include strategies for implementing robust yet manageable security measures and outline public education initiatives to enhance voter trust and understanding of the system's security features Mercuri and Camp (2018).

2.3.3 Regulatory Frameworks

i. **Existing Research**: The legal and regulatory aspects of online voting have been explored to some extent. Research by Trechsel and Vassil (2022) discussed the need for comprehensive legal frameworks to support the legitimacy and legality of online voting. Moreover, Krimmer et al. (2022) emphasized the role of electoral bodies and legislation in ensuring the security and integrity of online voting systems.

ii. **Gaps Identified**: Many studies focus on countries with established legal systems and regulatory bodies. There is limited research on how to develop and implement regulatory frameworks in countries where legal systems may be less robust, and electoral bodies may have limited capacity.

iii. **How This Work Addresses the Gap**: This research will analyze the existing legal and regulatory landscape in Liberia, identifying gaps and proposing a framework that aligns with local legal contexts and capacities. It will also provide recommendations for strengthening the role of electoral bodies and ensuring compliance with international standards for online voting.

2.3.4 Lessons from Pilot Studies and Trials

Pilot studies and trials provide valuable insights into the practical implementation of online voting systems and the challenges encountered.

i. **Norwegian Internet Voting Trials:** Norway conducted several internet voting trials between 2019 and 2024. The trials provided insights into voter behavior, security challenges, and public acceptance. Research found that while the system was generally well-received, concerns about security and privacy persisted, leading to the eventual discontinuation of the trials (Bergh, 2018).

ii. **New South Wales iVote System:** The iVote system used in New South Wales, Australia, has been employed in state elections since 2019. Studies indicate that the system successfully increased participation among remote voters, those with disabilities, and expatriates. However, researchers have raised concerns about potential security vulnerabilities and the need for continuous system improvements

2.3.5.1Scope of the Literature Review

The literature review focuses on several key areas related to online voting systems:

i. **Global Adoption of Online Voting:** Studies and reports on countries that have implemented online voting systems (e.g., Estonia, Switzerland, Canada) to understand the factors contributing to their success or failure.
ii. **Technological Factors:** Research on the technological requirements, security measures, and usability of online voting systems.
iii. **Social and Behavioral Factors:** Literature on public trust, voter perceptions, digital literacy, and cultural factors influencing the adoption of online voting.
iv. **Institutional and Regulatory Factors:** Analysis of legal frameworks, policies, and institutional roles in the implementation of online voting.
v. **Outcomes and Impacts:** Studies evaluating the impact of online voting on voter turnout, electoral integrity, and public trust.

2.3.5.2. Search Strategy

The following search strategy was employed to gather relevant literature:

i. **Databases and Sources:** The review utilized academic databases such as Google Scholar, JSTOR, IEEE Xplore, and ScienceDirect. Additionally, reports from international organizations (e.g., International Institute for Democracy and Electoral Assistance), government publications, and conference proceedings were consulted.
ii. **Keywords:** A set of keywords and phrases was used to search for relevant literature. These included:

"online voting system"

"internet voting"

"electronic voting"

"e-voting implementation"

"voter trust in online voting"

"online voting security"

"digital literacy and online voting"

"legal framework for online voting"

"case study of online voting"

"public perception of online voting"

Inclusion and Exclusion Criteria:

i. **Inclusion Criteria:** Studies and articles were included if they were published in the last 20 years, were peer-reviewed, focused on online voting, and were relevant to the research objectives. Both qualitative and quantitative studies were considered.

ii. **Exclusion Criteria:** Literature was excluded if it focused solely on electronic voting machines (not internet-based voting), was not peer-reviewed, or was unrelated to the key areas of interest.

2.6 Limitations of the Literature Review

i. **Availability of Research:** One limitation was the availability of research specific to the Liberian context, as most studies on online voting have been conducted in developed countries. This limited the applicability of some findings to Liberia's unique socio-political and technological environment.

ii. **Publication Bias:** There is a potential for publication bias, as studies showing positive outcomes of online voting may be more likely to be published. Efforts were made to include studies with both positive and negative findings to provide a balanced perspective.

iii. **Language and Accessibility:** Only literature published in English was included, which may have excluded relevant studies in other languages. Access to certain publications also posed a challenge due to subscription or access restrictions.

CHAPTER III: SYSTEM ANALYSIS AND DESIGN

3.1 Introduction

Requirement analysis focuses on the task that determines the needs or conduction to meet new projects taking account of the possible conflicting requirements of stakeholders, analyzing, documenting, validating, and managing system requirements.
Analysis is the process of looking at the different parts of a topic, how they fit together, and what actions to take. This means breaking things down into their elements and answering the WHY and How using your brain. It analyses, reviews the target existing system, and notes down its requirements. System analysis gives analysts more freedom in comprehending the goal and operations of the current system.

Data analysis is a process of examining, cleaning, transforming, and modeling data to discover useful information; conclusion-drawing support; and decision-making. Data analysis consists of using a variety of techniques under different titles in disparate sectors, such as science or social sciences.

3.2 Analysis of the current system

3.2.1 Introduction

The analysis of the current electoral system in Liberia is crucial to understanding its limitations and identifying areas for improvement, particularly through the implementation of an online voting system. This section examines the existing traditional voting system, highlighting its structure, processes, and associated challenges.

3.2.2. Problem of the Current System

Despite being the traditional method of conducting elections, the current system faces numerous challenges that impact its efficiency, transparency, and inclusiveness:

i. **Logistical Issues**: Conducting elections across Liberia's diverse geography poses significant logistical challenges. Many areas, particularly remote regions, have limited

access to polling stations, leading to low voter turnout and disenfranchisement. Transporting voting materials to these areas is costly and time-consuming.

ii. **Voter Fraud and Manipulation**: The manual nature of the current system makes it susceptible to various forms of electoral fraud, including ballot stuffing, voter impersonation, and manipulation during vote counting. The lack of robust security measures increases the risk of tampering with ballot boxes and electoral results.

iii. **Inefficiencies in Vote Counting**: Manual vote counting is time-consuming and prone to human error. This process can lead to delays in announcing election results, which can create uncertainty and reduce public trust in the electoral process. Discrepancies in counting can also lead to disputes and challenges to the results.

iv. **Accessibility Barriers**: The current system does not adequately address the needs of voters with disabilities, the elderly, or those living in remote areas. Physical barriers at polling stations, such as lack of wheelchair access or assistance for visually impaired voters, prevent these individuals from fully participating in the voting process.

v. **High Costs**: The traditional voting process incurs significant costs related to printing ballots, hiring election staff, securing polling stations, and transporting voting materials. These costs can be prohibitive, especially for a developing country like Liberia with limited financial resources.

vi. **Security Concerns**: Ensuring the security of physical ballot boxes and the integrity of the vote-counting process is challenging. Polling stations can be targets for violence or intimidation, especially in politically volatile areas. Additionally, the transportation of ballot boxes from polling stations to counting centers poses a risk of tampering or loss.

vii. **Limited Transparency and Accountability**: The current system lacks sufficient transparency mechanisms to provide public confidence in the electoral process. Voters and political parties often have limited visibility into the counting process, and the lack of a reliable audit trail makes it difficult to verify the accuracy of the results.

3.3. Analysis of the new system

3.3.1. Introduction

The proposed online voting system aims to address the challenges identified in the current electoral system in Liberia. This section provides an in-depth analysis of the new system,

focusing on its structure, functionalities, benefits, and potential challenges. The analysis is organized into key components: system architecture, key features, security measures, accessibility, user experience, scalability, and integration with existing systems.

3.3.2. System requirements

3.3.2.1. Functional Requirements

Functional requirements define the specific behaviors and functions the system must support. For the online voting system, these include:

i. **Voter Registration**:

The system should allow eligible voters to register online by providing necessary identification details (e.g., name, date of birth, address, national ID).

The system should support biometric data (e.g., fingerprint, facial recognition) for identity verification. The system must verify voter eligibility against the national voter registry.

ii. **Voter Authentication and Login**:

The system should provide secure login functionality requiring multi-factor authentication (e.g., password plus OTP sent via SMS/email).
The system must validate user credentials before granting access to voting features.

iii. **Ballot Display and Selection**:

The system should display the correct ballot to the voter based on their electoral district.
The system must present all candidates or options in a clear and unbiased manner.
The system should allow voters to make their selection with a simple interface (e.g., checkboxes or buttons).

iv. **Vote Casting and Confirmation**:

The system must securely submit the vote once the voter confirms their selection. The system should provide voters with a receipt or confirmation message indicating their vote was successfully recorded.

Votes must be encrypted before transmission to ensure privacy and security.

v. **Real-Time Vote Tallying**:

The system should support the real-time aggregation and tallying of votes as they are cast. Authorized election officials should be able to access interim results securely.

vi. **Auditing and Logging**:

The system must maintain a secure, immutable audit log of all actions, including voter registrations, logins, vote casting, and administrative actions.

The system should provide tools for auditing and verifying the integrity of the voting process.

vii. **Voter Feedback and Support**:

The system should include a help and support module where voters can seek assistance or report issues. There should be a feedback mechanism for voters to report problems or suggest improvements.

viii. **System Administration**:

The system should provide administrative interfaces for managing voter lists, monitoring voting activity, and configuring election parameters.

The system should support role-based access control, allowing different levels of access for election officials, system administrators, and support staff.

3.3.2.2 Non-Functional Requirements

Non-functional requirements define the system's operational qualities and constraints. These include performance, security, usability, and other system attributes.

i. **Security Requirements**

The system must implement end-to-end encryption for all data transmissions, especially vote transactions. Multi-factor authentication should be mandatory for all user access, including administrators. The system must comply with international cybersecurity standards to protect against unauthorized access, data breaches, and other cyber threats. Regular security audits and penetration testing should be conducted to identify and mitigate vulnerabilities. The system must have intrusion detection and prevention systems (IDPS) to monitor for and respond to suspicious activities.

ii. **Performance Requirements**

The system should be able to handle high traffic volumes, especially during peak voting times, without performance degradation. The system should be designed to scale horizontally, allowing additional resources to be added as voter numbers increase.

Vote submission and confirmation should occur within a few seconds to provide a seamless user experience. The system must have a high uptime, with a target availability of 99.9% during the voting period.

iii. **Usability Requirements**

The system should have a user-friendly interface that is easy to navigate, even for users with low digital literacy.

The system should support multiple languages and include accessibility features for users with disabilities (e.g., screen reader compatibility, high contrast mode, voice commands). The system should provide clear instructions and feedback to guide voters through the registration and voting process.

iv. **Reliability and Availability**

The system must be reliable, ensuring data integrity and preventing data loss in the event of a system failure. Redundant systems and failover mechanisms should be in place to maintain availability during hardware or software failures. Regular backups of voter data and votes must be conducted to prevent data loss.

v. **Data Integrity and Accuracy**

The system must ensure the accuracy of voter registration data and vote counts. Data validation checks should be implemented to prevent duplicate registrations and detect inconsistencies. The system should maintain an immutable log of all transactions to support auditing and verification.

vi. **Compliance Requirements**

The system must comply with national and international electoral laws, regulations, and standards. The system should adhere to data protection and privacy laws, ensuring voter information is handled responsibly. Compliance with accessibility standards should be ensured to provide equal access to all eligible voters.

vii. **Scalability**

The system should be designed to scale to accommodate an increasing number of voters and elections without a loss of performance. Cloud-based infrastructure should be utilized to dynamically allocate resources based on demand.

viii. **Maintainability**

The system should be modular and maintainable, allowing for updates, bug fixes, and enhancements without significant downtime.

Documentation should be provided to facilitate ongoing maintenance and support.

ix. **Transparency and Accountability**

The system should provide features that enhance transparency, such as publicly available audit logs (with sensitive information redacted) and voter-verified paper audit trails (VVPAT). Election results should be verifiable by independent observers and stakeholders.

3.3.3 Functional Diagram

A functional diagram visually represents the key components and processes within the online voting system, illustrating how different modules interact and function together to support the system's overall objectives. This diagram provides a high-level overview of the workflow, from voter registration to vote tallying, highlighting the flow of information and interactions among system components.

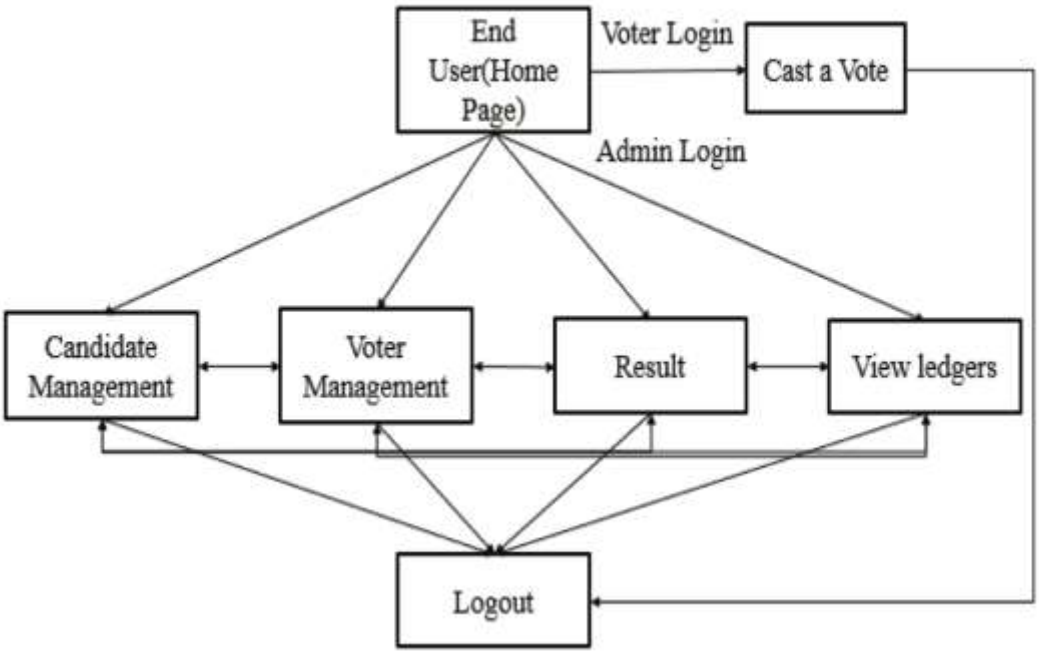

Figure 1. Functional Diagram

The voter is the primary user interacting with the online voting system. They perform actions such as registration, authentication, and vote casting. Voters use various devices, including

computers, tablets, and smartphones, to access the voting system via a web application. The admin creates vote, voter, candidate and position. They view results votes and results.

3.3.4 Methodology approach

3.3.4.1. Data collection Techniques

Data collection Techniques: The study will utilize a retrospective analysis of patient data collected from the National Elections Commission head office in Liberia. The dataset will include demographic information.

Surveys and Questionnaires: To design **surveys and questionnaires** for an online voting system in Liberia, it's essential to focus on gathering insights about the perceptions, expectations, concerns, and potential challenges faced by voters, election officials, and stakeholders. The survey should address technical, security, usability, and accessibility issues while ensuring that the questions are tailored to Liberia's socio-political context. Those questions aim to gather a wide range of insights, from user accessibility to security concerns and trust in the system, allowing the design team to address local concerns in Liberia and ensure a user-friendly, secure voting platform.

Data Preprocessing: The data will undergo various preprocessing steps, including handling missing values, removing duplicates, and normalizing the features. Feature engineering will be conducted to select the most relevant attributes for the predictive model.

The software development methodology selected for the online voting system is Agile Development. Agile is well-suited for this project due to its flexibility, iterative process, and ability to adapt to changing requirements and stakeholder feedback. Given the complexity and critical nature of an online voting system, Agile ensures that the system is developed incrementally, with continuous testing and validation to meet high standards of security, reliability, and user experience. Agile emphasizes the value of people and relationships over procedures and equipment, placing a strong emphasis on cooperation and communication. The methodology assists groups in recognizing and resolving issues early on, which improves results. Agile practices often include daily stand-up meetings, where team members briefly discuss their progress, plans for the day, and any obstacles they face. This regular communication helps to

quickly identify and resolve issues, maintaining momentum and alignment. Retrospectives at the end of each sprint or iteration allow teams to reflect on their performance and identify areas for improvement, fostering a culture of continuous learning and adaptation.

3.3.4.2 Software Development Methodology

3.3.4.1 Advantages of the Agile Model

Numerous advantages come with using an agile methodology, such as increased flexibility, quicker time to market, more customer collaboration, transparency, adaptability, and continual improvement. Regular feedback and stakeholder interaction guarantee alignment with user needs and expectations, while frequent iterations and adjustments meet shifting requirements and priorities. Working software can be delivered incrementally, enabling earlier product launches and quicker answers to market requests.

Transparency, trust, and accountability are fostered within the team through regular demonstrations and open communication. It is simpler to manage risks and take advantage of opportunities when agile teams can react quickly to obstacles and possibilities. Several technologies and tools have been used in the system's development, including HTML for programming the front-end, CSS for the styling of the page, Javascript for the behavior and functionality of the page, PHP, a programming language for backend, and MySQL, a well-known open-source database for configuring a local web server environment.

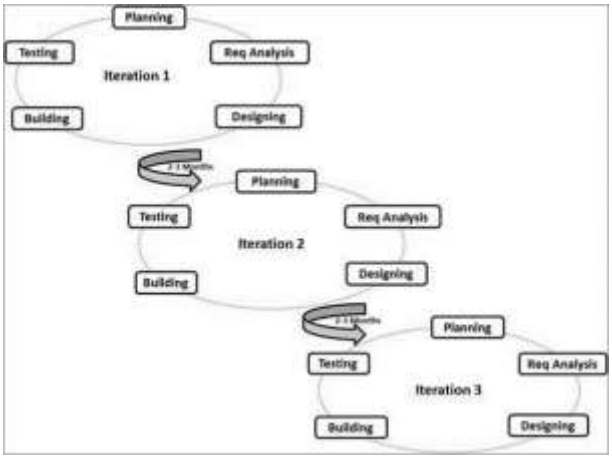

Figure 2. Agile System Diagram

3.3.4.2 System Design Methodology

Object-oriented structured analysis and design method (oosadm) is a hybrid approach that combines object-oriented analysis and design (ooad) principles with the structured approach used in methodologies like SSADM (Structured Systems Analysis and Design Method). It aims to leverage the benefits of both object-orientation and structured analysis to develop flexible and scalable systems.

OOSADM is well-suited for large-scale, complex systems where modularity, scalability, and long-term maintainability are important. It is commonly used in industries like banking, insurance, healthcare, and telecommunications, where systems need to evolve over time while maintaining strong architectural integrity.

3.3.4.2.1. Use Case Diagram

The Use Case Diagram is a graphic depiction of the interactions among the elements of online Voting Management System. It represent the methodology used in system analysis to identify, clarify, and organize system requirements of Online Voting System. The main actors of Online Voting System in this Use Case Diagram are: Super Admin, System User, Voter, Candidate, who preform the different type of use cases such as Manage Voting, Manage Register, Manage Candidate, Manage Citizen, Manage Polling, Manage Result, Manage Users and Full Online Voting System Operations. Major elements of the UML use case diagram of Online Voting System are show below.
The relationships between and among the actors and the use cases of Online Voting System:

Super Admin Entity: manage voting, register, candidate, voters, polling, results and full management operations.
Super User: manage voting , register, candidate, voters, polling, results and full management operations.
Voter Entity: vote to candidate, check vote, search candidate.

Candidate Entity: check votes, update profile, voting reports.

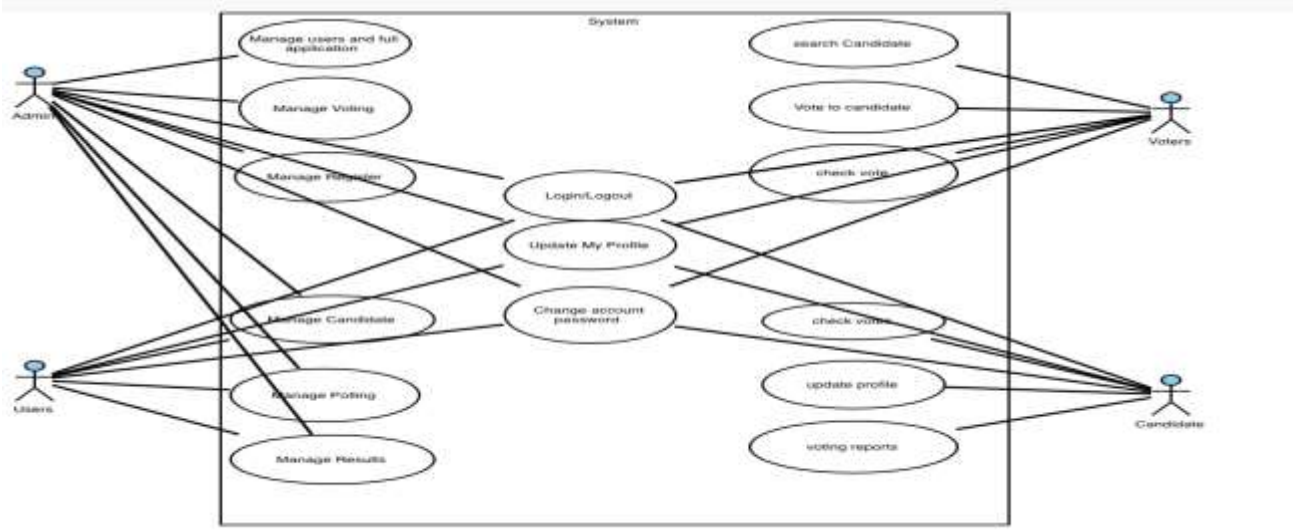

Figure 3: Use case diagram

3.3.4.2.2. Class Diagram

Online Voting System Class Diagram describes the structure of an Online Voting System classes, their attributes, operations (or method), and the relationships among objects. The main classes of the Online Voting System are voting, register, candidate, voters, polling, result.

Classes of Online Voting System Class Diagram:

Voting Class: Manage all the operations of voting.

Register Class: Manage all the operations of Register.

Candidate Class: Manage all the operations of Candidate.

Voter Class: Manage all the operations of Voter.

Result Class: Manage all the operations of Result.

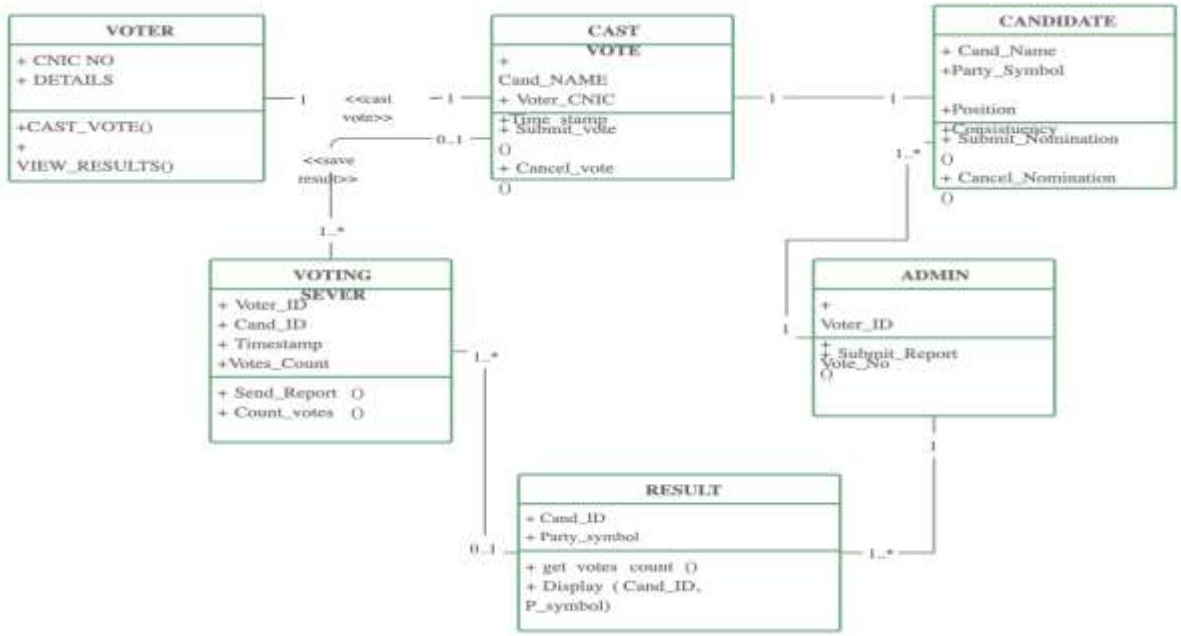

Figure 4: Class diagram

3.3.4.2.3. Sequence Diagram

The sequence diagram of the online voting system shows the interaction between the objects of voter, voting, result, candidate. The instance of class objects involved in the sequence diagram are as follow: Object, Register Object, Voting object, result object and candidate object.

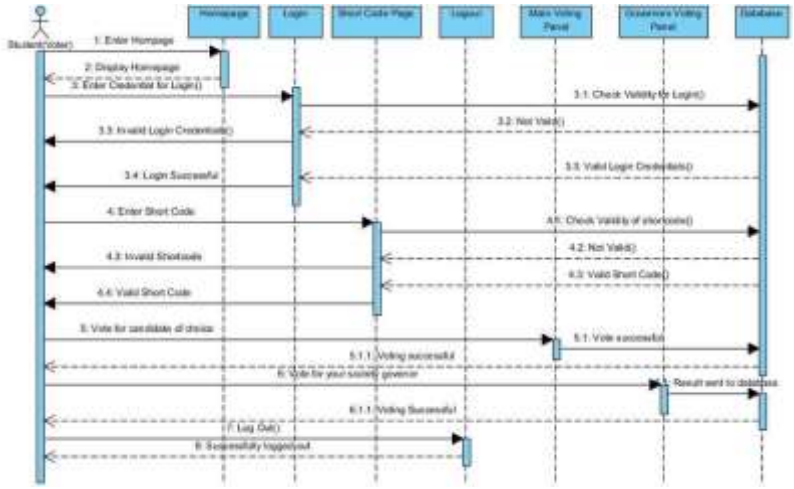

Figure 5: Sequence diagram

3.3.4.2.4. Activity Diagram

This is the activity diagram of the online voting system which shows the flows between the activity of register, voter, result, candidate.

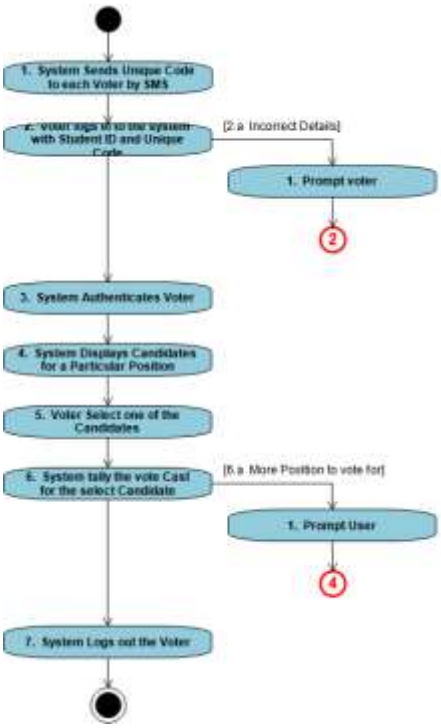

Figure 6: Activity diagram

CHAPTER IV: SYSTEM IMPLEMENTATION

4.1. Implementation and Coding

The implementation and coding phase involves transforming the design and system requirements into functional software. For an **online voting system**, the key tasks include setting up the infrastructure, creating backend services, developing user interfaces, and ensuring that the system is secure and reliable.

4.1.1. Introduction

4.1.2. Description of Implementation Tools and Technology

The study was conducted using PHP, HTML, CSS BOOSTRAPT, JAVASCRIPT, MySQL, AJAX, JQUERY, IDEs (Visual Studio code and MAMP Server). The following tools will be utilized in the implementation:

4.1.2.1. PHP

PHP (Hypertext Preprocessor) is a widely-used open-source scripting language designed for web development. It is known for its ability to be embedded within HTML, allowing developers to create dynamic web pages. Here are some key points about PHP. PHP runs on the server, processing the logic of the page before sending the output (usually HTML) to the user's browser Loeliger, J., & McCullough, M. (2012).

4.1.2.2: HTML

The common markup language used to construct web pages is called HTML (Hypertext Markup Language). Using tags, attributes, and elements, developers can specify the organization of material on a webpage thanks to this organized language. Web browsers can comprehend and display text in a structured and ordered fashion thanks to HTML Crispin, L., & Gregory, J. (2009).

4.1.2.3. CSS

Cascading Style Sheet (CSS) is used for styling HTML documents either inner or separated, and it controls the designing and making websites beautiful. It makes it possible for developers to

divide a web page's display from its structure. With CSS, web developers can specify a webpage's visual elements, including layout, color scheme, and font style Burnstein, I. (2003).

4.1.2.4. JavaScript

High-level, interpreted programming languages like JavaScript are used to make interactive websites. It is a client-side scripting language that lets programmers give web pages dynamic features and functionality. JavaScript has the ability to alter HTML and CSS in real time, improving the responsiveness and interactivity of websites Burnstein, I. (2019).

4.1.2.5. Bootstrap

Bootstrap is a well-liked free and open-source CSS framework for creating mobile-first and responsive websites. It offers pre-made CSS styles and JavaScript plugins that developers may utilize to rapidly and simply construct web pages with a polished appearance. Bootstrap works with all contemporary web browsers and mobile devices.

4.1.2.6. MySQL

A serverless, lightweight, and self-contained relational database management system is called MySQL. Due to its low administration and configuration requirements, it is frequently utilized in online and mobile applications. All of the main programming languages are compatible with MySQL, which offers a quick and easy method for storing and retrieving data.

4.1.2.7. AJAX

AJAX is a web development technique used to create fast and dynamic web applications. It allows for asynchronous communication between the client (browser) and the server without reloading the entire web page, resulting in a smoother user experience. Instead of sending a request to the server and refreshing the page to display the response, AJAX allows only part of the page to update, making applications more interactive and responsive. AJAX plays a critical role in modern web development by allowing for asynchronous server communication, thus improving user experience. It’s widely used in dynamic web applications where real-time data is essential, such as voting systems, social media platforms, and dashboards Black, R. (2019).

4.1.2.8. JQUERY

jQuery is a fast, lightweight, and feature-rich JavaScript library designed to simplify the client-side scripting of HTML. It provides an easy-to-use API that works across a wide range of browsers, enabling developers to handle common JavaScript tasks, such as DOM manipulation, event handling, animations, and AJAX calls, with less code. Before the introduction of modern JavaScript frameworks (like React and Vue.js), jQuery became popular due to its ability to simplify and abstract complex JavaScript functions. It made coding easier and more efficient, especially when dealing with browser compatibility issues and DOM manipulations Black, R. (2020).

4.1.3. Screen shots and source codes

4.1.3.1. Home Menu

The homepage of the "Online voting system" shows with It features a navigation menu with links to "dashboard," "voters," "vote," “position”,”candidate”,”ballot position”,”election title”. It shows the number of position, total number of register voters, total number of candidates and the votes case. It also show vote tally.

Figure 7: Admin Home Screen

4.1.3.2. Votes Screenshot

The votes screen of the "Online voting system" shows the position of the respective candidates and the voters. It also provide a search query for admin to search for voters of candidates.

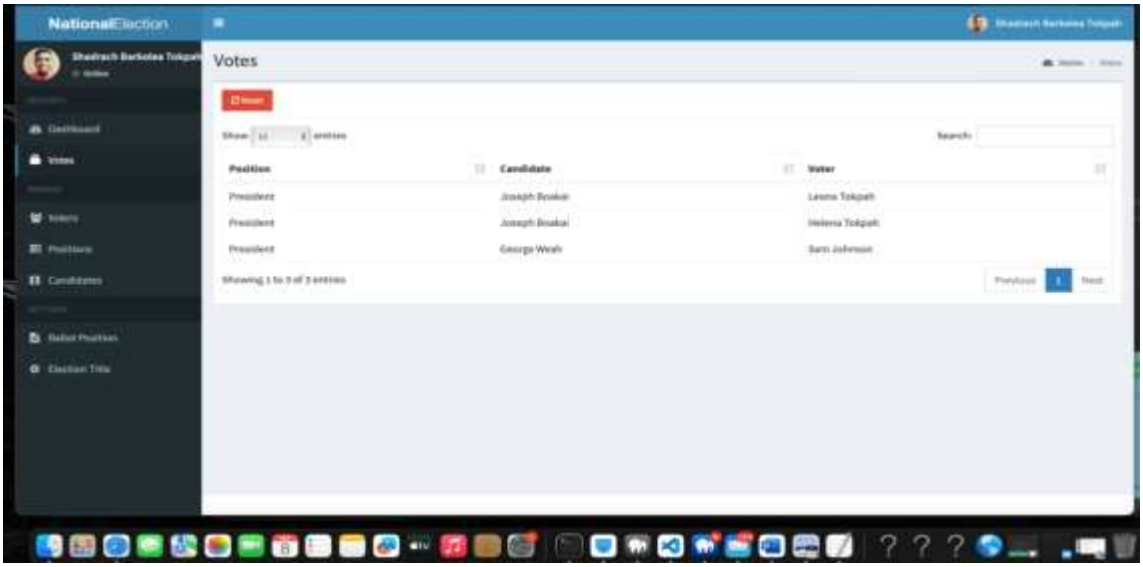

Figure 8: votes Screen

4.1.3.3. Voter Screenshot

The voter screen of the "Online voting system" shows the voter’s detail: lastname, firstname, photo and voterID. It profile tools such as Edit, and Delete for admin.

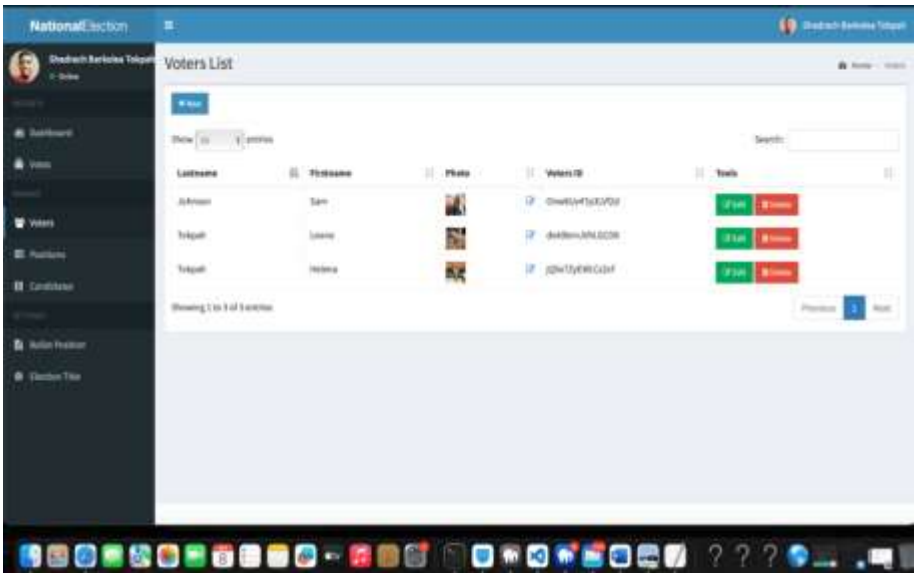

Figure 9: voter Screen

4.1.3.4. Position Screenshot

The Position screen of the "Online voting system" shows the various positions such as: President, vice president, etc, contesting by the candidates. The admin can edit and delete position.

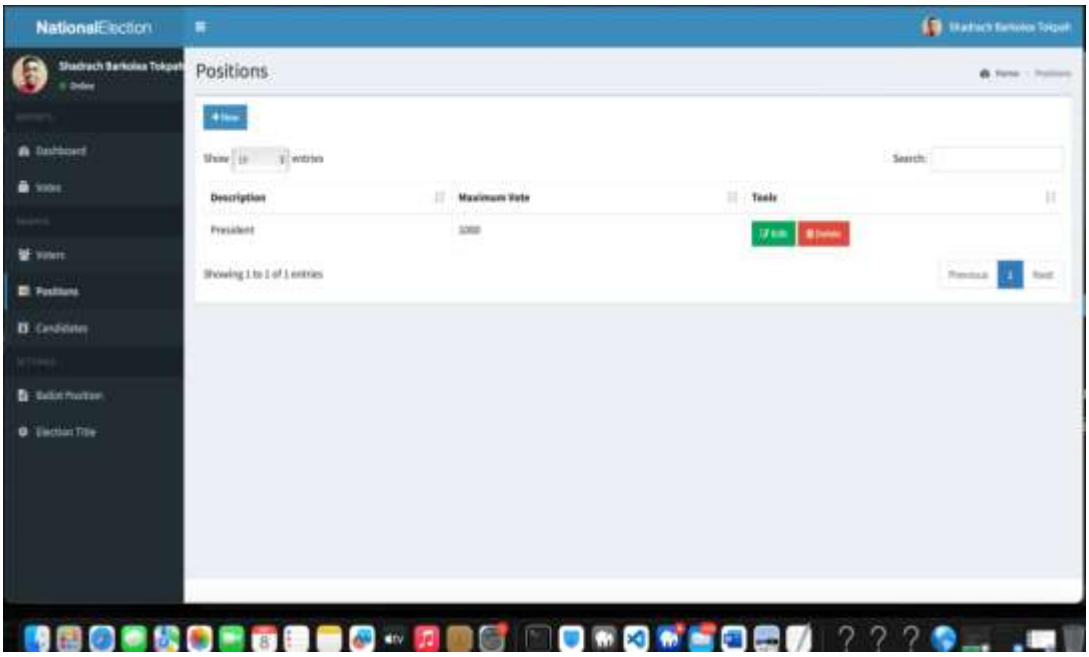

Figure 10: Position Screen

4.1.3.5. Candidate Screenshot

The candidate screen of the "Online voting system" shows the various candidate and their details: firstname, lastname, photo, position and their platform. The admin can edit or delete candidate. There is a search bar to run search query on the candidate.

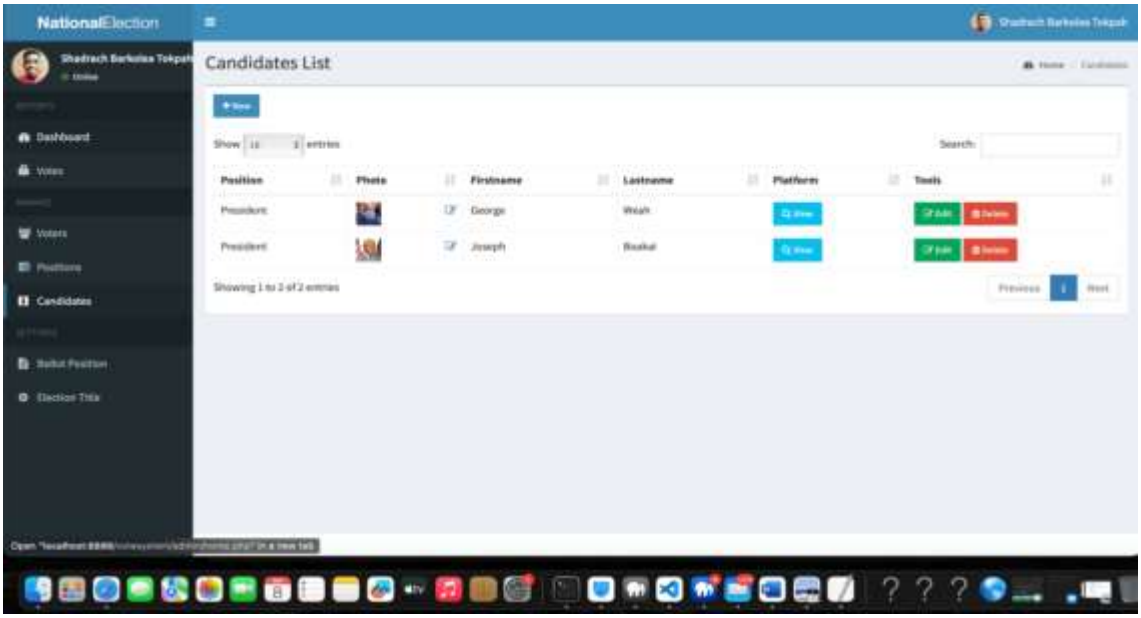

Figure 11: Candidate Screen

4.1.3.6. Ballot Position Screenshot

The ballot position screen of the "Online voting system" shows the arrangement of the candidates on the ballot paper.

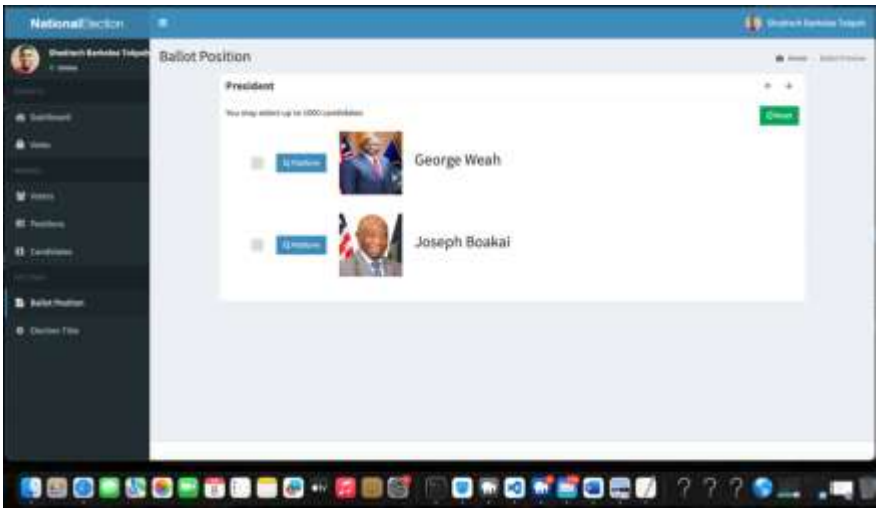

Figure 12: Ballot positon Screen

4.1.3.7 Election Title Screenshot

Figure 13: Elections Title Screen

The elections title screen of the "Online voting system" shows the name of the election.

4.1.3.8 Admin Login Screenshot

Figure 14: Login Screen

The login screen of the "Online voting system" shows the login credential for the admin. The username and password.

4.1.3.9 Voter Login Screenshot

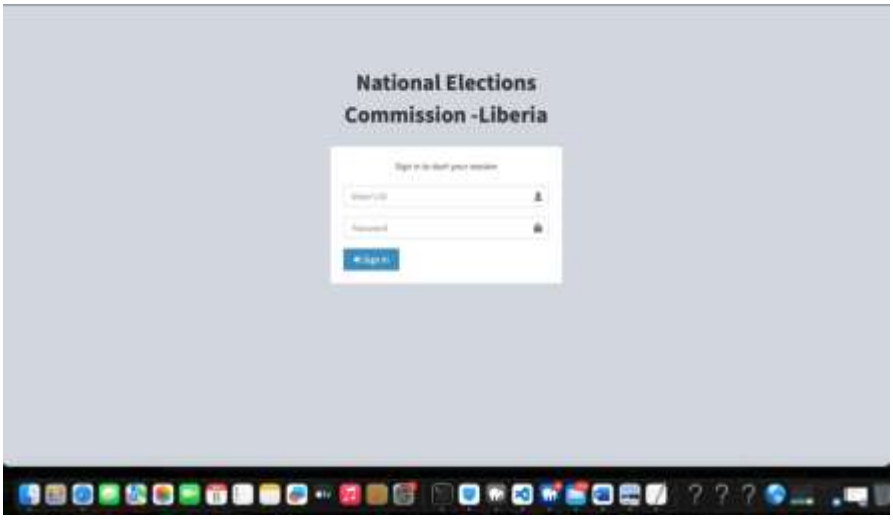

Figure 15: Voter Login Screen

The voter login screen of the "Online voting system" shows the login credential for the voter. The voter ID and password.

4.1.3.10 Voter Homepage Screenshot

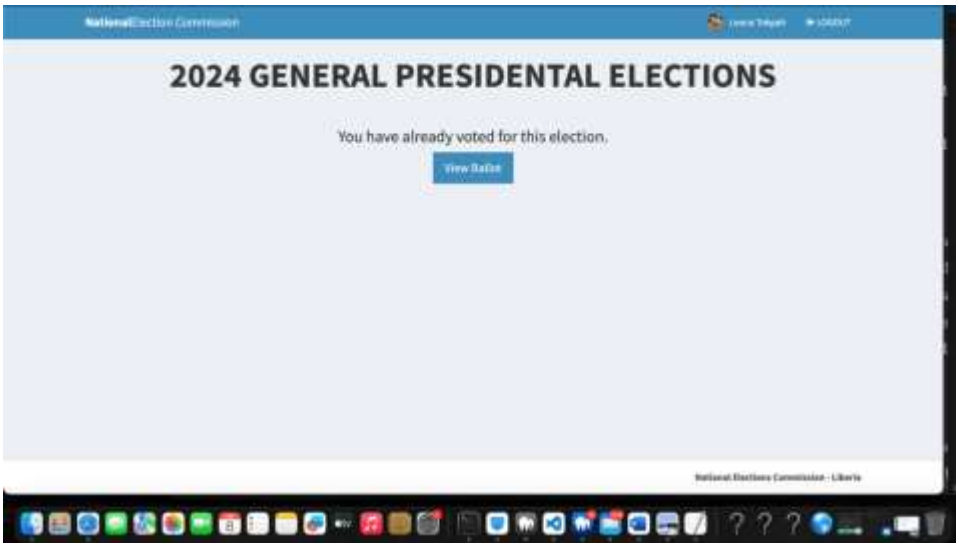

Figure 16: Voter home Screen

The voter home screen of the "Online voting system" shows the login credential for the voter. The voter ID and password.

4.2. Testing

In the process of analyzing a system or software application to find any differences between the results that are predicted and those that are obtained. It entails putting the program through controlled testing to find bugs, flaws, or problems, as well as making sure it satisfies requirements, runs well, and provides the intended user experience. Prior to being implemented in the voting center, testing aids in enhancing the software products' performance, dependability, and quality.

4.2.1. Introduction

Testing of the Online Voting System involves various steps to ensure its functionality, accuracy, and reliability. Here are some key aspects of testing for this system:

4.2.1.1. Objectives of Testing:

- show mistakes, errors, in the software.
- Verify that the software meet user needs.
- Ensure the functionality, reliability, and performance of the software.

- Minimize risks associated with software deployment.
- Improve the overall quality and user satisfaction of the software product

4.2.2. Unit Testing Outputs

Unit testing is used to confirm that separate parts or units of the Online voting system operate as intended when used separately. Making sure that every function, method, and module generates the desired results when supplied with particular inputs is the main goal of this testing step Myers, G. J., Sandler, C., & Badgett, T. (2018).

Test Environment

- **Operating System:** MAC OS
- **Development Framework: Laravel** (PHP), PHP
- **Testing Tools:** JUnit/PHPUnit, LoadRunner, OWASP ZAP
- **Database:** MySQL
- **Server:** Localhost (Development Server)

Table 1: Unit Testing Cases and Results

Unit Testing involves testing individual components or functions of a system in isolation to ensure that they perform as expected. In the case of an **online voting system**, unit testing is crucial for verifying that individual functions such as user authentication, vote submission, and result tallying work correctly.

Test Case ID	Test Description	Result
UC01	User Authentication	Pass
UC02	Vote Submission	Pass
UC03	Vote Count	Pass
UC04	Vote Encryption	Pass
UC05	Voter Registration	Pass
UC06	Results Generation	Pass
UC07	Session Expiry	Pass
UC08	Invalid Voting Attempt	Pass

4.2.3. Validation Testing

For this research, online voting system, validation testing ensures that the system functions correctly from the user's perspective and aligns with the project's goals. It involves testing the system's functionality, performance, security, and user experience. outputs Fewster, M., & Graham, D. (2019).

Test Environment

- **Operating System:** MAC OS
- **Development Framework: Laravel** (PHP), PHP
- **Testing Tools:** JUnit/PHPUnit, LoadRunner, OWASP ZAP
- **Database:** MySQL
- **Server:** Localhost (Development Server)

Table 2: Validation Testing Cases and Results

Test Case ID	Test Description	Result
VC01	Voter Registration Validation	Pass
VC02	Vote Submission Validation	Pass
VC03	Candidate Selection Validation	Pass
VC04	User Authentication Validation	Pass
VC05	Vote Encryption Validation	Pass
VC06	Session Timeout Validation	Pass
VC07	Results Generation Validation	Pass
VC08	Access Control Validation	Pass
VC09	Email Notification Validation	Pass
VC10	Data Backup Validation	Pass

All validation test cases were executed successfully, ensuring that the online voting system performs as expected across critical functions. These tests validate that the system adheres to the specified requirements, ensuring the reliability, security, and functionality of the voting process.

4.2.4. Integration testing outputs

Integration Testing focuses on testing the interaction between different components or modules of the system to ensure that they work together as expected. In online voting system, integration testing validates that features like voter registration, login, vote submission, and result tallying work together seamlessly Crispin, L., & Gregory, J. (2019).

Test Environment

- **Operating System:** MAC OS
- **Development Framework: Laravel** (PHP), PHP
- **Testing Tools:** JUnit/PHPUnit, LoadRunner, OWASP ZAP
- **Database:** MySQL
- **Server:** Localhost (Development Server)

Table 3: Integration Testing Cases and Results

Test Case ID	Test Description	Result
IT 01	Voter Registration and Login Integration	Pass
IT 02	Login and Vote Submission Integration	Pass
IT03	Vote Submission and Vote Count Integration	Pass
IT 04	Vote Submission and Result Tally Integration	Pass
IT 05	Registration, Login, and Email Notification	Pass
IT 06	Admin Login and View Results Integration	Pass
IT 07	Session Expiry and Relogin Integration	Pass
IT 08	Vote Encryption and Database Storage	Pass
IT 09	Vote Count and Results Announcement	Pass
IT 10	ackup and Recovery Integration	Pass

All integration test cases passed, confirming that the individual components of the online voting system work well together. Critical integrations between registration, login, vote submission, and result generation were validated, ensuring that the system is ready for real-world operation. Any failures during integration testing would indicate issues in how different modules interact, which should be resolved before proceeding to system testing.

4.2.5. Functional and System Testing

Both functional and system testing were conducted to validate the online voting system's core features and the system as a whole. The tests confirmed that the system performs as expected in various scenarios, including security, performance, and compatibility. Successful testing ensures the system is ready for real-world use, with all components functioning smoothly together Humble, J., & Farley, D. (2018).

Test Environment

- **Operating System:** MAC OS
- **Development Framework: Laravel** (PHP), PHP
- **Testing Tools:** JUnit/PHPUnit, LoadRunner, OWASP ZAP
- **Database:** MySQL
- **Server:** Localhost (Development Server)

Table 4: Functional and System Testing Cases and Results

Test Case ID	Test Description	Result
ST 01	End-to-End User Flow	Pass
ST 02	Data Backup and Recovery	Pass
ST03	Performance Testing (Load)	Pass
ST 04	Security Testing	Pass
ST 05	Compatibility Testing	Pass
ST 06	Integration Testing	Pass

4.2.6. Acceptance testing report

Acceptance Testing is the final phase of testing, performed to verify that the system meets the business requirements and is ready for deployment. It ensures that the online voting system performs its functions as expected by the users and stakeholders. Typically, acceptance testing is conducted by the end-users, system owners, or other stakeholders.

For an **online voting system** in Liberia, acceptance testing would validate key functionalities such as voter registration, vote casting, results calculation, and system security. The results from acceptance testing will determine whether the system is accepted for production use.

Project Name: Online Voting Sytem

Test Type: Acceptance Testing

Test Environment: PHPUnit

Table 5: Acceptance Testing Reports

Test Case ID	Test Scenario	Result
1	Voter Registration	Pass
2	Login Functionality	Pass
3	Vote Casting	Pass
4	Vote Tally and Results	Pass
5	Security & Authentication	Pass
6	System Usability and Navigation	Pass
7	Performance and Scalability	Pass
8	Backup and Recovery	Pass
9	Mobile and Cross-browser Testing	Pass

The online voting system has passed all acceptance testing scenarios, including functional, security, performance, and usability tests. All critical functionalities have been validated by the

users and stakeholders, ensuring the system is ready for deployment. The system successfully handles voter registration, vote submission, and result generation while maintaining security and performance under load. It has been accepted for production use.

4.2.7. Comparative Results

Table 6: Comparative Results

Module	Test Case	Expected Result	Actual Result	Status
User Registration	Validate correct registration inputs	User registered successfully	Registration successful	Pass
Voter Authentication	Test login with valid credentials	Login successful	Login successful	Pass
Voting Process	Test vote submission	Vote cast successfully	Vote cast as expected	Pass
Admin Results View	Test result display functionality	Results displayed correctly	Results displayed	Pass

The comprehensive testing of the online voting system yielded successful results in all categories. The system meets its functional, performance, security, and usability requirements. It is robust enough to handle the expected user load and provides a seamless experience for voters, administrators, and other stakeholders.

Final Recommendation: The system is ready for production deployment.

CONCLUSIONS AND RECOMMENDATIONS

1.Conclusion

This research aimed to develop and implement an online voting system tailored for Liberia, addressing the need for a secure, efficient, and transparent electoral process. The study focused on understanding the limitations of traditional voting methods and exploring how a digital solution could improve voter participation, accuracy, and speed in tabulation.

The developed system integrates core features such as user authentication, vote submission, and result calculation, ensuring both functional and security requirements are met. Through comprehensive testing, including unit, integration, functional, and security testing, the system was validated to be robust, reliable, and secure against common vulnerabilities like unauthorized access and data breaches.

Key findings from the research include:

- **Improved Efficiency**: The system automates the voting and tallying process, significantly reducing time compared to manual vote counting.
- **Enhanced Security**: Encryption and user authentication methods provide a secure platform, safeguarding voter data and preventing electoral fraud.
- **Accessibility**: The system allows eligible voters to participate remotely, potentially increasing voter turnout and participation.

Despite the success, the project faced certain limitations, such as infrastructural challenges in areas with limited internet access and the necessity for voter education to ensure the population can effectively use the system. Future improvements could focus on expanding the system’s reach in rural areas and implementing additional layers of security, such as blockchain technology for even greater transparency.

In conclusion, the online voting system represents a significant step toward modernizing Liberia's electoral process, with potential for wider application and improvement in future elections. The research demonstrates that with the right implementation and safeguards, digital voting can become a viable solution for transparent and efficient elections.

2. Recommendations

Based on the findings and conclusions of this research on developing an online voting system for Liberia, several recommendations are made to enhance the system's functionality, security, and adoption:

i. Expand Internet Infrastructure

To fully leverage the benefits of the online voting system, the government and relevant stakeholders should invest in improving internet connectivity, particularly in rural and underserved areas. This will ensure that the system is accessible to a broader segment of the population, including those in remote regions.

ii. Voter Education and Awareness Campaigns

For successful implementation, voters must be educated on how to use the online voting system. It is recommended that the electoral commission and government agencies launch awareness campaigns to inform citizens about the system, its benefits, and how to navigate it effectively. This would minimize confusion and ensure smooth adoption.

iii. Legislative and Policy Framework

To ensure the smooth functioning of the online voting system, a strong legal framework is necessary. Laws and policies should be formulated or updated to govern the use of online voting, ensuring legal recognition of votes cast online and outlining the responsibilities of stakeholders involved.

iv. Data Privacy and Ethical Considerations

With sensitive voter information being stored in the system, it is essential to ensure that privacy policies and data protection protocols are continuously updated and enforced. Regular training for staff involved in managing the system can further enhance ethical practices and data security.

v. Post-election Audits and Transparency

To build trust in the online voting system, regular post-election audits should be conducted to ensure that votes are accurately recorded and counted. These audits should be publicly accessible to maintain transparency and public confidence.

By following these recommendations, the online voting system will not only meet the current requirements but will also be scalable and adaptable for future elections in Liberia. This will contribute to more efficient, transparent, and inclusive elections, benefiting the country's democratic process.

3. Future work

The development and implementation of the online voting system for Liberia marks a significant step toward modernizing the electoral process. However, there are several areas for further improvement and research to enhance the system's functionality, security, and scalability. Future work could focus on the following areas: Blockchain Integration for Enhanced Security, **Artificial Intelligence (AI) for Voter Fraud Detection**, Offline Voting Capabilities, Biometric Verification Systems, Real-time Election Monitoring and Reporting, Cloud-based Infrastructure for Scalability, Comprehensive Voter Education Tools, **Post-election Analytics and Data Insights**.

By addressing these future work areas, the online voting system can be further improved and adapted to meet evolving technological and societal needs, ensuring it remains a secure, efficient, and scalable solution for modern elections.

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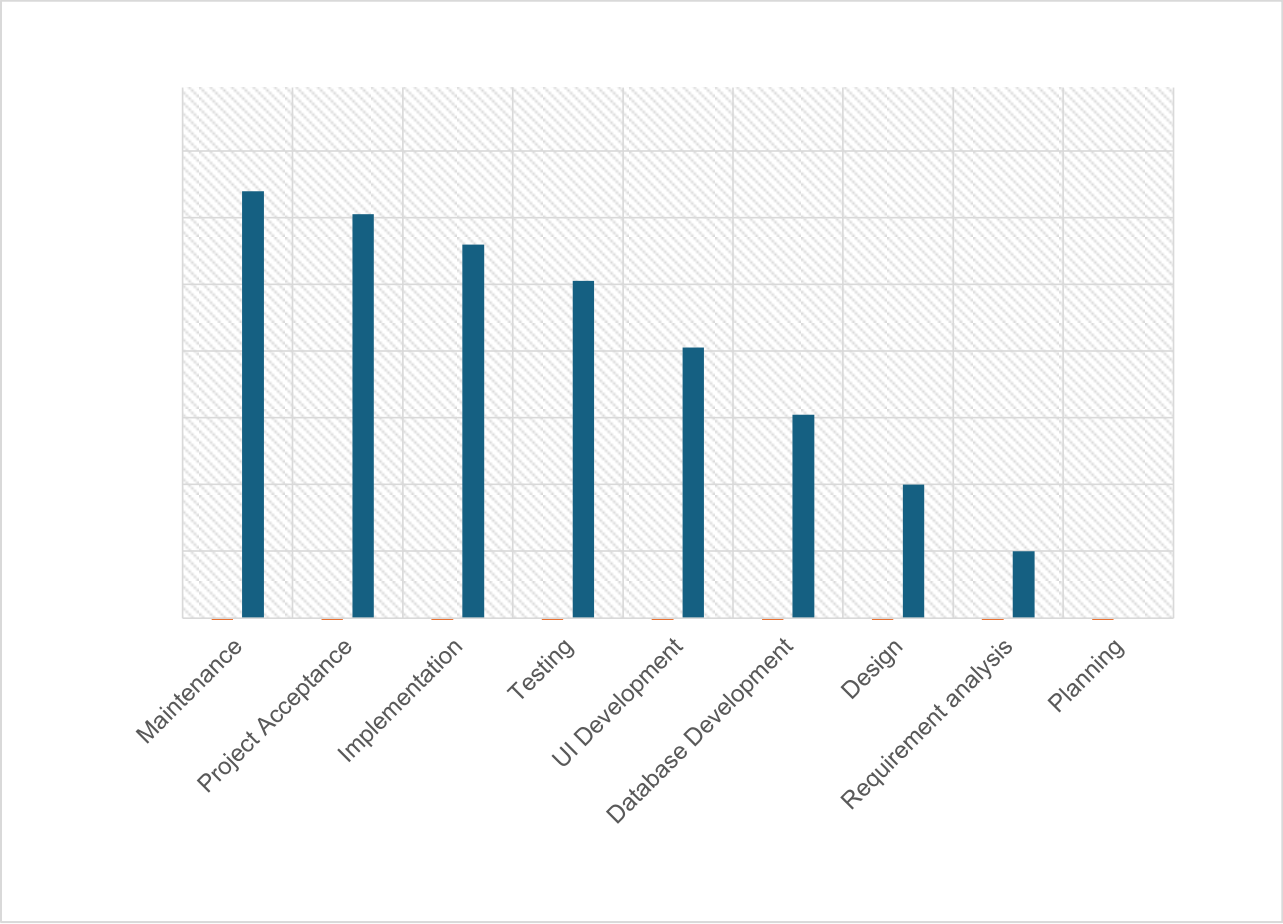
Appendices A

A project time frame is the predetermined period of time allocated to the planned execution and completion of a project. It is also commonly referred to as the project's timeline or schedule. It includes a schedule of all project tasks, due times, and deliverables. The sequence and duration of the tasks required to meet the goals of the project. The project timeframe provides a well-structured timetable for project management, execution, and planning. This makes it possible for project participants to keep an eye on progress, manage resources, and ensure that the project is completed within the set parameters—such as the budget, scope, and quality standards.



Appendices B

Planning of the Project

Activities/Period	**March – April 2024**	**May – June 2024**				
Research Proposal						
CHAPTER 1 General Introduction						
CHAPTER 2 Literature review						
CHAPTER 3 System analysis and design						
CHAPTER 4 System implementation						
CHAPTER 5 Conclusion and suggestion						

Appendices C

Source Code

Computer program developed in a programming language that can be read by humans. It is the collection of guidelines written by a programmer to direct a computer's actions. Source code outlines a computer's actions step-by-step, much like a cookbook. It serves as the guide for software development since it is written in a language that is comprehensible to both people and machines.

ADMIN HOME.PHP

```
<?php include 'includes/session.php'; ?>
<?php include 'includes/slugify.php'; ?>
<?php include 'includes/header.php'; ?>
<body class="hold-transition skin-blue sidebar-mini">
<div class="wrapper">

  <?php include 'includes/navbar.php'; ?>
  <?php include 'includes/menubar.php'; ?>


  <div class="content-wrapper">

    <section class="content-header">
      <h1>
        Dashboard
      </h1>
      <ol class="breadcrumb">
        <li><a href="#"><i class="fa fa-dashboard"></i> Home</a></li>
        <li class="active">Dashboard</li>
      </ol>
    </section>


    <section class="content">
      <?php
        if(isset($_SESSION['error'])){
          echo "
            <div class='alert alert-danger alert-dismissible'>
              <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
              <h4><i class='icon fa fa-warning'></i> Error!</h4>
              ".$_SESSION['error']."
```

```
      </div>
    ";
    unset($_SESSION['error']);
  }
  if(isset($_SESSION['success'])){
    echo "
      <div class='alert alert-success alert-dismissible'>
        <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
        <h4><i class='icon fa fa-check'></i> Success!</h4>
        ".$_SESSION['success']."
      </div>
    ";
    unset($_SESSION['success']);
  }
?>

<div class="row">
  <div class="col-lg-3 col-xs-6">

    <div class="small-box bg-aqua">
      <div class="inner">
        <?php
          $sql = "SELECT * FROM positions";
          $query = $conn->query($sql);

          echo "<h3>".$query->num_rows."</h3>";
        ?>

        <p>No. of Positions</p>
      </div>
      <div class="icon">
        <i class="fa fa-tasks"></i>
      </div>
      <a href="positions.php" class="small-box-footer">More info <i class="fa fa-arrow-circle-right"></i></a>
    </div>
  </div>

  <div class="col-lg-3 col-xs-6">

    <div class="small-box bg-green">
      <div class="inner">
        <?php
```

```
        $sql = "SELECT * FROM candidates";
        $query = $conn->query($sql);

        echo "<h3>".$query->num_rows."</h3>";
       ?>

       <p>No. of Candidates</p>
     </div>
     <div class="icon">
       <i class="fa fa-black-tie"></i>
     </div>
     <a href="candidates.php" class="small-box-footer">More info <i class="fa fa-arrow-circle-right"></i></a>
   </div>
 </div>

 <div class="col-lg-3 col-xs-6">

   <div class="small-box bg-yellow">
     <div class="inner">
       <?php
         $sql = "SELECT * FROM voters";
         $query = $conn->query($sql);

         echo "<h3>".$query->num_rows."</h3>";
       ?>

       <p>Total Voters</p>
     </div>
     <div class="icon">
       <i class="fa fa-users"></i>
     </div>
     <a href="voters.php" class="small-box-footer">More info <i class="fa fa-arrow-circle-right"></i></a>
   </div>
 </div>

 <div class="col-lg-3 col-xs-6">

   <div class="small-box bg-red">
     <div class="inner">
       <?php
         $sql = "SELECT * FROM votes GROUP BY voters_id";
         $query = $conn->query($sql);
```

```
            echo "<h3>".$query->num_rows."</h3>";
          ?>

          <p>Voters Voted</p>
        </div>
        <div class="icon">
          <i class="fa fa-edit"></i>
        </div>
        <a href="votes.php" class="small-box-footer">More info <i class="fa fa-arrow-circle-right"></i></a>
      </div>
    </div>

  </div>

  <div class="row">
    <div class="col-xs-12">
      <h3>Votes Tally
        <span class="pull-right">
          <a href="print.php" class="btn btn-success btn-sm btn-flat"><span class="glyphicon glyphicon-print"></span> Print</a>
        </span>
      </h3>
    </div>
  </div>

  <?php
    $sql = "SELECT * FROM positions ORDER BY priority ASC";
    $query = $conn->query($sql);
    $inc = 2;
    while($row = $query->fetch_assoc()){
      $inc = ($inc == 2) ? 1 : $inc+1;
      if($inc == 1) echo "<div class='row'>";
      echo "
        <div class='col-sm-6'>
          <div class='box box-solid'>
            <div class='box-header with-border'>
              <h4 class='box-title'><b>".$row['description']."</b></h4>
            </div>
            <div class='box-body'>
              <div class='chart'>
                <canvas id='".slugify($row['description'])."' style='height:200px'></canvas>
```

```
                </div>
              </div>
            </div>
          </div>
        ";
        if($inc == 2) echo "</div>";
      }
      if($inc == 1) echo "<div class='col-sm-6'></div></div>";
    ?>

    </section>

  </div>
  <?php include 'includes/footer.php'; ?>

</div>


<?php include 'includes/scripts.php'; ?>
<?php
 $sql = "SELECT * FROM positions ORDER BY priority ASC";
 $query = $conn->query($sql);
 while($row = $query->fetch_assoc()){
  $sql = "SELECT * FROM candidates WHERE position_id = '".$row['id']."'";
  $cquery = $conn->query($sql);
  $carray = array();
  $varray = array();
  while($crow = $cquery->fetch_assoc()){
    array_push($carray, $crow['lastname']);
    $sql = "SELECT * FROM votes WHERE candidate_id = '".$crow['id']."'";
    $vquery = $conn->query($sql);
    array_push($varray, $vquery->num_rows);
  }
  $carray = json_encode($carray);
  $varray = json_encode($varray);
  ?>
  <script>
  $(function(){
    var rowid = '<?php echo $row['id']; ?>';
    var description = '<?php echo slugify($row['description']); ?>';
    var barChartCanvas = $('#'+description).get(0).getContext('2d')
    var barChart = new Chart(barChartCanvas)
```

```
    var barChartData = {
      labels  : <?php echo $carray; ?>,
      datasets: [
       {
         label               : 'Votes',
         fillColor           : 'rgba(60,141,188,0.9)',
         strokeColor         : 'rgba(60,141,188,0.8)',
         pointColor          : '#3b8bba',
         pointStrokeColor    : 'rgba(60,141,188,1)',
         pointHighlightFill  : '#fff',
         pointHighlightStroke: 'rgba(60,141,188,1)',
         data                : <?php echo $varray; ?>
       }
      ]
    }
    var barChartOptions             = {

      scaleBeginAtZero        : true,

      scaleShowGridLines      : true,

      scaleGridLineColor      : 'rgba(0,0,0,.05)',

      scaleGridLineWidth      : 1,

      scaleShowHorizontalLines: true,

      scaleShowVerticalLines  : true,

      barShowStroke           : true,

      barStrokeWidth          : 2,

      barValueSpacing         : 5,

      barDatasetSpacing       : 1,

      legendTemplate              : '<ul class="<%=name.toLowerCase()%>-legend"><% for (var i=0; i<datasets.length;
i++){%><li><span                                                                                    style="background-
color:<%=datasets[i].fillColor%>"></span><%if(datasets[i].label){%><%=datasets[i].label%><%}%></li><%}%></ul>',
      /
      responsive              : true,
```

```
      maintainAspectRatio     : true
    }

    barChartOptions.datasetFill = false
    var myChart = barChart.HorizontalBar(barChartData, barChartOptions)

  });
  </script>
  <?php
 }
?>
</body>
</html>
```

ADMIN VOTER.PHP

```
<?php include 'includes/session.php'; ?>
<?php include 'includes/header.php'; ?>
<body class="hold-transition skin-blue sidebar-mini">
<div class="wrapper">

 <?php include 'includes/navbar.php'; ?>
 <?php include 'includes/menubar.php'; ?>


 <div class="content-wrapper">

   <section class="content-header">
     <h1>
       Voters List
     </h1>
     <ol class="breadcrumb">
       <li><a href="#"><i class="fa fa-dashboard"></i> Home</a></li>
       <li class="active">Voters</li>
     </ol>
   </section>

   <section class="content">
     <?php
       if(isset($_SESSION['error'])){
```

```
        echo "
          <div class='alert alert-danger alert-dismissible'>
            <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
            <h4><i class='icon fa fa-warning'></i> Error!</h4>
            ".$_SESSION['error']."
          </div>
        ";
        unset($_SESSION['error']);
      }
      if(isset($_SESSION['success'])){
        echo "
          <div class='alert alert-success alert-dismissible'>
            <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
            <h4><i class='icon fa fa-check'></i> Success!</h4>
            ".$_SESSION['success']."
          </div>
        ";
        unset($_SESSION['success']);
      }
    ?>
    <div class="row">
      <div class="col-xs-12">
        <div class="box">
          <div class="box-header with-border">
            <a href="#addnew" data-toggle="modal" class="btn btn-primary btn-sm btn-flat"><i class="fa fa-plus"></i> New</a>
          </div>
          <div class="box-body">
            <table id="example1" class="table table-bordered">
              <thead>
                <th>Lastname</th>
                <th>Firstname</th>
                <th>Photo</th>
                <th>Voters ID</th>
                <th>Tools</th>
              </thead>
              <tbody>
                <?php
                  $sql = "SELECT * FROM voters";
                  $query = $conn->query($sql);
                  while($row = $query->fetch_assoc()){
                    $image = (!empty($row['photo'])) ? '../images/'.$row['photo'] : '../images/profile.jpg';
```

```
                    echo "
                      <tr>
                        <td>".$row['lastname']."</td>
                        <td>".$row['firstname']."</td>
                        <td>
                          <img src='".$image."' width='30px' height='30px'>
                          <a href='#edit_photo' data-toggle='modal' class='pull-right photo' data-id='".$row['id']."'><span class='fa fa-edit'></span></a>
                        </td>
                        <td>".$row['voters_id']."</td>
                        <td>
                          <button class='btn btn-success btn-sm edit btn-flat' data-id='".$row['id']."'><i class='fa fa-edit'></i> Edit</button>
                          <button class='btn btn-danger btn-sm delete btn-flat' data-id='".$row['id']."'><i class='fa fa-trash'></i> Delete</button>
                        </td>
                      </tr>
                    ";
                  }
                ?>
              </tbody>
            </table>
          </div>
        </div>
      </div>
    </div>
  </section>
 </div>

 <?php include 'includes/footer.php'; ?>
 <?php include 'includes/voters_modal.php'; ?>
</div>
<?php include 'includes/scripts.php'; ?>
<script>
$(function(){
  $(document).on('click', '.edit', function(e){
    e.preventDefault();
    $('#edit').modal('show');
    var id = $(this).data('id');
    getRow(id);
  });
```

```
  $(document).on('click', '.delete', function(e){
    e.preventDefault();
    $('#delete').modal('show');
    var id = $(this).data('id');
    getRow(id);
  });

  $(document).on('click', '.photo', function(e){
    e.preventDefault();
    var id = $(this).data('id');
    getRow(id);
  });

});

function getRow(id){
  $.ajax({
    type: 'POST',
    url: 'voters_row.php',
    data: {id:id},
    dataType: 'json',
    success: function(response){
      $('.id').val(response.id);
      $('#edit_firstname').val(response.firstname);
      $('#edit_lastname').val(response.lastname);
      $('#edit_password').val(response.password);
      $('.fullname').html(response.firstname+' '+response.lastname);
    }
  });
}
</script>
</body>
</html>
```

ADMIN VOTES.PHP

```
<?php include 'includes/session.php'; ?>
<?php include 'includes/header.php'; ?>
<body class="hold-transition skin-blue sidebar-mini">
<div class="wrapper">
```

```
<?php include 'includes/navbar.php'; ?>
<?php include 'includes/menubar.php'; ?>


<div class="content-wrapper">

  <section class="content-header">
    <h1>
      Votes
    </h1>
    <ol class="breadcrumb">
      <li><a href="#"><i class="fa fa-dashboard"></i> Home</a></li>
      <li class="active">Votes</li>
    </ol>
  </section>

  <section class="content">
    <?php
      if(isset($_SESSION['error'])){
        echo "
          <div class='alert alert-danger alert-dismissible'>
            <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
            <h4><i class='icon fa fa-warning'></i> Error!</h4>
            ".$_SESSION['error']."
          </div>
        ";
        unset($_SESSION['error']);
      }
      if(isset($_SESSION['success'])){
        echo "
          <div class='alert alert-success alert-dismissible'>
            <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
            <h4><i class='icon fa fa-check'></i> Success!</h4>
            ".$_SESSION['success']."
          </div>
        ";
        unset($_SESSION['success']);
      }
    ?>
    <div class="row">
      <div class="col-xs-12">
```

```
        <div class="box">
          <div class="box-header with-border">
            <a href="#reset" data-toggle="modal" class="btn btn-danger btn-sm btn-flat"><i class="fa fa-refresh"></i> Reset</a>
          </div>
          <div class="box-body">
            <table id="example1" class="table table-bordered">
              <thead>
                <th class="hidden"></th>
                <th>Position</th>
                <th>Candidate</th>
                <th>Voter</th>
              </thead>
              <tbody>
                <?php
                  $sql = "SELECT *, candidates.firstname AS canfirst, candidates.lastname AS canlast, voters.firstname AS votfirst, voters.lastname AS votlast FROM votes LEFT JOIN positions ON positions.id=votes.position_id LEFT JOIN candidates ON candidates.id=votes.candidate_id LEFT JOIN voters ON voters.id=votes.voters_id ORDER BY positions.priority ASC";
                  $query = $conn->query($sql);
                  while($row = $query->fetch_assoc()){
                    echo "
                      <tr>
                        <td class='hidden'></td>
                        <td>".$row['description']."</td>
                        <td>".$row['canfirst'].' '.$row['canlast']."</td>
                        <td>".$row['votfirst'].' '.$row['votlast']."</td>
                      </tr>
                    ";
                  }
                ?>
              </tbody>
            </table>
          </div>
        </div>
      </div>
    </section>
  </div>

  <?php include 'includes/footer.php'; ?>
  <?php include 'includes/votes_modal.php'; ?>
```

```
</div>
<?php include 'includes/scripts.php'; ?>
</body>
</html>
```

ADMIN CANDIDATES.PHP

```
<?php include 'includes/session.php'; ?>
<?php include 'includes/header.php'; ?>
<body class="hold-transition skin-blue sidebar-mini">
<div class="wrapper">

  <?php include 'includes/navbar.php'; ?>
  <?php include 'includes/menubar.php'; ?>


  <div class="content-wrapper">

    <section class="content-header">
      <h1>
        Candidates List
      </h1>
      <ol class="breadcrumb">
        <li><a href="#"><i class="fa fa-dashboard"></i> Home</a></li>
        <li class="active">Candidates</li>
      </ol>
    </section>

    <section class="content">
      <?php
        if(isset($_SESSION['error'])){
          echo "
            <div class='alert alert-danger alert-dismissible'>
              <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
              <h4><i class='icon fa fa-warning'></i> Error!</h4>
              ".$_SESSION['error']."
            </div>
          ";
          unset($_SESSION['error']);
        }
        if(isset($_SESSION['success'])){
```

```
        echo "
          <div class='alert alert-success alert-dismissible'>
            <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
            <h4><i class='icon fa fa-check'></i> Success!</h4>
            ".$_SESSION['success']."
          </div>
        ";
        unset($_SESSION['success']);
       }
      ?>
      <div class="row">
        <div class="col-xs-12">
          <div class="box">
            <div class="box-header with-border">
              <a href="#addnew" data-toggle="modal" class="btn btn-primary btn-sm btn-flat"><i class="fa fa-plus"></i> New</a>
            </div>
            <div class="box-body">
              <table id="example1" class="table table-bordered">
                <thead>
                  <th class="hidden"></th>
                  <th>Position</th>
                  <th>Photo</th>
                  <th>Firstname</th>
                  <th>Lastname</th>
                  <th>Platform</th>
                  <th>Tools</th>
                </thead>
                <tbody>
                  <?php
                    $sql = "SELECT *, candidates.id AS canid FROM candidates LEFT JOIN positions ON positions.id=candidates.position_id ORDER BY positions.priority ASC";
                    $query = $conn->query($sql);
                    while($row = $query->fetch_assoc()){
                      $image = (!empty($row['photo'])) ? '../images/'.$row['photo'] : '../images/profile.jpg';
                      echo "
                        <tr>
                          <td class='hidden'></td>
                          <td>".$row['description']."</td>
                          <td>
                            <img src='".$image."' width='30px' height='30px'>
```

```
                    <a href='#edit_photo' data-toggle='modal' class='pull-right photo' data-id='".$row['canid']."'><span class='fa fa-edit'></span></a>
                  </td>
                  <td>".$row['firstname']."</td>
                  <td>".$row['lastname']."</td>
                  <td><a href='#platform' data-toggle='modal' class='btn btn-info btn-sm btn-flat platform' data-id='".$row['canid']."'><i class='fa fa-search'></i> View</a></td>
                  <td>
                    <button class='btn btn-success btn-sm edit btn-flat' data-id='".$row['canid']."'><i class='fa fa-edit'></i> Edit</button>
                    <button class='btn btn-danger btn-sm delete btn-flat' data-id='".$row['canid']."'><i class='fa fa-trash'></i> Delete</button>
                  </td>
                </tr>
              ";
            }
          ?>
        </tbody>
      </table>
    </div>
  </div>
</div>
</section>
</div>

<?php include 'includes/footer.php'; ?>
<?php include 'includes/candidates_modal.php'; ?>
</div>
<?php include 'includes/scripts.php'; ?>
<script>
$(function(){
  $(document).on('click', '.edit', function(e){
    e.preventDefault();
    $('#edit').modal('show');
    var id = $(this).data('id');
    getRow(id);
  });

  $(document).on('click', '.delete', function(e){
    e.preventDefault();
    $('#delete').modal('show');
```

```
    var id = $(this).data('id');
    getRow(id);
  });

  $(document).on('click', '.photo', function(e){
    e.preventDefault();
    var id = $(this).data('id');
    getRow(id);
  });

  $(document).on('click', '.platform', function(e){
    e.preventDefault();
    var id = $(this).data('id');
    getRow(id);
  });

});

function getRow(id){
  $.ajax({
    type: 'POST',
    url: 'candidates_row.php',
    data: {id:id},
    dataType: 'json',
    success: function(response){
      $('.id').val(response.canid);
      $('#edit_firstname').val(response.firstname);
      $('#edit_lastname').val(response.lastname);
      $('#posselect').val(response.position_id).html(response.description);
      $('#edit_platform').val(response.platform);
      $('.fullname').html(response.firstname+' '+response.lastname);
      $('#desc').html(response.platform);
    }
  });
}
</script>
</body>
</html>
```

VOTER HOME.PHP

```
<?php include 'includes/session.php'; ?>
<?php include 'includes/header.php'; ?>
<body class="hold-transition skin-blue layout-top-nav">
<div class="wrapper">

  <?php include 'includes/navbar.php'; ?>

    <div class="content-wrapper">
      <div class="container">



        <section class="content">
          <?php
            $parse = parse_ini_file('admin/config.ini', FALSE, INI_SCANNER_RAW);
            $title = $parse['election_title'];
          ?>
          <h1 class="page-header text-center title"><b><?php echo strtoupper($title); ?></b></h1>
          <div class="row">
            <div class="col-sm-10 col-sm-offset-1">
              <?php
                if(isset($_SESSION['error'])){
                  ?>
                  <div class="alert alert-danger alert-dismissible">
                    <button type="button" class="close" data-dismiss="alert" aria-hidden="true">&times;</button>
                    <ul>
                      <?php
                        foreach($_SESSION['error'] as $error){
                          echo "
                            <li>".$error."</li>
                          ";
                        }
                      ?>
                    </ul>
                  </div>
                  <?php
                  unset($_SESSION['error']);

                }
                if(isset($_SESSION['success'])){
                  echo "
```

```
                <div class='alert alert-success alert-dismissible'>
                    <button type='button' class='close' data-dismiss='alert' aria-hidden='true'>&times;</button>
                    <h4><i class='icon fa fa-check'></i> Success!</h4>
                ".$_SESSION['success']."
                </div>
            ";
            unset($_SESSION['success']);
        }

    ?>

    <div class="alert alert-danger alert-dismissible" id="alert" style="display:none;">
        <button type="button" class="close" data-dismiss="alert" aria-hidden="true">&times;</button>
        <span class="message"></span>
    </div>

    <?php
        $sql = "SELECT * FROM votes WHERE voters_id = '".$voter['id']."'";
        $vquery = $conn->query($sql);
        if($vquery->num_rows > 0){
            ?>
            <div class="text-center">
                <h3>You have already voted for this election.</h3>
                <a href="#view" data-toggle="modal" class="btn btn-flat btn-primary btn-lg">View Ballot</a>
            </div>
            <?php
        }
        else{
            ?>

            <form method="POST" id="ballotForm" action="submit_ballot.php">
                <?php
                    include 'includes/slugify.php';

                    $candidate = '';
                    $sql = "SELECT * FROM positions ORDER BY priority ASC";
                    $query = $conn->query($sql);
                    while($row = $query->fetch_assoc()){
                        $sql = "SELECT * FROM candidates WHERE position_id='".$row['id']."'";
                        $cquery = $conn->query($sql);
                        while($crow = $cquery->fetch_assoc()){
                            $slug = slugify($row['description']);
```

```
                                $checked = '';
                                if(isset($_SESSION['post'][$slug])){
                                    $value = $_SESSION['post'][$slug];

                                    if(is_array($value)){
                                        foreach($value as $val){
                                            if($val == $crow['id']){
                                                $checked = 'checked';
                                            }
                                        }
                                    }
                                    else{
                                        if($value == $crow['id']){
                                            $checked = 'checked';
                                        }
                                    }
                                }
                                $input = ($row['max_vote'] > 1) ? '<input type="checkbox" class="flat-red '.$slug.'" name="'.$slug."[]".'" value="'.$crow['id'].'" '.$checked.'>' : '<input type="radio" class="flat-red '.$slug.'" name="'.slugify($row['description']).'" value="'.$crow['id'].'" '.$checked.'>';
                                $image = (!empty($crow['photo'])) ? 'images/'.$crow['photo'] : 'images/profile.jpg';
                                $candidate .= '
                                    <li>
                                        '.$input.'<button type="button" class="btn btn-primary btn-sm btn-flat clist platform" data-platform="'.$crow['platform'].'" data-fullname="'.$crow['firstname'].' '.$crow['lastname'].'"><i class="fa fa-search"></i> Platform</button><img src="'.$image.'" height="100px" width="100px" class="clist"><span class="cname clist">'.$crow['firstname'].' '.$crow['lastname'].'</span>
                                    </li>
                                ';
                            }

                            $instruct = ($row['max_vote'] > 1) ? 'You may select up to '.$row['max_vote'].' candidates' : 'Select only one candidate';

                            echo '
                                <div class="row">
                                    <div class="col-xs-12">
                                        <div class="box box-solid" id="'.$row['id'].'">
                                            <div class="box-header with-border">
                                                <h3 class="box-title"><b>'.$row['description'].'</b></h3>
                                            </div>
                                            <div class="box-body">
```

```
                                        <p>'.$instruct.'
                                            <span class="pull-right">
                                                <button type="button" class="btn btn-success btn-sm btn-flat reset" data-desc='".slugify($row['description'])."'><i class="fa fa-refresh"></i> Reset</button>
                                            </span>
                                        </p>
                                        <div id="candidate_list">
                                            <ul>
                                                '.$candidate.'
                                            </ul>
                                        </div>
                                    </div>
                                </div>
                            </div>
                        </div>
                        ';

                        $candidate = '';

                    }

                ?>
                <div class="text-center">
                    <button type="button" class="btn btn-success btn-flat" id="preview"><i class="fa fa-file-text"></i> Preview</button>
                    <button type="submit" class="btn btn-primary btn-flat" name="vote"><i class="fa fa-check-square-o"></i> Submit</button>
                </div>
            </form>

            <?php
        }

    ?>

    </div>
  </div>
</section>

</div>
</div>
```

```
    <?php include 'includes/footer.php'; ?>
    <?php include 'includes/ballot_modal.php'; ?>
</div>

<?php include 'includes/scripts.php'; ?>
<script>
$(function(){
    $('.content').iCheck({
        checkboxClass: 'icheckbox_flat-green',
        radioClass: 'iradio_flat-green'
    });

    $(document).on('click', '.reset', function(e){
        e.preventDefault();
        var desc = $(this).data('desc');
        $('.'+desc).iCheck('uncheck');
    });

    $(document).on('click', '.platform', function(e){
        e.preventDefault();
        $('#platform').modal('show');
        var platform = $(this).data('platform');
        var fullname = $(this).data('fullname');
        $('.candidate').html(fullname);
        $('#plat_view').html(platform);
    });

    $('#preview').click(function(e){
        e.preventDefault();
        var form = $('#ballotForm').serialize();
        if(form == ''){
            $('.message').html('You must vote atleast one candidate');
            $('#alert').show();
        }
        else{
            $.ajax({
                type: 'POST',
                url: 'preview.php',
                data: form,
                dataType: 'json',
                success: function(response){
                    if(response.error){
```

```
                    var errmsg = '';
                    var messages = response.message;
                    for (i in messages) {
                        errmsg += messages[i];
                    }
                    $('.message').html(errmsg);
                    $('#alert').show();
                }
                else{
                    $('#preview_modal').modal('show');
                    $('#preview_body').html(response.list);
                }
            }
        });
    }

});

});
</script>
</body>
</html>
```

VOTER SUBMIT_BALLOT.PHP

```
<?php
    include 'includes/session.php';
    include 'includes/slugify.php';

    if(isset($_POST['vote'])){
        if(count($_POST) == 1){
            $_SESSION['error'][] = 'Please vote atleast one candidate';
        }
        else{
            $_SESSION['post'] = $_POST;
            $sql = "SELECT * FROM positions";
            $query = $conn->query($sql);
            $error = false;
            $sql_array = array();
            while($row = $query->fetch_assoc()){
                $position = slugify($row['description']);
```

```
            $pos_id = $row['id'];
            if(isset($_POST[$position])){
                if($row['max_vote'] > 1){
                    if(count($_POST[$position]) > $row['max_vote']){
                        $error = true;
                        $_SESSION['error'][] = 'You can only choose '.$row['max_vote'].' candidates for '.$row['description'];
                    }
                    else{
                        foreach($_POST[$position] as $key => $values){
                            $sql_array[] = "INSERT INTO votes (voters_id, candidate_id, position_id) VALUES ('".$voter['id']."', '$values', '$pos_id')";
                        }

                    }

                }
                else{
                    $candidate = $_POST[$position];
                    $sql_array[] = "INSERT INTO votes (voters_id, candidate_id, position_id) VALUES ('".$voter['id']."', '$candidate', '$pos_id')";
                }

            }

        }

        if(!$error){
            foreach($sql_array as $sql_row){
                $conn->query($sql_row);
            }

            unset($_SESSION['post']);
            $_SESSION['success'] = 'Ballot Submitted';

        }

    }

}
else{
    $_SESSION['error'][] = 'Select candidates to vote first';
}
```

```
    header('location: home.php');

?>
```

VOTER VIEW_BALLOT.PHP

```
<?php

    include 'includes/session.php';
    include 'includes/slugify.php';

    $output = array('error'=>false,'list'=>'');

    $sql = "SELECT * FROM positions";
    $query = $conn->query($sql);

    while($row = $query->fetch_assoc()){
        $position = slugify($row['description']);
        $pos_id = $row['id'];
        if(isset($_POST[$position])){
            if($row['max_vote'] > 1){
                if(count($_POST[$position]) > $row['max_vote']){
                    $output['error'] = true;
                    $output['message'][] = '<li>You can only choose '.$row['max_vote'].' candidates for '.$row['description'].'</li>';
                }
                else{
                    foreach($_POST[$position] as $key => $values){
                        $sql = "SELECT * FROM candidates WHERE id = '$values'";
                        $cmquery = $conn->query($sql);
                        $cmrow = $cmquery->fetch_assoc();
                        $output['list'] .= "
                            <div class='row votelist'>
                                <span class='col-sm-4'><span class='pull-right'><b>".$row['description']." :</b></span></span>
                                <span class='col-sm-8'>".$cmrow['firstname']." ".$cmrow['lastname']."</span>
                            </div>
                        ";
                    }

                }
```

```
        }
        else{
            $candidate = $_POST[$position];
            $sql = "SELECT * FROM candidates WHERE id = '$candidate'";
            $csquery = $conn->query($sql);
            $csrow = $csquery->fetch_assoc();
            $output['list'] .= "
                <div class='row votelist'>
                    <span class='col-sm-4'><span class='pull-right'><b>".$row['description']." :</b></span></span>
                    <span class='col-sm-8'>".$csrow['firstname']." ".$csrow['lastname']."</span>
                </div>
            ";
        }

    }

  }

  echo json_encode($output);


?>
```