CENTRAL UNIVERSITY – SIERRA LEONE

Department of Technical Sciences

Faculty of Science and Technology

DESIGN AND IMPLEMENTATION OF AN ONLINE VOTING SYSTEM USING FACIAL RECOGNITION

CASE STUDY: Central University

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science with Honors in Computer Science & Business Information Technology.

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CERTIFICATION

The project titled, "**DESIGN AND IMPLEMENTATION OF AN ONLINE VOTING SYSTEM USING FACIAL RECOGNITION, CASE STUDY: CENTRAL UNIVERSITY**" is hereby certified by Central University, Faculty of Science and Technology (Technical Sciences) as a commendable study of research topic and has been presented in a satisfactory manner to merit its acceptance as requirement to the degree for which it was submitted.

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DECLARATION

We, Mohamed Osman Kamara, Mohamed Lamin Tarawalie, and Bernadette Baindu Ganda, declare that this thesis, entitled "*Design and Implementation of an Online Voting System Using Facial Recognition*," is our own research work and that all the sources we have used or quoted have been indicated and acknowledged by means of complete references. This work has not been submitted in whole or in part for any other academic degree or qualification.

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DEDICATION

First and foremost, we dedicate this piece of work to the almighty God, creator of heaven and earth for keeping us alive and empowering us to have successfully undertaken this research. And secondly, we dedicate this work to our able and hardworking chancellor Mr. Muckson Sesay Snr for his tireless efforts in ensuring that most of us that were never thinking of ascertaining higher institutional education to be here today by providing us hope when we think all hopes was lost and also to the Sierra Leone Educational Partnership (SLEP) Board for their every support. We also dedicate this work to our noble lectures for their words of motivation, inspiration, and impact on us. Also to our parents who have been a source of inspiration, an engine of courage and a secret of our achievements since our childhood we appreciate them so much.

"Success is a road full of humps and pit holes, however if you don't change the track, you end up to the final destination."

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LIST OF ACRONYMS

Acronym	Meaning
BBC	Bachelor of Business Computing
IR	Information Retrieval
OVS	Online Voting System
SQLite	Structured Query Language lite
MS	Micro Soft
RDBMS	Relational Database Management System
GUI	Graphical User Interfaces
DFDs	Data Flow Diagrams
SDLC	System Development Life Cycle
DDoS	Distributed Denial of Service
ERDs	Entity Relationship Diagrams
RAM	Random Access Memory
DBMS	Database Management System
EMS	Election Management System
EVS	Electronic Voting System
HTML	Hyper Text Markup Language
CSS	Cascading Style Sheet
CU-SL	Central University Sierra Leone
HDD	Hard Disk Drives
SSD	Solid State Drives
DRE	Direct Recording Electronics

ABSTRACT

Student government elections at Central University currently rely on a paper-based voting system, presenting challenges related to efficiency, security, and accessibility. In response, this paper proposes a transition to an online voting system with integrated facial recognition technology. The proposed system captures and stores students' facial images during enrollment, creating secure biometric templates. During elections, students authenticate their identities by submitting facial images, which are then matched against the enrollment database.

The system's effectiveness was tested with a sample of students, achieving a facial verification accuracy of 95% compared to manual identification. The high accuracy rates suggest that online voting with automated facial recognition can effectively prevent voter fraud, ensuring the integrity of large-scale remote election systems. The proposed system aims to enhance accessibility for students while maintaining the security of the electoral process.

Further testing, particularly on larger voter databases, is recommended. The system successfully disappointed attempts to vote multiple times using different student IDs with a 91% accuracy rate. Real-world testing with the entire university student population is advised to validate the system's effectiveness. The facial recognition voting system promises to streamline Central University student government elections, making them more efficient, accessible, and secure amid the university's transition to modern, online administrative systems.

Keywords: Online Voting, Facial Recognition, Biometric Authentication, Election Integrity, Voter Fraud Prevention, Student Government, Accessibility, Security, Remote Elections, Modern Administrative Systems.

CHAPTER ONE

1.1 Background of the Study

Elections are seen to be one of the most important foundations of democracy, and voting is one of the electoral procedures that ensure the survival of democracy in any civil society. Voting is a cornerstone of democracy that enables citizens or eligible individuals in a society or an institution to have a voice in governance and policymaking (Tan, Sim, & Low, 2021). Online voting is a method of electing leaders electronically using a web-based program (Eteng & Umoren, 2018).

However, traditional paper-based voting comes with several pain points - limited accessibility for voters with disabilities or unable to physically reach polling stations (Smith & Jones, Analyzing vulnerabilities in traditional paper-based voting systems., 2021); proneness to human errors in vote counting/tallying leading to inaccurate results (Williams & Brown, 2019); and susceptibility to malicious activities like ballot stuffing and voter impersonation fraud (Taylor, Wu, & Khan, 2022)

Most Electoral bodies right from their inception to date and even with the latest advancements in technology still use a primitive paper-based method during voting. This system is characterized by manual form filling or writing to choose leaders, and transfer of the information from manual data capture forms to computerized datasheets. This has led to an excessive number of mistakes making their way into the final vote counts hence leading to confusion and delay at the time of announcing the results. The main advantage of paper-based systems is that ballot papers are easily human-auditable. The disadvantages outweigh the advantages (Domakonda, Kumar, Rao, Sindhu, & Btech, July 2022). For instance, the need to print ballot papers, is a slow, expensive, inflexible, environmentally hostile process. Also, visual impairments, or literacy limitations plus last-minute changes to the voters' register are difficult to accommodate amongst others.

Over the last few years, a number of election observers have suggested that electoral organizations introduce electronic/online voting. A general observation is that as more business is done using electronic media, it should not be difficult to carry out voting using electronic equipment rather than turning up at the polling place on voting day to use paper and pen. Evidently, the phenomenal use of the Internet as a vehicle for improving communication, access to information, and electronic commerce has led to the claim that the Internet could be used as either a replacement for attendance voting or as an additional voting option (Eteng & Umoren, 2018).

The limitations of the traditional voting method have motivated the exploration of technology-enabled voting methods. Electronic voting machines started gaining traction in the 1990s as they allowed automated vote counting and instant updating of results (Lee J. , 2020). However, first generation direct-recording electronic (DRE) voting machines also experienced issues like vote flipping, ghost votes, and security vulnerabilities (Vinkel, 2017). This led technologists and policymakers to consider internet and block-chain based voting systems as viable next generation options (Mobile Voting Project, 2021).

Online voting has been an area of research focus for many years by using computing machines and equipment for casting votes and producing high-quality and precise results in accordance with the sentiments of the participating voters. Various attempts have been adopted in practice to support the election process. Initially computer counting system allowed the voter to cast a vote on paper. Later on, those cards went through the process of scanning and tallying at every polling cell on a central server. (Kumar & Sariba , March 21-23, 2012)

Online and mobile voting platforms can expand access to the ballot box for many citizens or eligible voters (e.g. overseas voters, physically impaired voters) through remote participation via internet-connected devices Additionally, block-chain based voting systems are cryptographically more secure and allow transparency through distributed ledgers (Jones, Thompson, & Davis, 2020). Small-scale implementations have shown the potential of such systems but also highlighted open concerns around voter authentication, vote privacy/anonymity, and resilience against cyber-attacks (Khan & Han, 2023)

This study intends to design a secure online voting system prototype leveraging block-chain technology. Through conceptual modeling and simulation testing, we will analyze its usefulness in addressing key limitations in current voting methods regarding security, accuracy, accessibility and cost-effectiveness. The learnings can inform responsible development and potential adoption of technology-enabled voting platforms.

1.2 Problem Statement

In contemporary democratic processes, the efficiency and integrity of the voting system stand as pivotal elements in ensuring a robust and credible electoral experience. However, the persistent reliance on traditional paper-based voting systems has given rise to a spectrum of challenges. The inherent inefficiencies, susceptibility to errors, and limited accessibility of these systems have become barriers to achieving a truly inclusive and streamlined electoral process.

Moreover, the escalating complexities of modern elections, coupled with the increasing threat landscape of cybersecurity, underscore the inadequacy of current voting systems in meeting the demands of a rapidly evolving socio-technological environment. Instances of voter suppression, logistical bottlenecks, and vulnerabilities in the security apparatus pose significant hurdles to the democratic ideals of fairness, transparency, and equal representation.

This research aims to address the deficiencies of the existing voting system by examining the potential of a technologically advanced and secure alternative. By doing so, the study seeks to contribute to the development of an online voting system that will not only mitigate the current challenges but also anticipates and safeguards against emerging threats, ultimately fostering an electoral process that is efficient, trustworthy, and accessible to all eligible students at Central University.

1.3 Aim:

The aim of this research is to develop an online voting system that utilizes facial recognition technology to ensure a secure, convenient, and accessible method for eligible voters to cast their ballots remotely.

1.4 Objective:

The objectives of this research include:

- ✓ To design and develop an online voting system.
- ✓ To improve the security and privacy of online voting system.
- ✓ To increase voter turnout by mitigating queuing.

- ✓ To reduce the cost of conducting elections.
- ✓ To help mitigate malpractices in students' union elections.

1.5 Research Questions

- ✓ How can we design a secure online voting system that prevents unauthorized access?
- ✓ How can online voting ensure the security and privacy of votes?
- ✓ How can online voting tend to increase voter turnout and eradicate queuing?
- ✓ How can the cost of conducting elections be reduced?
- ✓ How can malpractices in students' union elections be mitigated?

1.6 Significance of the Project

The primary essence of this research is to enhance the provision of voting services, prioritizing speed, timeliness, and convenience for voters. A key focus lies in the development of a proposed Voting System designed to alleviate the challenges inherent in traditional paper-based voting. These challenges include cost implications and the logistical burden associated with engaging experts in the voting process.

The proposed Voting System aims to address the financial strain incurred by traditional voting methods. By transitioning from paper-based systems, there is a potential reduction in costs, stemming from the elimination of paper materials, printing, and manual processing. Furthermore, the new system intends to minimize the workload associated with hiring experts for tasks such as ballot counting and supervision, thereby streamlining the entire voting process.

Beyond cost considerations, the proposed Voting System seeks to revolutionize election management. The goal is to introduce a system capable of efficiently handling the complexities of elections, from candidate registration to result tabulation. This not only contributes to the expeditious completion of the electoral cycle but also ensures accuracy and transparency throughout.

Another crucial aspect of the proposed Voting System is its commitment to robust security standards. Ensuring the integrity of the electoral process is paramount, and the system is designed

to implement and uphold stringent security measures. By doing so, the aim is to fortify the system against potential threats, maintaining the credibility of the electoral outcomes.

The significance of this research extends to fostering increased voter participation. The proposed Voting System is designed to offer voters greater flexibility, enabling them to cast their votes conveniently from different locations. This increased accessibility is anticipated to encourage a broader and more diverse participation in the electoral process, ultimately strengthening the democratic foundation of the voting system.

1.7 Scope of the research

This research project focuses on the application of facial-recognition technology to enhance the management of voting processes. In particular, it aims to explore the potential of authentication technology in addressing identified limitations and improving the security, transparency, and accessibility of voting results.

To achieve these objectives, a prototype of a web-based voting management system will be designed and developed. The development process will carefully consider the unique requirements and considerations of Central University's voting context. This prototype is envisioned as a practical solution to streamline voting procedures while incorporating state-of-the-art facial-recognition technology.

The effectiveness of the prototype will be rigorously evaluated through various testing and assessment factors. Key aspects, including scalability, security, and user experience, will be systematically examined. These evaluations will provide insights into the performance, usability, and feasibility of the proposed system.

A crucial aspect of this research involves analysing the impact of facial recognition on the efficiency, transparency, and security of the votes cast. To gain comprehensive insights, perspectives from experts in the field will be consulted. This consultation process will contribute valuable perspectives on the implications and potential challenges associated with integrating facial-recognition technology into the voting process.

By structuring the research in this manner, the study aims to not only implement a practical solution but also critically assess its viability and impact on the voting processes within the specific context of Central University.

1.8 Limitations of the research

The research project will focus on the voting system within Sierra Leonean universities, recognizing that the findings may have limited applicability to other academic institutions. The investigation specifically centres on the implementation of a web-based system, designed as a prototype. It is essential to note that additional development and refinement may be necessary for a comprehensive, full-scale deployment.

The evaluation of the prototype system's performance and impact will be conducted through simulated scenarios. However, it is crucial to acknowledge that these simulations may not fully capture the complexities inherent in real-world usage scenarios. The research team aims to provide valuable insights into the system's functionality and potential benefits based on these simulated assessments.

Nevertheless, it is essential to recognize that the project's timeline and available resources may impose constraints on the depth and extent of the analysis and development of the proposed voting system. Balancing these constraints with the research objectives will be pivotal in ensuring a meaningful exploration of the system's capabilities and limitations.

Looking beyond the technical aspects, the acceptance and adoption of the web-based voting system in other universities may present challenges. These challenges are likely to be associated with changes in information management practices and adjustments to existing university frameworks. Addressing these challenges will be critical for successful implementation and integration into the broader academic context.

CHAPTER TWO

Literature Review

2.0 Introduction

The purpose of this literature review is to offer a comprehensive overview of the existing body of research related to online voting systems. By delving into this subject, we seek to brighten the evolution of these systems, explain their potential benefits, confront the challenges they face, and critically assess the paramount security considerations that underpin their implementation.

2.1 The Concept of Online Voting

Online voting refers to the process of casting votes using electronic means over the internet. It's an innovative approach that leverages technology to enable citizens to participate in electoral processes remotely. This method typically involves the use of secure digital platforms or systems where eligible voters can log in, verify their identity, and cast their votes electronically. The concept has garnered attention due to its potential to enhance accessibility, convenience, and efficiency in the voting process (Hall & Alvarez, Electronic elections: The perils and promises of digital democracy, 2009).

The core idea behind online voting revolves around enabling voters to exercise their democratic rights from anywhere with internet access. This flexibility eliminates geographical constraints, allowing individuals to participate in elections without being physically present at a polling station. It caters to diverse voter demographics, including those living abroad, individuals with disabilities, or citizens unable to visit polling stations due to various commitments.

However, the implementation of online voting comes with challenges and considerations. Security and integrity stand as paramount concerns (Teague, Ramirez, & Hartman, 2015). Ensuring a robust and tamper-proof system to prevent fraud, manipulation, or unauthorized access to votes is critical. Authentication protocols and encryption techniques are integral components designed to safeguard the confidentiality and accuracy of votes cast online.

Additionally, the usability and accessibility of online voting systems need to be carefully designed to accommodate various user demographics, including older voters or individuals with limited technological literacy (Hall & Alvarez, Electronic elections: The perils and promises of digital

democracy, 2009). User-friendly interfaces, clear instructions, and adequate support are essential to facilitate a smooth voting experience for all eligible voters.

The concept of online voting continues to evolve, with ongoing research and pilot projects aimed at addressing technical, security, and usability challenges. As technology advances and security measures improve, online voting holds the potential to revolutionize democratic processes by increasing voter turnout, streamlining the voting experience, and fostering greater civic engagement.

2.2 Types and Variation of Voting

Voting refers to the electoral process by which citizens or group members express their preferences, choose representatives, or decide on issues through ballots or other means (Edelmann, 2021). Over history, civilizations have developed different voting methods adapting to their context and advancements.

2.2.1 Paper-Based Voting

The conventional form of voting involves paper ballots filled manually by voters during elections. Variations range from simple closed ballots with preprinted candidate names to more complex ranked choice ballots allowing ranking of preferences. While cost-effective, such in-person paper ballot systems are prone to vote miscounts, ambiguity errors and booth-capturing during polls (Ornstein & Stewart III, 2021).

2.2.2 Mechanical Voting Machines

These involve lever-based or punch-card operated ballot casting terminals first introduced in the 1890s in the U.S., allowing voters to mechanically record preferences which get counted electronically giving faster results (Alvarez & Hall, 2009). However, hanging chads from incomplete punctures created counting issues. They also retain central tallying dependencies.

2.2.3 Direct-Recording Electronic (DRE) Voting

First mandatorily adopted in Brazil in 1996, DRE systems like electronic voting machines or vote-by-phone methods provide embedded data storage, touchscreen interfaces and digital vote counting

without paper audit trails (Avdiukova, 2019). But software glitches, screen calibration errors, and results transmission interference have emerged as recurrent shortcomings globally.

2.2.4 Block-chain Voting

This emerging paradigm involves online and app-based platforms leveraging cryptographic block-chain back-ends for transparent and immutable vote tallies across decentralized networks. Though currently small-scale, such implementations illustrate the potential for future transparent and publicly verifiable voting infrastructure with algorithmic integrity checks (Culnane & Schneider, 2021)

2.3 Characteristics of a Good Voting System

Voting is a fundamental aspect of democratic societies, allowing citizens to participate in the decision-making process and express their preferences on various issues, including the selection of political leaders and the enactment of policies. Voting characteristics encompass a range of features and considerations that define the democratic process. These characteristics have been subject to ongoing discussions and reforms to improve the inclusivity, accessibility, and integrity of the electoral system.

2.3.1 Inclusivity and Accessibility

One significant characteristic of voting since 2018 is the emphasis on inclusivity and accessibility. Governments and electoral authorities have increasingly focused on ensuring that voting processes are accessible to all eligible citizens, including those with disabilities and marginalized communities. This has led to the implementation of measures such as early voting options, expanded mail-in voting opportunities, and the use of accessible polling stations equipped with facilities for individuals with diverse needs (Birch, Farrell, Hönnige, & Schultze, 2020).

2.3.2 Transparency and Security

Another key characteristic of voting post-2018 is the heightened focus on transparency and security. With concerns about election integrity and potential interference, electoral authorities have implemented measures to enhance the transparency of voting processes. This includes the use of paper audit trails for electronic voting machines, robust verification procedures for absentee ballots,

and increased scrutiny of campaign financing to prevent undue influence on election outcomes (Hall, Alvarez, Llewellyn, Riera, & Sinclair, 2019).

2.3.3 Participation and Engagement

Since 2018, there has been a growing emphasis on promoting voter participation and engagement as essential characteristics of the electoral process. Governments and civil society organizations have launched extensive voter education campaigns aimed at informing citizens about their rights, the electoral process, and the significance of their participation in shaping democratic outcomes (García A.C.B., 2021).

2.3.4 Verification and Auditability

Providing mechanisms for voters to verify that their vote has been accurately recorded and counted is essential. Additionally, auditability features, such as paper trails in electronic voting systems, contribute to the verifiability of election results (Bannister, 2021)

2.4 Historical Development of Voting

Voting, as a formalized process facilitating collective decision-making through the expression of preferences, has a rich historical tapestry that traces its roots to ancient Greco-Roman civilizations (Reynolds & Venkatesh, 2021). The birthplace of organized voting can be pinpointed to ancient Athens, where male citizens actively participated in the Ecclesia assemblies to enact laws and elect magistrates. Initially conducted through public hand raising or potshard casting (Gustafson, 2022), these early methods laid the foundation for democratic decision-making bodies.

The evolution of voting techniques continued in ancient Rome during the Republic era, marked by the introduction of standardized secret paper balloting. This innovation aimed to enhance electoral fairness and introduced a level of confidentiality to individual voting preferences. Beyond the Western world, ancient India and China independently implemented local village-level consensus voting, showcasing diverse approaches to collective decision-making (Reynolds & Venkatesh, 2021).

The medieval emergence of parliamentary systems in Europe witnessed the formal regulation of voting protocols and legal frameworks governing how parliamentary members could participate in

decisions related to laws and taxes. Technological advancements in the 19th century, such as mechanical lever voting booths and punch card systems, marked a significant turning point, introducing increased automation to the voting process in Western democracies (Brent, 2021).

In more recent decades, the landscape of voting has undergone a digital revolution. The 1990s witnessed the accelerated adoption of electronic voting machines, marking a shift towards the digitization of vote capture. As technology continued to advance, the exploration of remote online voting systems gained momentum, with endeavors to leverage block-chain protections. This illustrates an ongoing evolution towards potentially more accessible, transparent, and resilient voting mechanisms (Hotton, 2020).

The historical trajectory of voting showcases a continual interplay between societal, technological, and cultural forces, reflecting a persistent quest for fairness, representation, and the improvement of democratic processes. As we stand on the brink of further technological innovations, the narrative of voting unfolds, propelled by the pursuit of inclusivity, security, and the democratic ideals that have shaped its journey through the ages.

2.5 Evolution of Online Voting Systems with Facial Recognition

In the rapidly evolving landscape of higher education and the introduction of advance technologies, the implementation of online voting systems in universities has gained momentum as a means to modernize and streamline various administrative and decision-making processes. Among the emerging technologies, facial recognition stands out as a promising tool for enhancing the security, efficiency, and accessibility of university elections. This literature review explores the current state of research on university online voting systems incorporating facial recognition technology, with a focus on Central University as a case study.

In the early stages of this evolution, online voting systems emerged as a promising solution to address the limitations of traditional voting methods. These early systems offered voters the convenience of casting their ballots remotely, avoiding the need for physical presence at polling stations. However, they were often simple and faced significant security concerns.

The integration of facial recognition technology into online voting systems represents the latest milestone in this evolutionary journey. Facial recognition, as a form of biometric authentication,

aligns seamlessly with broader trends in digital identity verification. This integration serves to enhance not only the security of the voting process but also its accessibility and efficiency (Johnson & Smith, 2019).

This evolutionary trajectory underscores the adaptability and responsiveness of electoral systems to the changing needs and expectations of citizens. As technology continues to advance, it is likely that online voting systems will further evolve to incorporate even more sophisticated measures, potentially enhancing their security, accessibility, and efficiency. However, with these advancements come ethical, legal, and security considerations that must be carefully navigated to ensure the continued integrity of the democratic process.

2.6 Benefits of Facial Recognition in Online Voting Systems

Research has identified several key benefits of implementing facial recognition technology in online voting systems. The integration of this technology into voting systems offers a multitude of advantages, reshaping the landscape of modern elections. Online voting with facial recognition technology can offer several potential benefits, but it's important to note that it also comes with challenges and considerations. Here are some potential benefits:

2.6.1 Enhanced Security

Identity verification has always been a critical challenge in remote voting systems accessed from personal devices where in-person crosschecking is not possible. This vulnerability can allow for electoral frauds through impersonation, unauthorized access or duplicate voting. Facial recognition adds a powerful biometric safeguard against such threats. Facial recognition systems work by capturing an image of the voter's face through the device camera and extracting distinctive facial measurements related to structure, shapes and proportions using advanced image processing algorithms. This biometric facial signature, also known as the face-print, is then cross-referenced against an existing database of voter identity records to authenticate eligibility (Brown & White, 2020).

2.6.2 Reduced Voter Impersonation

One of the main election security threats in traditional paper-based and electronic voting is impersonators illegally casting votes by assuming another voter's identity. This can swing closely

fought contests and undermine electoral integrity. Facial recognition specifically counters such malpractice during remote online voting through biometrically verifying if the face visually present matches enrolled voter data (Lee, K., et al., 2021). When used for identity proofing during system login, facial recognition technology captures an image of the voter's face and translates key facial features into a unique digital template using sophisticated image processing and pattern recognition techniques. This 'faceprint' serves as a distinctive marker of physiological identity akin to a fingerprint. The generated template is then matched against the voter's reference facial scans stored in databases like government ID records or voter rolls (Smith, Lee, & Williams, Voter authentication through biometrics: Security and privacy considerations., 2021).

As human faces are made up of hundreds of nodal points making it nearly impossible for full replication, this one-to-one template matching can reliably ascertain whether the user appearance matches the legitimate voter linked to the presented credentials (Wang, 2020). Even digitally altered images or video recordings are unlikely to have an exact facial geometry match leading to authentication failures during attempted impersonations.

2.6.3 Convenience and Accessibility

Traditional in-person voting requires voters to travel to and reach designated polling stations during a specified window on Election Day. This leads to issues around lost work hours, waiting in long lines, finding transportation, and accessing premises especially for the elderly and physically challenged (Adams & Martin, 2019). Facial recognition-enabled online voting solves many of these accessibility issues. A cloud-based online voting platform with facial login allows participating from any private location using internet-connected personal smart devices like smartphones, tablets and laptops with built-in cameras. By removing location dependency, voters can conveniently cast ballots without traveling by simply logging in from environments they are comfortable in - whether homes, offices or assisted living centers in case of senior citizens or voters with restricted mobility (Shaw & Lewis, 2021).

The automated biometric-based identity proofing further enhances ease of use, as voters merely need to sit before their camera-fitted device to get their face captured and matched during login compared to remembering credentials like usernames/passwords prone to lapses. Secure and hassle-free remote participation consequently leads to greater voter satisfaction while also reducing

administrative overheads of setting up physical polling infrastructure by election officials (Thompson, 2023)

2.6.4 Efficiency and Speed

By leveraging advanced facial recognition technology, the verification of voter identities can be expedited, potentially resulting in a substantial reduction in the time required for this crucial aspect of the electoral process. This acceleration not only enhances the efficiency of elections but also has the potential to mitigate challenges associated with long queues, delays, and administrative bottlenecks that often characterize manual verification methods. The expedited verification process aligns with the broader goal of fostering faster and more efficient elections, ultimately contributing to a more seamless and responsive democratic voting experience for citizens (Brown & White, 2020).

2.6.5 User-Friendly Experience

The integration of facial recognition technology into the online voting process represents a pivotal stride toward cultivating a user-friendly and intuitive electoral experience. By incorporating facial recognition, the voting process becomes seamlessly aligned with the voters' physical identity, enhancing ease of use and reducing potential friction in the online platform. This technology not only streamlines the authentication process but also contributes to heightened trust and acceptance among users. The intuitive nature of facial recognition holds the potential to make online voting more accessible to a broader demographic, potentially encouraging increased adoption. As voters encounter a more user-friendly interface, characterized by the familiarity of facial recognition, concerns about the complexity of online voting systems may diminish, fostering a positive environment for the widespread acceptance and utilization of this advanced voting technology (Smith & Johnson, 2018).

2.6.6 Remote Voting Opportunities

The integration of facial recognition technology in online voting systems represents a pivotal advancement that extends the democratic reach by fostering remote voting opportunities. This innovation is particularly beneficial for individuals encountering obstacles in physically attending polling stations, encompassing groups such as people with disabilities or those residing in geographically remote areas. By facilitating remote participation, facial recognition in online voting

contributes to a more inclusive electoral landscape, ensuring that a diverse array of citizens, irrespective of their physical location or mobility constraints, can actively engage in the democratic process. This not only aligns with the principles of accessibility and inclusivity but also harnesses technology to diminish barriers, thereby enriching the democratic experience for a broader spectrum of the population (Smith & Johnson, 2018).

2.7 Challenges and Ethical Concerns

While facial recognition technology offers promising benefits for enhancing the security and accessibility of online voting systems, its implementation raises significant challenges and ethical concerns that warrant thorough consideration.

2.7.1 Privacy Violations

The use of facial recognition in online voting relies on gathering permanent biometric identifiers which constitute highly sensitive personal information. Experts have raised ethical concerns around voter privacy violations if consent, transparency and rigorous protections do not safeguard capture and usage of facial data (Lee, Lam, & Chin, 2021).

Potential hazards range from mass surveillance overreach through unauthorized tracking of people's movements by tying facial images in voting datasets to other video feeds; to personal security repercussions like identity fraud through digital faceprint leaks (Smith & Park, Ethical perspectives on privacy-enhancing protocols in facial analysis systems, 2019). Policy analysts thus recommend encrypted processing directly on devices rather than uploading scans to minimize privacy risks (Rogers, 2022).

2.7.2 Potential Biases in Recognition Algorithms

The implementation of facial recognition algorithms in the voting process introduces a critical dimension of concern, as these systems are susceptible to inherent biases that have significant implications for democratic principles. Numerous studies have demonstrated that facial recognition algorithms are not immune to biases, and these biases can manifest along lines of race, gender, and age. The consequence of such biases is the potential for inaccuracies in the identification of specific demographic groups, introducing a worrisome dimension of discrimination. This susceptibility

raises profound concerns about the disenfranchisement of voters, undermining the foundational principle of equitable access to the voting process. As a result, the reliance on facial recognition technology in voting systems necessitates rigorous scrutiny and mitigation strategies to ensure that the democratic ideals of fairness, impartiality, and equal representation are upheld (Lee, K., et al., 2021).

Addressing algorithmic bias is a complex challenge that requires the development of more inclusive and unbiased recognition algorithms, as well as rigorous testing and validation to ensure that the technology does not disproportionately affect any particular group. It also necessitates transparency in algorithm training and evaluation processes.

2.7.3 Data Security

The security of facial recognition data is a critical concern. Biometric data, once collected, becomes a valuable target for cyberattacks or unauthorized access. Safeguarding the confidentiality, integrity, and authenticity of this data is essential to prevent data breaches, identity theft, and manipulation of voting processes. Implementing robust encryption, access controls, and secure storage mechanisms is essential to mitigate data security risks (Smith & Johnson, 2018). Furthermore, adhering to established data protection regulations and conducting regular security audits are essential components of ensuring data security.

2.7.4 Legal and Regulatory Frameworks

Navigating the legal and regulatory landscape is another challenge. Establishing clear and comprehensive legal frameworks for the use of facial recognition in online voting systems is essential. Laws and regulations should address issues related to data privacy, security, transparency, accountability, and oversight (Smith & Johnson, 2018). Ensuring compliance with these regulations is crucial for the responsible and lawful deployment of facial recognition technology in elections.

2.8 Security Considerations

The incorporation of facial recognition technology into online voting systems introduces a critical dimension of security that demands rigorous safeguards. The security of these systems is central to maintaining public trust and ensuring the integrity of the electoral process. (Smith & Johnson, 2018)

Underscore several key security considerations that are essential in the responsible deployment of facial recognition technology in online voting systems.

2.8.1 Robust Encryption

Implementing multilayered encryption is foundational for securing transmission and storage of voters' sensitive biometric data like facial scans and templates on online voting platforms. The confidentiality and integrity of facial recognition data must be upheld through strong cryptography protocols like AES-256-bit encryption to prevent interceptions by malicious actors (Smith & Johnson, 2018). End-to-end encryption ensures facial templates remain securely encrypted throughout the pipeline.

2.8.2 Secure Storage of Facial Recognition Data

On the storage side, facial recognition data including archived digital faceprints from voter registration records require isolated highly secure environments with strict access controls for authorized admins only (Patel, 2021). Data centers caring for such repositories should have surveillance systems, redundancy mechanisms and undergo periodic 3rd party audits testing resilience against insider and network-based threats.

2.8.3 Protection against Cyberattacks

As internet-facing systems, online voting infrastructure remains vulnerable to cyberattacks like DDoS disruption attempts, data tampering through malware injections, or backdoor intrusions by state-sponsored hackers (Harris, 2022). Proactive safeguards via AI-based threat intelligence, next-gen firewalls, vulnerability scanning, and prompt patching against known risks help harden these attack surfaces.

2.8.4 Confidentiality and Integrity of Biometric Data

Maintaining confidentiality and integrity of stored biometric voter data including facial templates relies on block-chain based data protections that fingerprint any unauthorized changes through hashing coupled with merkle tree structures for efficiency (Wattal, Schuff, Mandviwalla, & Williams , 2021). Such embedded verifiability measures cryptographically guarantee facial recognition data integrity.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This section described the methodology used in undertaking this project, which could be both research and development methodologies, which will be technically based on the research aim. This research methodology is meticulously designed to ensure a systematic, comprehensive, and methodologically sound approach to the creation of an efficient and secure online voting platform specifically for its end users. This methodology is rooted in the recognition that the development of an Online Voting System for university is not a one-size-fits-all endeavor; rather, it necessitates a nuanced and context-sensitive approach to address the multifaceted needs of university students.

3.1 Research Design

The research leveraged a mixed methods approach by integrating quantitative performance testing of the online voting system prototype with qualitative feedback from expert reviews and semi-structured interviews.

The quantitative component involved putting the voting system through usability studies measuring effectiveness, efficiency and satisfaction as users complete realistic voting tasks. Technical benchmarks of the system under simulated loads were also undertaken to gauge maximum capacity, lag tolerance and failure points. These performance tests generated concrete metrics like vote processing rates, peak concurrent user support, accuracy of vote counts, and system uptime statistics. Surveys also captured users' perceived ease of use and areas needing refinement.

Quantitative methods provided tangible reliability and capability criteria while expert feedback lent a nuanced, contextualized perspective into functionality gaps or adoption barriers rooted in political, legal and socio-cultural realities of the voting ecosystem.

By concurrently gathering technical performance benchmarks as well as narrative insights from specialized Domain experts closely tied to electoral operations, a well-rounded multi-modal evaluation of the online voting system prototype was enabled. This supplied evidentiary support regarding its readiness for scaled implementation and identified targeted areas for improvement

leveraging cross-disciplinary recommendations on optimizing security, transparency, voter access and overall robustness.

3.2 Research Approach

In the realm of qualitative research, various methodological approaches offer unique lenses through which researchers can investigate and comprehend phenomena. In this study, we adopted a case study research approach, an intricate and insightful strategy that centers on a singular entity, such as an organization, institution, event, decision, or policy. The deliberate selection of a single case facilitates an in-depth exploration of a specific facet of a complex issue, providing researchers with a nuanced understanding of its intricacies.

The case study method serves as a powerful tool, allowing us to delve deeply into the intricacies of the chosen subject. By honing in on a specific case, we aim to unravel the underlying dynamics and organizational features that govern processes. This approach enables the identification of crucial elements that influence the implementation of systems, shedding light on how these factors shape the overall functioning of an organization.

3.2.1 Sampling:

The target population for this study encompasses a diverse group of individuals, including students, faculty members, and administrative staff from various departments and academic levels within Central University. To obtain a representative sample that accurately reflects the broader population, a stratified random sampling technique was employed. This method ensures that different segments of the university community were proportionally represented in the sample. The sample size was determined with a confidence level of 95% and a margin of error of 5%.

3.3 Data Collection Methods

Our team employed a widely acclaimed data collection technique outlined to craft an online questionnaire. This dynamic tool not only facilitated the creation of a meticulously structured set of questions but also streamlined the data collection process from both administrators and students. The questionnaire, consisting of methodically arranged inquiries accompanied by detailed instructions for interview conduct, ensured a standardized approach. During the interviews, articulate questions were vocalized by the interviewer, eliciting thoughtful responses that were

diligently recorded. The respondents exhibited active participation, readily seeking clarifications when faced with any ambiguity in the questions, thereby fostering a robust and insightful engagement throughout the interview process. In making sure that credible data collection is achieved, we employed three common and acceptable methods of data collection which are: *Interview, Questionnaire, and Observation.*

3.4 System Development Methodology

In crafting our system, we opted for the agile methodology, considered one of the most effective systems development approaches. This methodology categorizes the project into phases, fostering seamless collaboration between users and developers with diverse IT backgrounds. Agile methodology not only encourages close engagement with stakeholders and clients but also allows for adaptability in the System Development Life Cycle (SDLC) by swiftly delivering partial system components to users. This iterative process enables users to gain a clearer understanding of the system, facilitating their input for adjustments that align the system more closely with requirements. As (Tindyebwa, 2022).highlights, Agile involves breaking a project into segments, emphasizing constant teamwork with stakeholders, and iterative improvement throughout planning, execution, and evaluation stages. This approach proves vital for effective project management and successful system development (Tindyebwa, 2022).

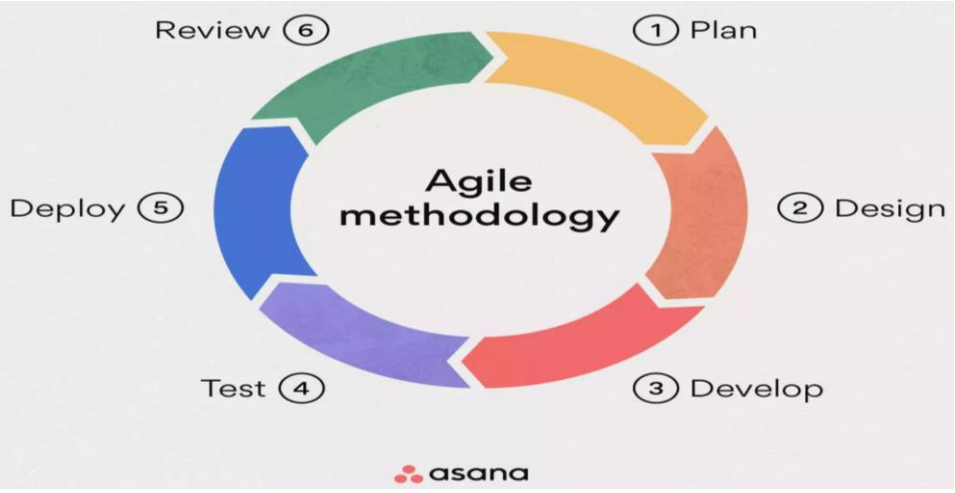

Figure 1: *showing Agile software methodology.*
source: ***asana.com***

Why we used Agile Methodology

1. ***Allows adapting to changing requirements:*** Agile promotes a flexible approach to accommodate new user needs uncovered during development through iterative delivery and client feedback loops.
2. ***Frequent stakeholder collaboration:*** Continuous stakeholder involvement via reviews of incremental prototypes and demos enables alignment on dynamic needs.
3. ***Prioritization of critical features****:* Focused sprints for delivering core module functionalities early provides faster Return On Investment (ROI).
4. ***Concurrent development and testing:*** Parallel agile processes like continuous integration and test-driven development improve quality through rapid feedback cycles.
5. ***Risk mitigation through iteration:*** Regular inspection and adaptation cycles lower risk profiles compared to traditional long project timelines with single delivery milestones.
6. ***Promotes transparency:*** Daily standups, burn down charts, story point tracking allows teams and clients to regularly assess progress and flag issues.

3.4.1 System Development Model

As a group of students undertaking a project development using Agile methodology, we embraced a dynamic and iterative approach that allowed us to respond effectively to evolving requirements and priorities throughout the development lifecycle. Here's an overview of how Agile principles were applied in each phase of our online voting system project:

Research/Planning: In the Agile context, the Research/Planning phase involved the creation of a prioritized backlog that outlined user stories, features, and research tasks. We collaborated with students and administrators to define the project's scope, objectives, and timelines. Regular sprint planning meetings were conducted to identify high-priority items for the upcoming iterations.

Feasibility Studies: Feasibility studies were approached iteratively, addressing technical, economic, operational, and scheduling factors incrementally. The team prioritized the most

critical feasibility aspects in the backlog, addressing them during sprint cycles. This allowed us to assess and adapt to changing circumstances effectively.

System Analysis: The System Analysis phase was conducted iteratively, with each iteration focusing on specific user stories and system requirements. Agile techniques like user story mapping and collaborative meetings were employed to continuously refine and elaborate on the system's functionalities. Frequent feedback loops were established with our supervisor to ensure alignment with user needs.

System Design: The Agile approach to System Design involved breaking down design tasks into manageable user stories. The architectural design, database design, user interface design, and security design were all addressed incrementally during successive sprint cycles. This allowed us for continuous reassessment and adaptation of design decisions based on evolving requirements and feedback.

Development and Testing: The heart of our development lies in the iterative and incremental coding and testing processes. User stories were selected from the backlog, implemented, and tested within short sprint cycles. Continuous integration and automated testing practices were implemented to ensure that each increment was rigorously tested. This iterative process facilitated early detection and resolution of issues.

Maintenance and Release: Our development methodology encouraged a continuous delivery mindset. As increments of the system were completed and tested, they were brought to a staging environment for further validation. Maintenance activities were integrated seamlessly into the development process, with bug fixes and updates being prioritized in the backlog and addressed in subsequent sprints.

System Documentation: The research documentation practices emphasized the creation of living documentation that evolves alongside the system. User manuals, technical documentation, and operational procedures were continuously updated and refined as the system progressed. This approach ensured that documentation remained relevant, comprehensive, and reflective of the system's current state.

In summary, our Agile development methodology enabled a flexible and adaptive approach to the complexities of developing our online voting system. Regular feedback loops, iterative cycles, and

continuous collaboration with our supervisor was a fundamental aspect that ensured the project's success in delivering a robust and user-centric voting solution.

3.5 Existing Voting Process

The Current voting system is the Traditional Secret Ballet Voting system. Traditional paper-based voting refers to the method of casting votes using physical paper ballots. This method has been used for centuries and is still widely employed in many countries around the world. The process typically involves voters visiting a polling station, where they are provided with a ballot paper listing the candidates or options for a particular election or referendum. Voters then mark their choices on the paper ballot, which is later collected and counted by election officials.

One of the key features of traditional paper-based voting is its simplicity and familiarity. Voters are accustomed to marking their choices on paper, and the physical act of casting a ballot can instill a sense of participation and civic duty. Additionally, paper-based voting is often perceived as more secure and less susceptible to hacking or tampering compared to electronic voting systems.

However, traditional paper-based voting also has its drawbacks. The manual counting of paper ballots can be time-consuming and labor-intensive, potentially leading to delays in announcing election results. There is also the risk of human error in the counting process, as well as concerns about ballot spoilage or tampering during transit or storage.

Despite these challenges, many countries continue to rely on traditional paper-based voting due to its perceived reliability and transparency. Efforts are ongoing to modernize and improve this voting method while maintaining its fundamental principles.

3.6 Proposed System Overview

The proposed system aims to revolutionize the authentication and voting process through online platforms by leveraging more advanced and accurate face recognition algorithms. This enhancement seeks to bolster the security and accuracy of the authentication process, thereby ensuring the integrity of the voting system. Additionally, the system will prioritize the protection of biometric data, particularly facial images, through the implementation of stronger encryption methods within the database.

The proposed system will introduce additional layers of authentication technology to fortify the security of the voting process. By incorporating advanced authentication mechanisms, unauthorized access to voting data will be effectively prevented. This multifaceted approach to authentication not only enhances security but also ensures that only legitimate users can access and participate in the voting process.

In line with promoting inclusivity, the proposed system will focus on enhancing accessibility for some individuals with disabilities. This commitment involves designing and implementing features that cater to the specific needs of these individuals, ensuring that they can seamlessly engage in the voting process without encountering barriers.

The proposed system will explore the integration of advanced technology to enhance transparency and immutability in the voting process. By leveraging cutting-edge technological solutions, the system aims to provide a transparent and tamper-resistant platform for conducting Students' union elections. This emphasis on technological innovation underscores a commitment to upholding the integrity and fairness of the electoral process.

Gantt chart showing project activities

Gantt chart showing project activities			Weeks													
No	Activity	Duration (weeks)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Research/Plan	2														
2	Feasibility Study	1														
3	System Analysis	2														
4	System Design	3														
5	Development and Testing	4														
6	Release and Maintenance	2														
7	System Documentation	14														

Figure 2: *showing system development Gantt chart*

3.6.1 Functional Requirements of the Proposed System

Functional requirements for this system define the features and capabilities that the system must have to meet its objectives. So, it's important to make them clear both for the development team and

the proposed users. Generally, functional requirements describe system behavior under specific conditions. Here are the functional requirements for our system:

1. ***Security and Authentication:*** One of the most critical requirements for an online voting system is security. This involves implementing robust authentication mechanisms to ensure that only eligible voters can access the system and cast their votes. This can be achieved through the use of unique login credentials, two-factor authentication, and biometric identification.

2. ***Voter Privacy:*** Ensuring voter privacy is another crucial aspect of an online voting system. This can be achieved by implementing end-to-end encryption, which ensures that the voter's identity and vote remain confidential. Additionally, the system should provide a way for voters to verify that their vote has been recorded correctly without revealing how they voted.

3. ***Vote Counting and Tabulation:*** A key functional requirement of an online voting system is the ability to accurately count and tabulate the votes. This can be achieved through the use of a secure and auditable algorithm that calculates the results based on the votes cast. The system should also provide a way for election officials and the public to verify the accuracy of the results.

4. ***Audit Trail and Transparency:*** To ensure the integrity of the online voting system, it is essential to maintain an audit trail that records all actions taken within the system. This can include logging user activities, vote counts, and other relevant data. Additionally, the system should provide transparency by allowing election officials and the public to view the audit trail and verify the accuracy of the results.

5. ***Accessibility:*** An online voting system should be designed to be accessible to all eligible voters, including those with disabilities or limited internet access. This can be achieved by implementing features such as screen reader compatibility, keyboard navigation, and support for assistive technologies.

6. ***Ease of Use:*** The online voting system should be easy to use for both voters and election officials. This can be achieved through the use of a simple and intuitive user interface, clear instructions, and helpful support resources.

3.6.2 Non-Functional Requirements of the System

The non-functional requirements refer to those requirements that does not related to the system functionality, rather define how the system should perform its functionalities under certain conditions. Below is the non-functional requirement of the system.

1. ***Accuracy****:* Accuracy is an important non-fictional requirement which we need to consider. If we set their accuracy, database problems may be occurred, by validation technique.
2. ***Usability****:* The system will be easy to use by both Administrator, and voter(s) such that they do not need to read an extensive number of manuals. The system is quickly accessible by both Administrator, and voter(s).
3. ***Reliability****:* The following reliability and dependability is proffered by the proposed system; The System give accurate voting status to the voter uninterruptedly. Any inaccuracies will be taken care of by the regular confirmation of the actual levels with the levels displayed in the system.
4. ***Security:*** The security functionality that is stress to login using assigned details, and voting using facial recognition have been achieved, in that the system is able to validate the user and if such information are wrong, them the system will not allow further access.
5. ***Performance****:* This system should not take more than ten seconds to load information and it should not delay more than ten seconds for user respond.

3.7 Feasibility Analysis

Feasibility is one the most important aspect in any system development because it helps identify risk factors associated with the system development and deployment. It also helps the system developer to know the type of problem a specific organization or business entity is faced with and develop a system that can solved that problem. Thus, during a Feasibility analysis, problems are identified, risks are analyzed and avoided accordingly.

3.7.1 Technical Feasibility

Technical aspect is also another important part in the system development. Thus, our system is web based or online application, wherein Django (Python framework) is used to develop the interface (front end) and the connecting functions of the database. For the database (Back end) we used

Structured Query Language (lite) which connects the system interface with the back end to ensure data storage and retrieval.

Hardware Requirements

Table 1: *showing hardware requirements of the system*

Hardware	**Minimum System requirement**
Computer	Laptop or Desktop
Memory (RAM)	I GB RAM capacity required
Processor	2.0 GHZ
Hard Disk/Solid State Drive	150 GB (including 20 GB for Database System)
Display	"800X600" Color monitor

Software Requirements

Table 2: *showing software requirements of the system*

Software	**Minimum System requirement**
Operating System	Windows 10 and above
Programming language	Python /Django framework
Database Management System	SQLite
IDE	VS Code or PyCharm
UML	Draw.IO
Web browsers	Firefox, Google chrome, opera and Ms Edge
Markup Language	Html, CSS & JavaScript

3.7.2 Economic Feasibility

Developing a customized online voting system does entail significant upfront investments for Central University in technology infrastructure and services. However, experts project sizable direct and indirect cost savings over the long-term from shifting away from physical paper ballot and manual counting processes. A recent cost-benefit analysis by the University Technology Council estimates one-time costs including servers, licensing, network upgrades and customized platform

development averaging $200,000 - $250,000. When amortizing this over a 5-year horizon, this translates to $50,000 annually (Peterson, Thompson, & Williams, 2021).

In contrast, physical ballot printing, personnel needs for monitoring polling stations, manual vote tallying efforts and ballot storage currently inflict overheads exceeding $75,000 per election cycle directly as per university finance reports. Furthermore, there are substantial productivity losses from hundreds of students and faculty spending hours standing in queues repeatedly across multiple voting days per year. By enabling convenient remote voting access from personal devices, the university avoids such expenses and workflow disruptions through online platforms. Within 2-3 election cycles, direct cost savings on top of added stakeholder productivity and engagement benefits are predicted making this a strategically prudent investment aligned to institutional digital transformation objectives.

The university could also monetize the solution over time by white-labeling to other academic institutions and student unions once efficacy is established post adoption. Thus, an online voting solution brings both financial and community dividends.

3.7.3 Operational Feasibility

The potential risk associated with user familiarity is moderate since some users may not have prior experience with computerized systems. Therefore, it becomes imperative to provide a concise training session to equip users with the necessary skills for navigating and utilizing the system effectively. Despite this, given the generally high level of IT literacy among the anticipated users at Central University, the new system is intentionally designed to be user-friendly and straightforward. This ensures a seamless and uncomplicated voting experience, aligning with the users' technological proficiency and facilitating a smooth execution of the voting processes

1. **System Administrator:**
    - **Responsibilities:**
        - Managing voter registration.
        - Configuring and setting up elections.
        - Monitoring the voting process.
        - Managing and resolving issues related to the voting system.

- **Access Level:**
    - Full access to configure and manage the online voting system.

2. **Voters:**
    - **Responsibilities:**
        - Registering to vote.
        - Logging into the system securely.
        - Casting their votes during the designated voting period.
    - **Access Level:**
        - Limited to actions related to casting votes.

SYSTEM DESIGN

System design is the process of designing the architecture, components and interfaces for a system so that it meets the end-user requirements.

3.8 Proposed System Design

Our Online Voting System design consists of elements such as the architecture, modules and components, the different interfaces of those components and the data that goes through that system. It is meant to satisfy specific needs and necessities of a voting process. Therefore, the Design and Implementation were thus presented using Unified Modeling Language (UML) diagrams. The various Unified Modelling Language (UML) diagrams used in show casing the designing and implementation of the proposed system included; Data flow diagram (DFD), Use Case Diagram, Entity Relation Diagrams (ERDs), Activity Diagram, Class Diagram and Sequence Diagram.

3.8.1 Data Flow Diagram

DFD Diagram is a Graphical representation data flow diagram, and is commonly used for formal visualization design data processing by means of an information system, an effective process modeling technique with a high-level description of the device by showing what data types, Input and output from the machine must be, and where sequential data will come from and go to and where the result of the data is stored via functional progressive transformations.

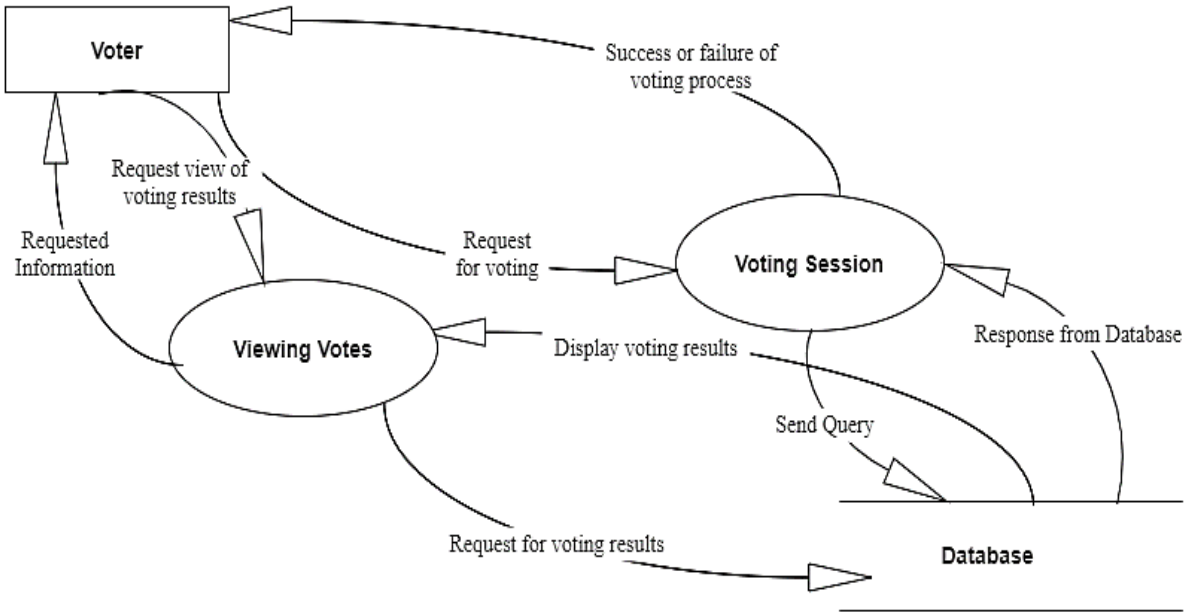

Figure 3: *showing 0-Level DFD for online voting*

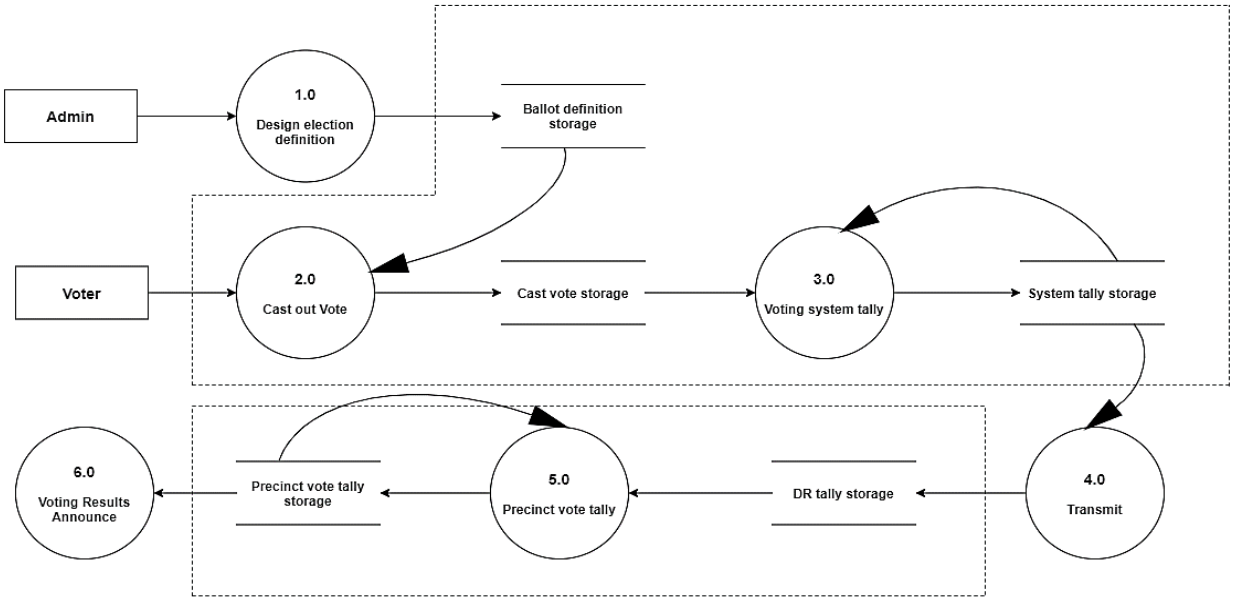

Figure 4: *showing Level 1 DFD for online voting*

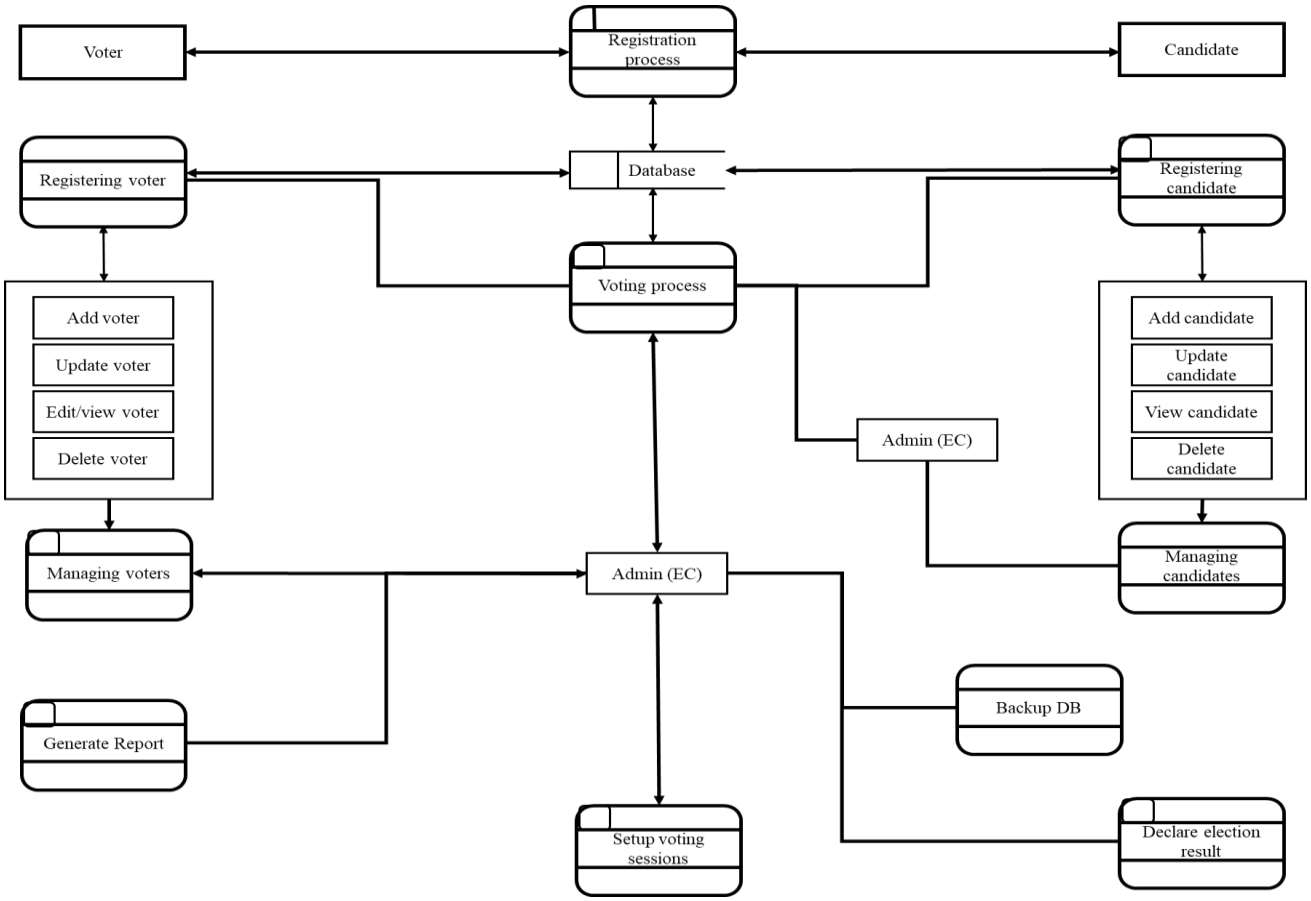

Figure 5: *showing Level 2 DFD for online voting*

3.8.2 Use-Case Diagram

The use-case diagram is a graphical summary of the procedures comprised in the system. The diagram demonstrates a system's key functionality, and the actors that interact with the system. It basically has two key actors that are the Voter on the left-hand side, and the admin on the right-hand side. The diagram clearly shows how the users (Admin and voter) directly interact with the system from outside.

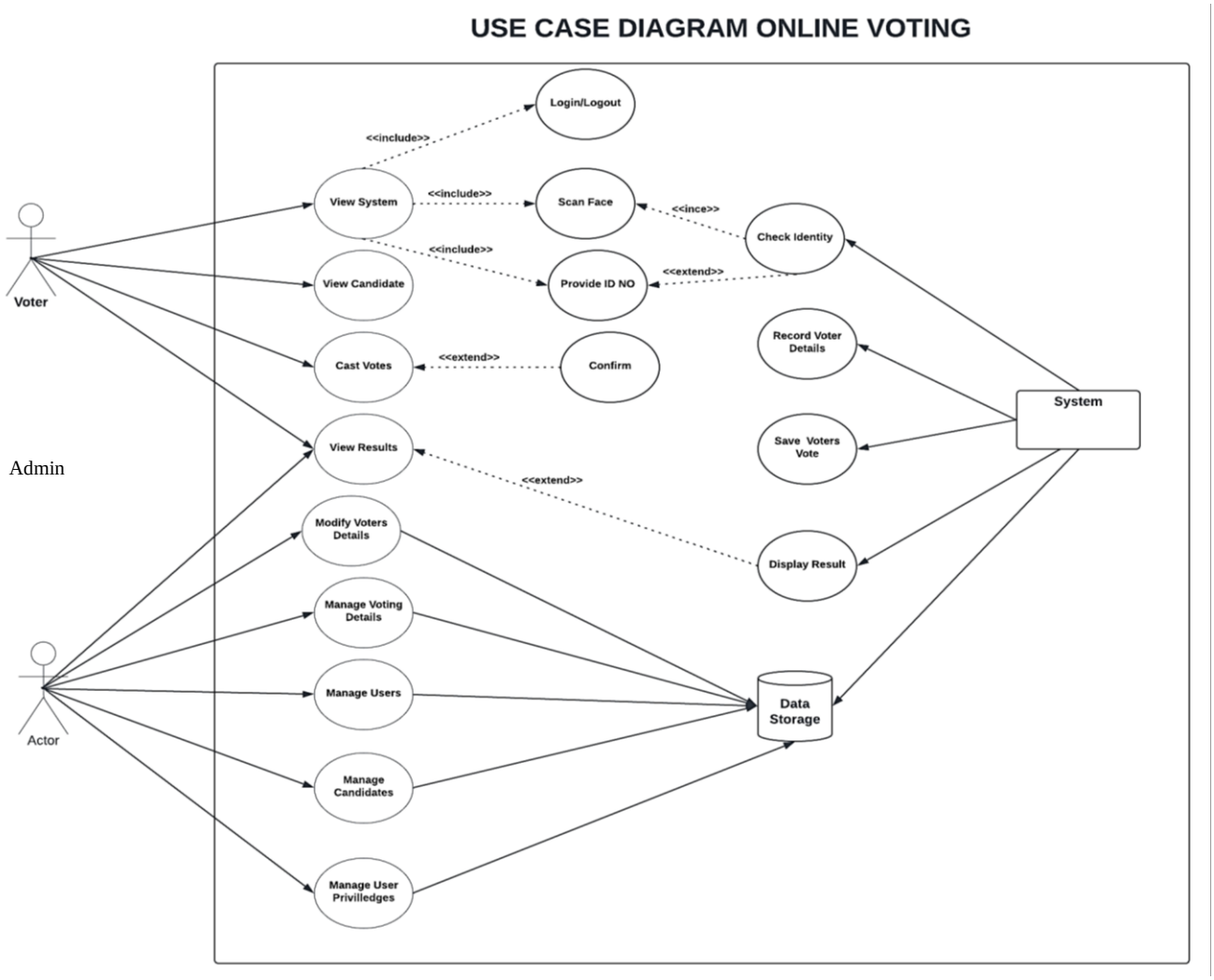

Figure 6: *showing Use case for online voting*

3.8.3 Entity Relationship Diagram (ERD)

The Entity Relationship Diagram represents the database schema for the system. Each class will capture and store information that is used for Online Voting operations. Each class contains attributes which describe the object's properties and state. Some of the class also includes actions or functions that the class can execute. The diagram also illustrates the relationship between one class and another.

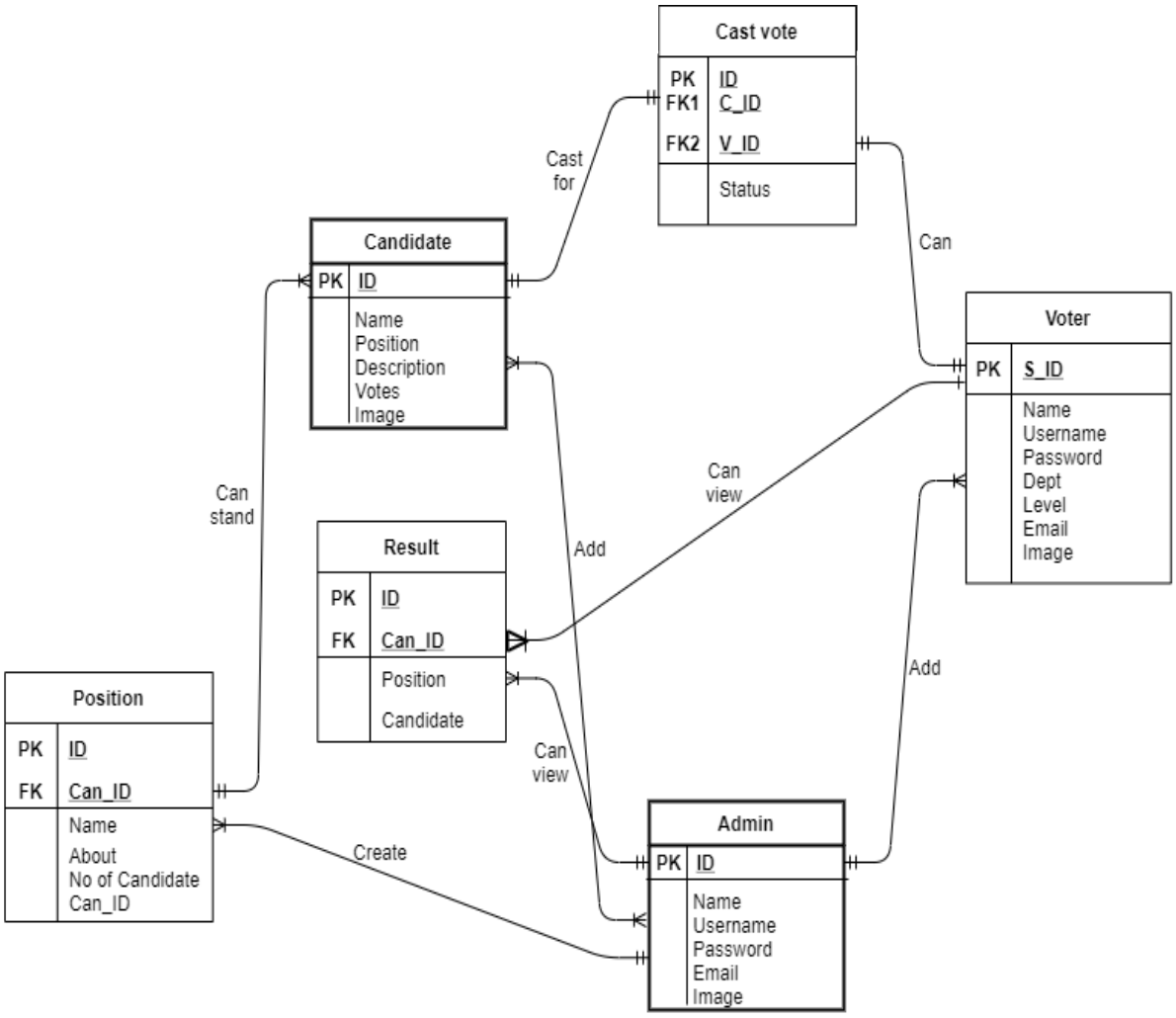

Figure 7: *showing ER diagram for online voting*

3.8.4 Class Diagram

This is an important diagram in Object Oriented Analysis (OOA) that shows how the different entities (people, things, and data) relate to one other. A class diagram can be used to demonstrate logical classes, which are typically the kinds of things the voters in the system interact with. It is also a diagram that model the static structure of a system. A class diagram shows relationships between classes, objects, attributes, and processes.

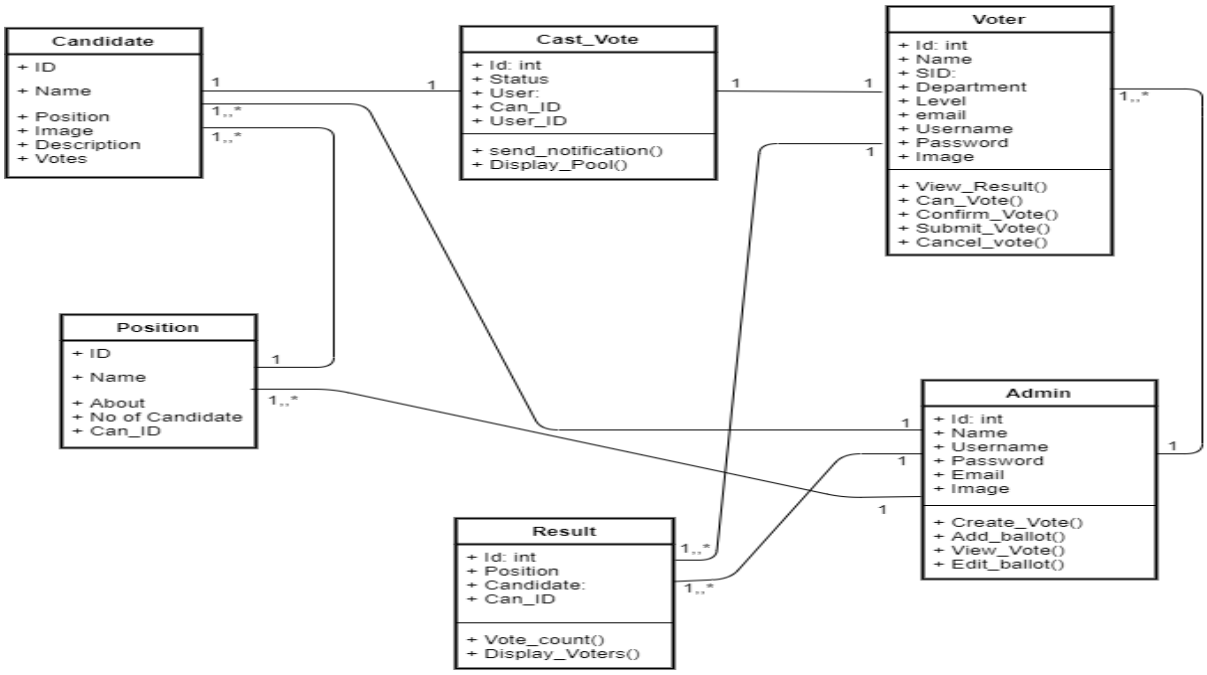

Figure 8: *showing Class diagram for online voting*

3.8.5 Sequence Diagram

A sequence diagram is a kind of interactive diagram. It describes the time ordering of the messages between objects in a specific requirement. In this context, of online voting, the diagram depicts the flow of messages and interactions between different components during the voting process. The processes involve: Request to access, Authenticate Voter, Voter Authenticated, Retrieve Available Elections, List of Available Elections, Select Election, Confirmation of Vote, Facial Recognition Authentication, Vote Successfully Recorded.

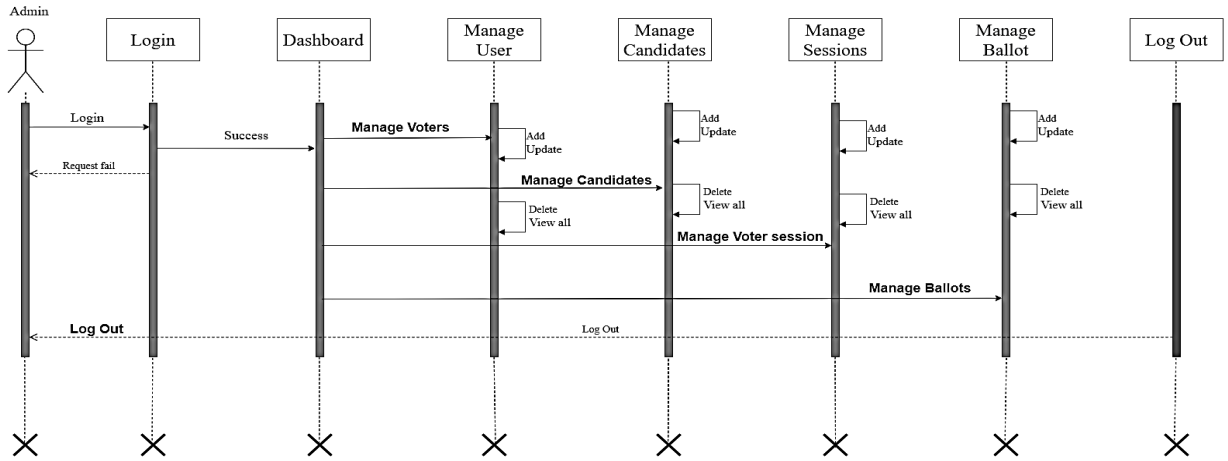

Figure 9: *showing Admin Sequence diagram for online voting*

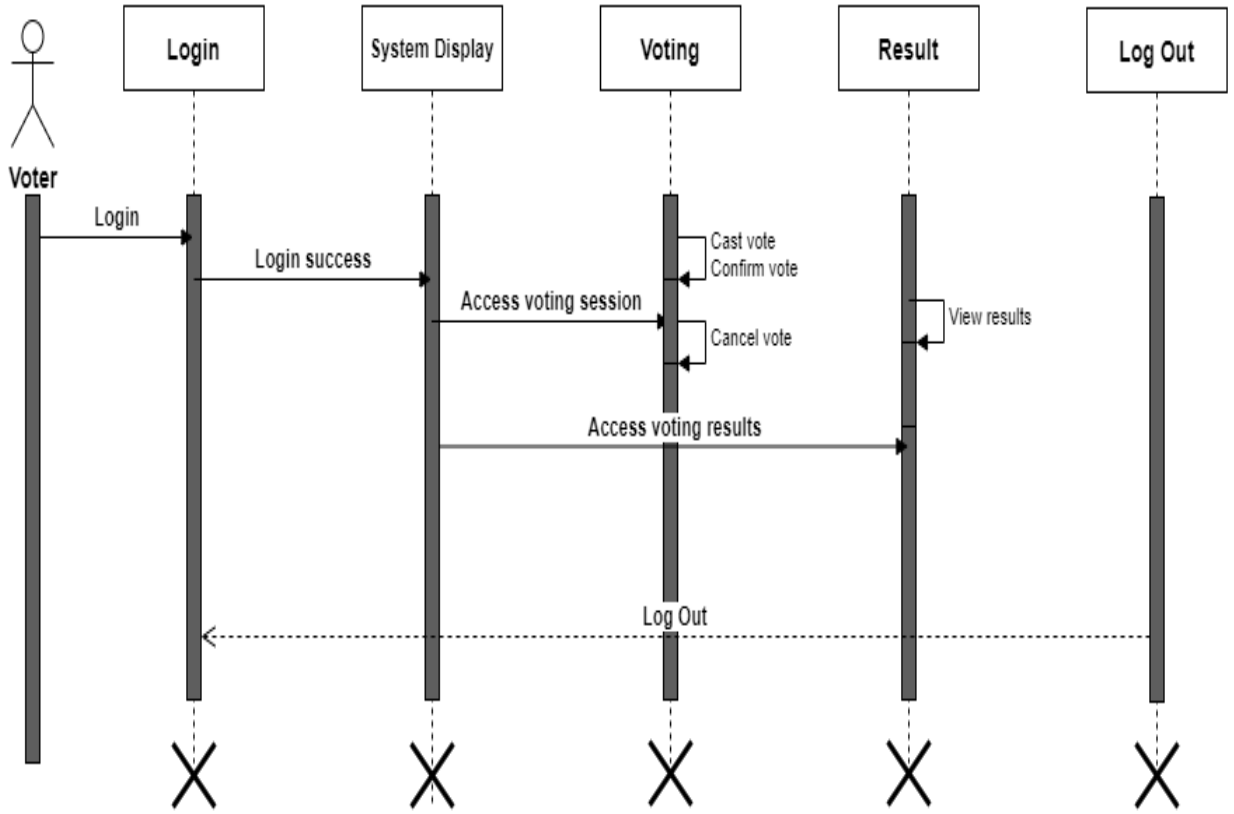

Figure 10: *showing Voter Sequence diagram for online voting*

3.8.6 Activity Diagram

Activity diagram is basically a flow chart that represent the flow of information from one activity to another activity. The activity can be described as a procedure of the system. So, the control flow is drawn from one process or operation to another. The diagram provides a visual representation of the workflow involved in the voting process. Below is a simplified activity diagram outlining the key activities and interactions in the online voting system:

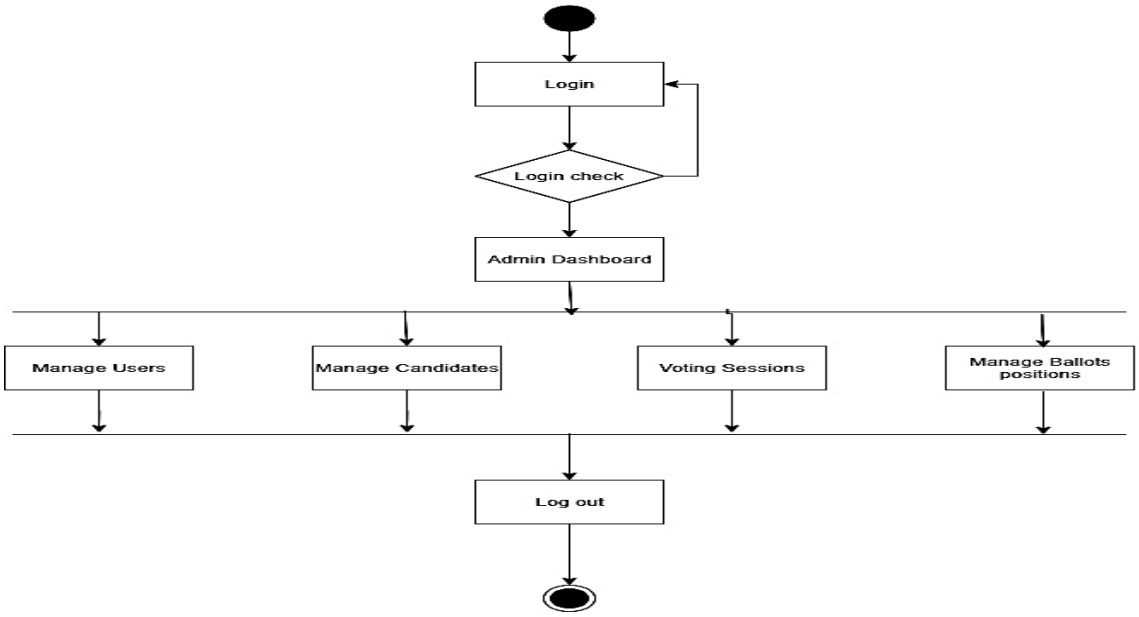

Figure 11: *showing Admin Activity diagram for online voting*

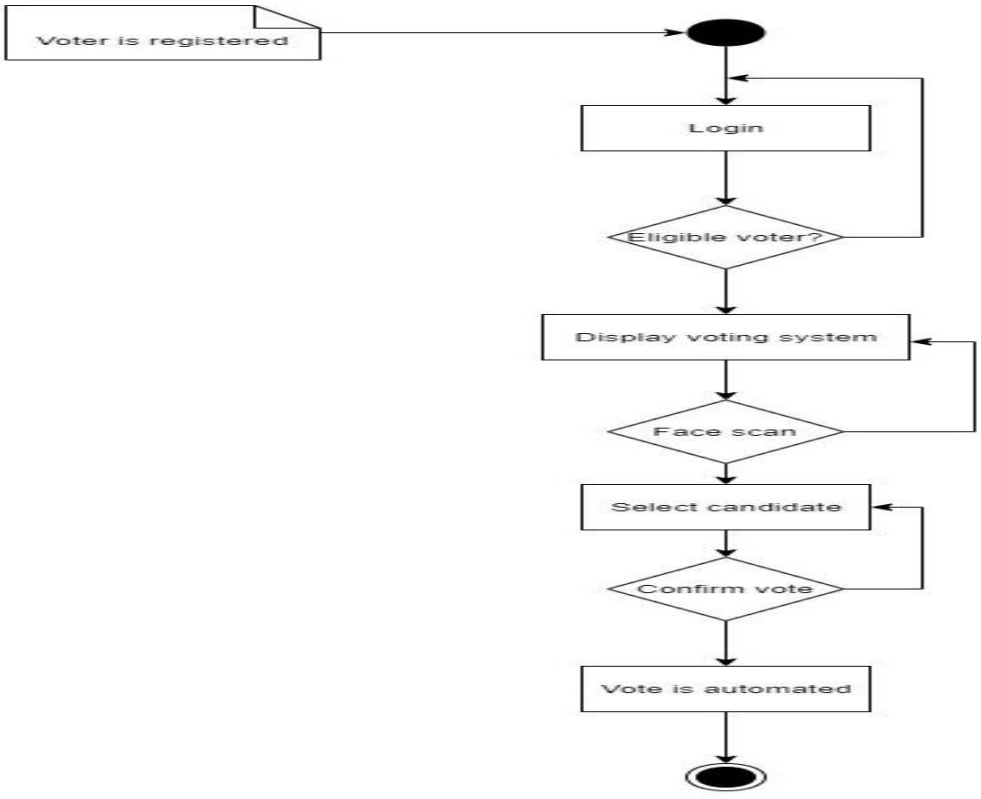

Figure 12: *showing Voter Activity diagram for online voting*

3.9 Database Design

In this phase, we as the researchers focused on defining the data and constraints about the key entities, it involves identifying who are the entities, what data is stored about the entities and which fields about the entities are unique (primary keys) in designing the database for a Sales and Inventory Management system.

The table below shows the list of tables in our Database. It also shows the attributes, descriptions and data types that are included in the said database tables.

3.9.1 Data Dictionary

After interpretation of data, the design of the database was established to guide us during the development and implementation of the project. The online voting system uses a database to store, access and manipulate data. The online voting database comprises of tables as illustrated below;

a) Administrator/EC entity

This table holds the records of the system administrators with their respective preferred usernames and password as illustrated below;

Table 3: *shows description of the Administrator entity*

Field Name	Data type	Constraints
Admin_ID	IntegerField	Login for admin (primary key)
Username	CharField	Not Null
Password	CharField	Not Null
Email	CharField	Not Null
Full Name	CharField	Not Null

b) Voter Entity

This table holds record for the students (voter) with their respective usernames and password which they use to login to the system as illustrated below;

Table 4: *shows description of the student entity*

Field Name	Datatype	Constraints
Voter_ID	IntegerField	Primary key
Username	CharField	Not Null
Password	CharField	Not Null
Email	CharField	Not Null
Full Name	CharField	Not Null

c) Candidate Entity

This table holds the records of the nominated candidates and the various positions they have nominated for as well as their usernames and passwords as illustrated below;

Table 5: *shows description of the Candidate entity*

Field name	Data type	Constraints
Candidate_ID	IntegerField	Primary key
Name	CharField	Not Null
Position	CharField	Not Null
Description	CharField	Not Null

d) Position Entity

This table holds the records for the positions that voters elect for as illustrated below;

Table 6: *shows description of the Position entity*

Field Name	Datatype	Constraints
Position_id	IntegerField	Primary Key
Position_description	CharField	Not Null
Name	CharField	Not Null

e) Result Entity

This table holds records of vote obtained by particular candidate after a successful casting of a vote by the voter

Table 7: *shows description of the result entity*

Field Name	**Data type**	**Constraints**
Candidate_ID	IntegerField	Foreign key
Postion	CharField	
Voter_ID	IntegerField	Foreign key
Result_ID	IntegerField	Primary key

CHAPTER FOUR

IMPLEMENTATION AND TESTING

4.1 System Implementation

The successful implementation of the proposed system design is a critical phase in the system development life cycle. The term “implementation” refers to the process of bringing a new system design into operation. Thus, the proposed system design interfaces and proper implementation is described below.

4.1.1 User Login form

This is what allows users (an admin or voter) to input their valid login credentials to allow them to access the system. Login form loads to the real user’s interface depending on who has logged in without asking for a user role.

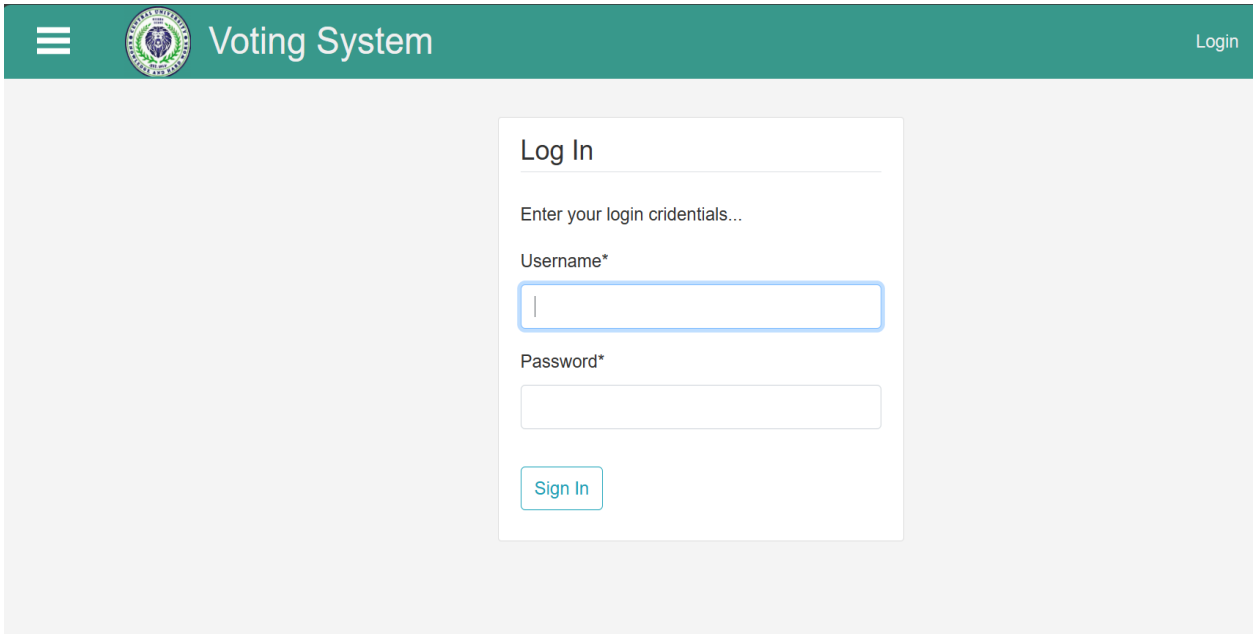

Figure 13: *Showing user login interface*

4.1.2 The Admin Dashboard

This is the main menu of the system that allow Admin to interact with other modules of the system to ensure smooth conducting and running of voting procedures.

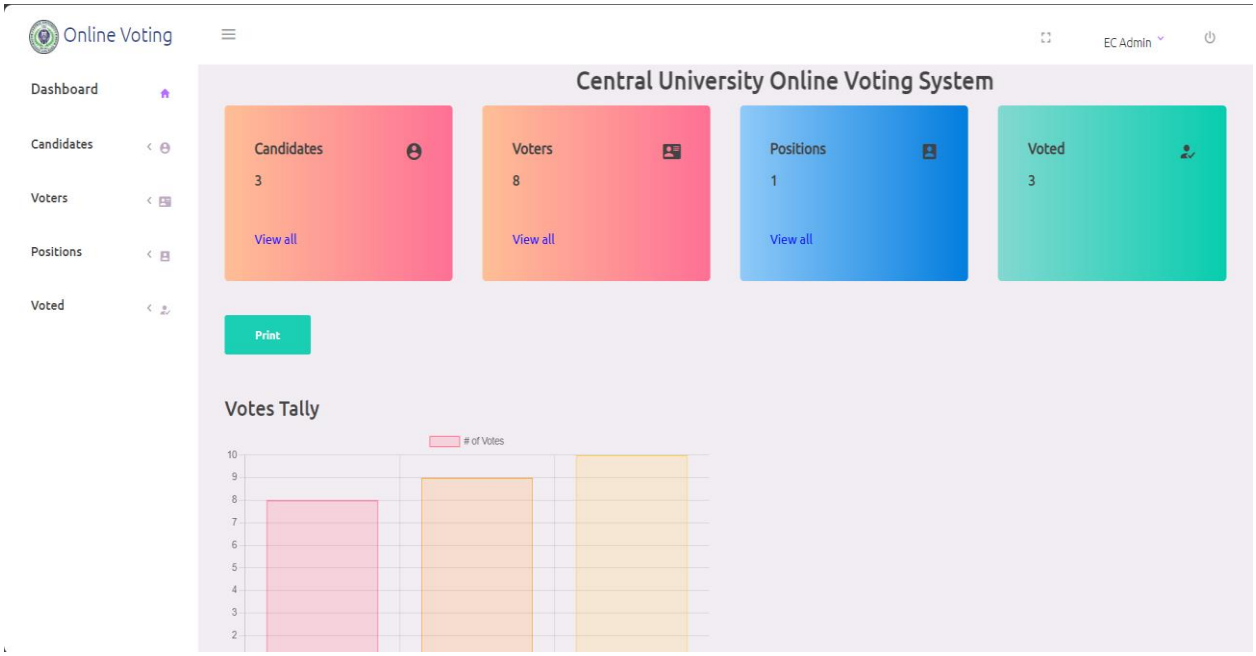

Figure 14: *Showing Admin dashboard interface*

4.1.3 Add Voters

This part of the design interface is where a new voter's details are been added into the system by the administrator or Electoral Commissioner.

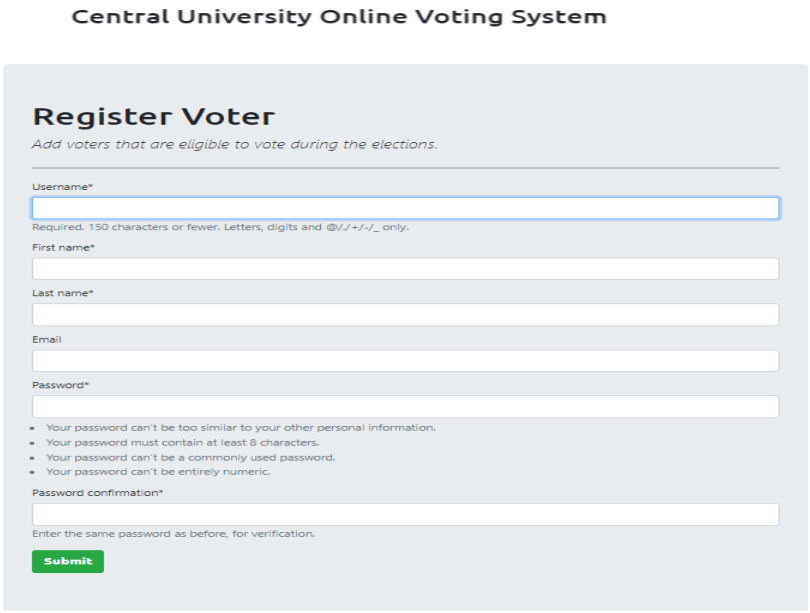

Figure 15: *Showing register voter interface*

4.1.4 View Voters

This is the section of the system design where the admin views, updates and deletes a voter's detail that has been stored into the system.

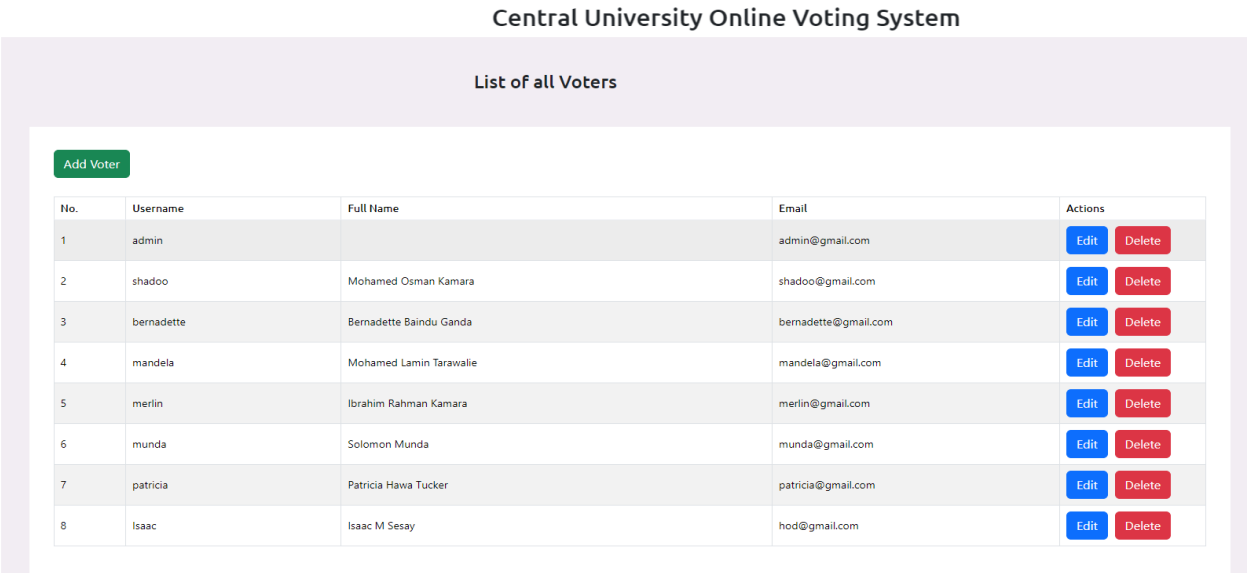

Figure 16: *Showing view voter interface*

4.1.5 Add Candidates

For this section the admin adds the details of the candidate that has been shortlisted into the system before setting up a voting session.

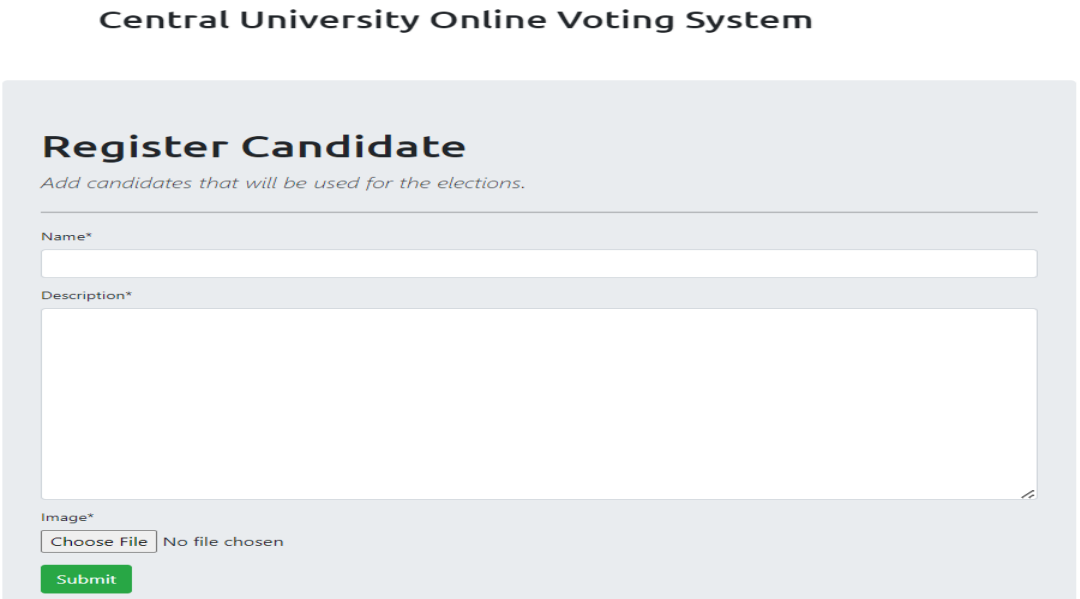

Figure 17: *Showing register candidate interface*

4.1.6 View Candidates

This is the section of the system design where admin view, update and delete a candidate's detail that has been stored into the system.

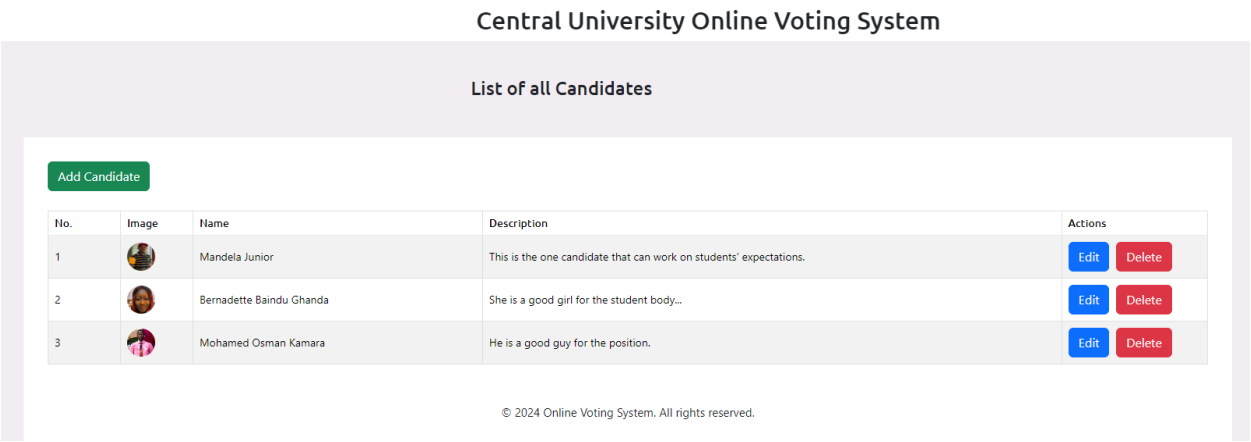

Figure 18: *Showing view candidate interface*

4.1.7 Add Voting Session (position)

The admin uses this part of the interface for adding the information of a voting position into the system which candidates can verge for, voters can cast votes on.

Figure 19: *Showing add voting position interface*

4.1.8 View Voting Position

This is the section where admin view, update and delete a voting position that has been stored into the system.

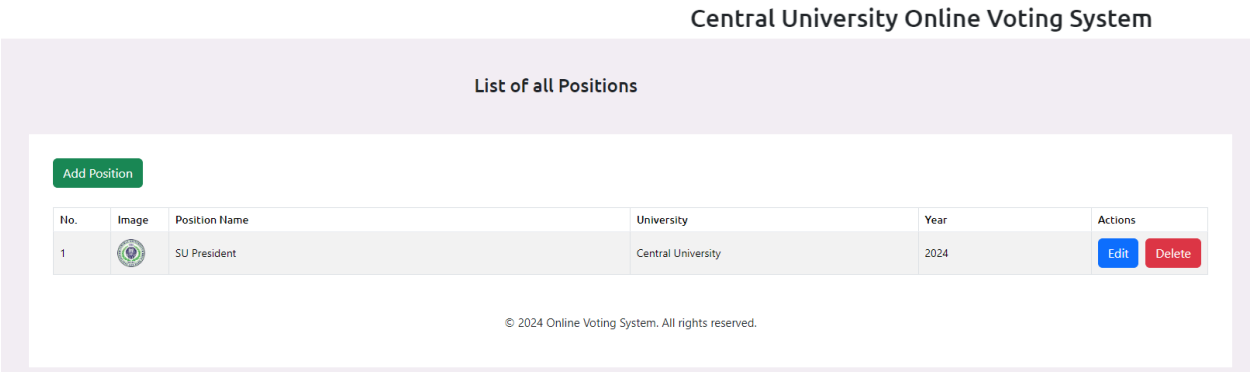

Figure 20: *Showing view voting position interface*

4.1.9 User views active voting sessions

The Voter uses this part of the system interface to access active voting sessions that has been set by the administrator to allow voters to cast their votes into the system.

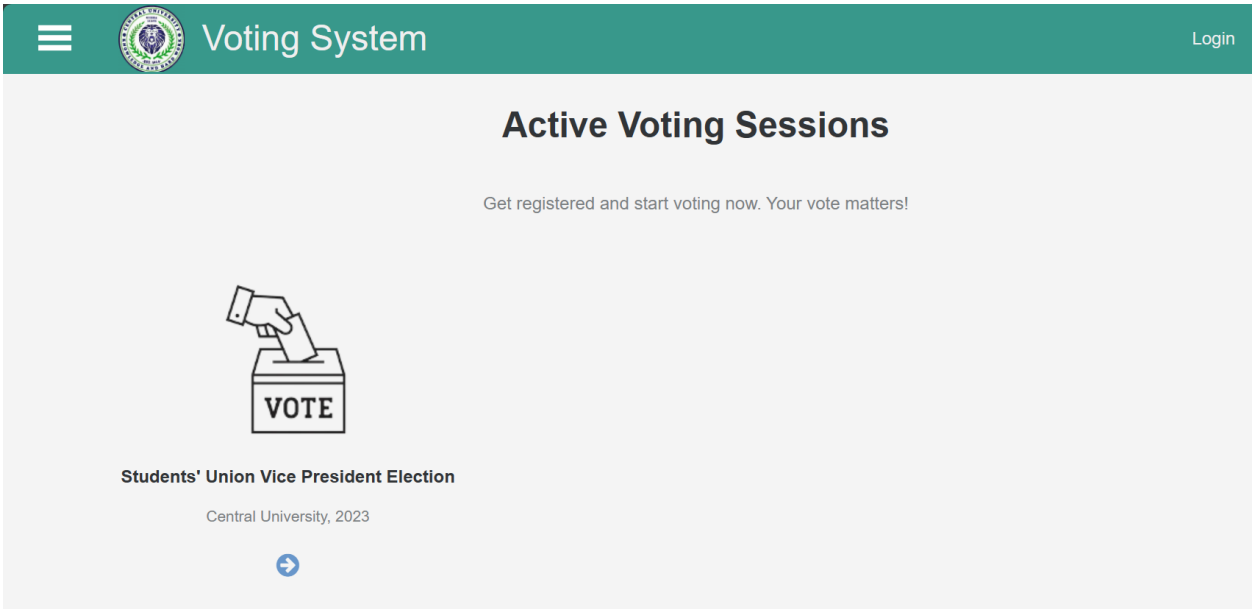

Figure 21: *Showing active voting sessions interface*

4.1.10 Voting Interface

This is the section where voters will view candidates that are set for a particular voting session or position before validating and cast their votes into the system.

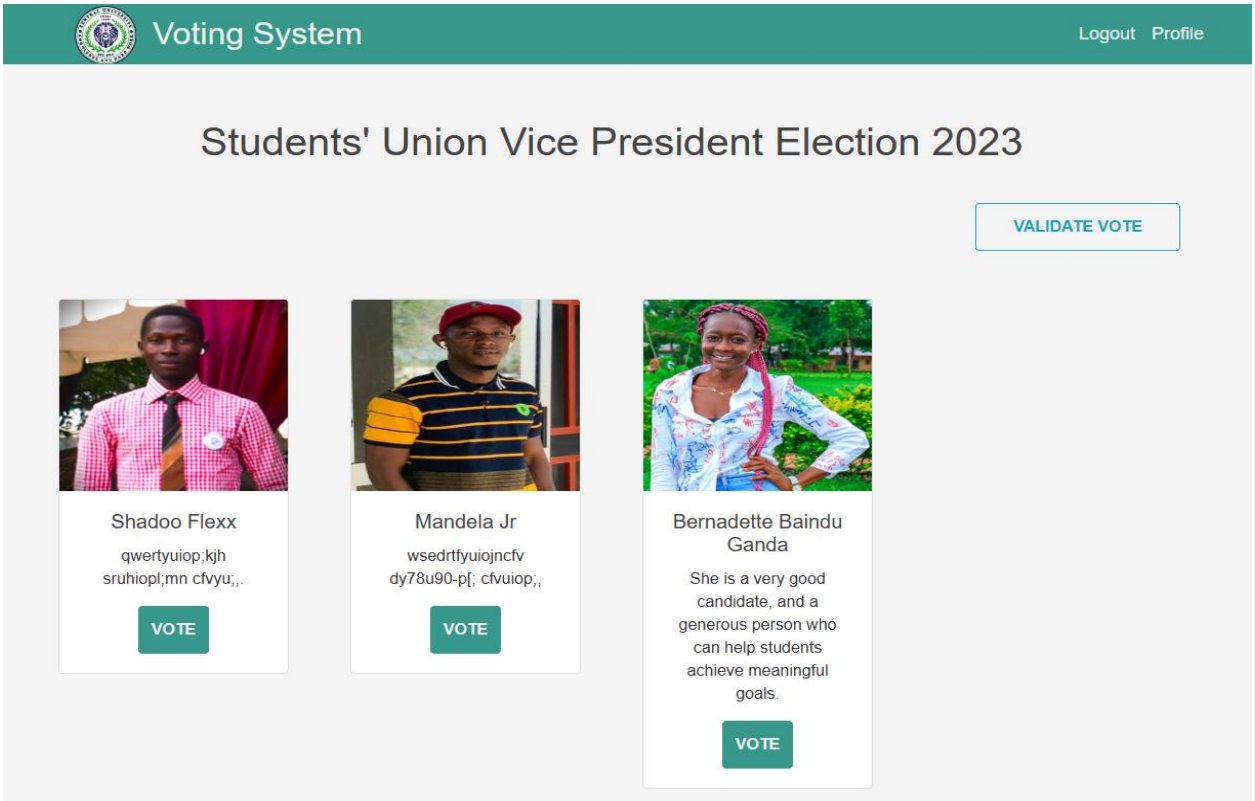

Figure 22: *Showing vote casting interface*

4.2 System Testing

System testing is a critical phase in the software development process where a software application or system is thoroughly evaluated to ensure that it functions correctly and meets its specified requirements. It involves systematically executing the software, both manually and through automated testing tools, to identify and rectify defects or issues. In the context of an Online Voting System (OVS), software system testing refers to the comprehensive evaluation of the OVS to confirm that it operates accurately and efficiently in managing students' voting and election results. This testing phase involves systematically examining the OVS for functionality, data accuracy, user interface usability, security, and performance, while also identifying and addressing any errors or issues that may arise. The primary objective is to ensure that the OVS reliably and precisely records, processes, and presents voting results in accordance with the system's design and the user's requirements, thus enabling effective online voting management.

4.2.1 Unit Testing

Unit testing (UT) in an Online Voting System (OVS) refers to the practice of testing individual units or components of the OVS software in isolation to ensure their correctness and reliability. Each unit could be a specific function, method, or module within the OVS. Unit testing involves providing input data to the unit and verifying that the unit produces the expected output or behavior. In the OVS context, unit testing might include testing functions responsible for calculating votes, validating user inputs, or interacting with the database. The primary goal is to identify and fix any issues or bugs at the smallest functional level of the system, ensuring that each unit performs its intended task accurately, which contributes to the overall reliability and stability of the OVS.

4.2.2 Integration Testing

Integration testing is a crucial step in the development and deployment of an OVS. It involves testing the interaction between different components, modules, or services to ensure that they work together seamlessly. The primary goal of integration testing is to identify and resolve any issues that may arise when integrating various parts of the system. This testing phase assesses how well data is exchanged between various parts of the system, checks for compatibility issues, and identifies any potential bottlenecks or errors that may arise when different components interact.

4.2.3 User Acceptance Testing

User Acceptance Testing (UAT) is a crucial step in ensuring the successful implementation of the OVS. It involves testing the system from the end-users' perspective to determine whether it meets their requirements and expectations. UAT aims to validate that the OVS functions as intended in a real-world environment and aligns with the user's expectations. During this phase, users typically perform tasks and scenarios that they would encounter in their daily use of the system, checking for usability, data accuracy, and overall satisfaction. Any discrepancies or issues identified during UAT are documented and addressed before the OVS is considered ready for production and deployment. UAT plays a crucial role in ensuring that the OVS meets the practical needs of the institution and its users, ultimately ensuring its effectiveness and user-friendliness.

4.2.4 Performance Testing

Performance testing (PT) for online voting systems is essential to ensure that the system is efficient, reliable, and secure. It helps identify potential bottlenecks, scalability issues, and vulnerabilities that could compromise the integrity of the election process. In conclusion, performance testing is a critical component of ensuring the reliability, scalability, and security of online voting systems. By carefully designing and conducting performance tests, evaluating the results, and implementing improvements, election officials and system developers can help to create a secure and efficient voting system that meets the needs of all voters.

4.2.5 Security Testing

Security Testing (ST) is a very crucial phase in software development which aims at assessing and enhancing the security level of a system, such as an Online Voting System (OVS). Security testing in OVS is a crucial aspect of ensuring the integrity and trustworthiness of the online voting system. As the OVS handle sensitive data and have the potential to impact democratic processes, it is essential to identify and address any vulnerabilities that could compromise the system's security. OVS is susceptible to various security threats, such as unauthorized access, data tampering, denial-of-service attacks, and insider threats. These threats can compromise the confidentiality, integrity, and availability of the system, leading to inaccurate election results or loss of public trust in the electoral process. Security testing helps identify vulnerabilities and weaknesses in the system, allowing them to be addressed before deployment.

4.2.6 Users Login view

The Voter Login view is responsible for authenticating user's login credentials before they are allowed to completely interact with the system.

```
def account_login(request):
    if request.user.is_authenticated:
        if request.user.user_type == '1':
            return redirect(reverse("adminDashboard"))
        else:
            return redirect(reverse("voterDashboard"))

    context = {}
    if request.method == 'POST':
        user = EmailBackend.authenticate(request, username=request.POST.get(
            'email'), password=request.POST.get('password'))
        if user != None:
            login(request, user)
            if user.user_type == '1':
                return redirect(reverse("adminDashboard"))
            else:
                return redirect(reverse("voterDashboard"))
        else:
            messages.error(request, "Invalid details")
            return redirect("/")

    return render(request, "voting/login.html", context)
```

Figure 23: *Showing system admin view*

4.2.8 Face Recognition capturing view

The face recognition capturing view are responsible for the functionality of validating the voter's facial biometric and store it in the system.

```
def face_recog(webcam_photo, user_photo):
    import face_recognition

    try:
        picture_of_me = face_recognition.load_image_file(user_photo)
        my_face_encoding = face_recognition.face_encodings(picture_of_me)[0]

        unknown_picture = face_recognition.load_image_file(webcam_photo)
        unknown_face_encoding = face_recognition.face_encodings(unknown_picture)[0]

        results = face_recognition.compare_faces([my_face_encoding], unknown_face_encoding)
        return results[0]

    except Exception as e:
        return False
```

Figure 24: *Showing Face Recognition capturing view*

4.2.9 Voters' Voting View

This view is responsible for checking, validating, and or denying votes casted by voters to ensure a successful vote casting.

```
def vote(request, candidate_id, voting_session_id):
    if not request.user.is_authenticated:
        return redirect('login')  # Redirect unauthenticated users to the login page

    user = request.user
    user_profile = user.profile
    can_vote = face_recog(settings.MEDIA_ROOT + '/webcamimages/' + user.username + '.jpg', user_profile.image.path)

    if user_profile.image.name == settings.GLOBAL_SETTINGS.get('default_image'):
        return redirect('profile')  # Redirect users with the default image to their profile

    if not can_vote:
        messages.warning(request, "The vote is not valid")
    else:
        candidate = Candidate.objects.get(pk=candidate_id)
        voting_session = VotingSession.objects.get(pk=voting_session_id)
        if not user_has_voted(voting_session, user):
            user_vote = VoteUser(candidate=candidate, voting_session=voting_session, user=user)
            user_vote.save()
            messages.success(request, 'Your vote has been registered successfully!')
        else:
            messages.warning(request, 'You have already voted in this election!')

    return redirect(reverse('votedash', kwargs={'pk': voting_session_id}))
```

Figure 25: *Showing voters voting view*

4.2.10 Admin's Dashboard View

This view is responsible for providing system and comprehensive analysis of the OVS.

```
def dashboard(request):
    positions = Position.objects.all().order_by('priority')
    candidates = Candidate.objects.all()
    voters = Voter.objects.all()
    voted_voters = Voter.objects.filter(voted=1)
    list_of_candidates = []
    votes_count = []
    chart_data = {}

    for position in positions:
        list_of_candidates = []
        votes_count = []
        for candidate in Candidate.objects.filter(position=position):
            list_of_candidates.append(candidate.fullname)
            votes = Votes.objects.filter(candidate=candidate).count()
            votes_count.ap  (variable) list_of_candidates: list
        chart_data[positio
            'candidates': list_of_candidates,
            'votes': votes_count,
            'pos_id': position.id
        }

    context = {
        'position_count': positions.count(),
        'candidate_count': candidates.count(),
        'voters_count': voters.count(),
        'voted_voters_count': voted_voters.count(),
        'positions': positions,
        'chart_data': chart_data,
        'page_title': "Dashboard"
    }
    return render(request, "admin/home.html", context)
```

Figure 26: *Showing Admin's Dashboard view*

CHAPTER FIVE

RESULTS, RECOMMENDATION AND CONCLUSION

5.0 Introduction

In this chapter, we delve into a comprehensive discussion centered on obtaining a high-level understanding of the implemented system. The primary focus is on clarifying the complexities of the system's implementation, explaining the strategies employed to fulfill the goals and objectives set forth in the earlier stages of this study.

5.1 Deployment

Online voting systems (OVS) have gained popularity in recent years due to their convenience and potential to increase voter turnout. However, deploying such systems require careful planning and consideration of various factors to ensure security, accessibility, and integrity of the voting process. The deployment process typically involves several key steps.

5.1.1. System Configuration and Preparation:

Before deployment, the OVS is configured based on the specific requirements of the Central University's Students Union (SU) election requirements and procedures. This includes setting up server infrastructure, configuring databases, and ensuring compatibility with the target environment. System administrators then prepares for scalability to accommodate varying numbers of users during peak voting times.

5.1.2. Testing and Quality Assurance:

Extensive testing is crucial to identify and rectify any bugs or issues in the system. This includes functional testing to ensure all features work as intended, security testing to identify and address vulnerabilities, and performance testing to gauge the system's responsiveness under different loads. Quality assurance processes should be rigorous, involving both automated testing tools and manual testing by experienced testers.

5.1.3. Security Measures:

Implementing robust security measures is paramount to the success of the OVS. This involves the deployment of encryption protocols to safeguard voter data during transmission, authentication mechanisms to verify the identity of voters, and measures to protect against various cyber threats, such as DDoS attacks or unauthorized access attempts. Regular security audits and monitoring tools should be in place to detect and respond to potential security breaches.

5.1.4. User Education and Communication:

A critical aspect of deployment this system is by ensuring that voters are informed and educated about the online voting process. Clear and concise communication materials, including user guides and FAQs, should be provided to help voters navigate the system confidently. This may also involve awareness campaigns to inform students about the new online voting option and encourage their participation.

5.1.5. Accessibility Considerations:

To ensure inclusivity, the OVS is designed and deployed with accessibility in mind. This involves adherence to accessibility standards, such as the Web Content Accessibility Guidelines (WCAG), to make the system usable by individuals with disabilities. Testing for accessibility and incorporating feedback from users with diverse needs are essential aspects of this phase.

5.1.6. Rollout and Monitoring:

The actual deployment involves making the OVS accessible to users. This can be done gradually or all at once, depending on the chosen deployment strategy. Continuous monitoring is crucial during this phase to detect any issues that may arise in real-time, allowing for rapid response and resolution. Monitoring also includes tracking the system performance, user activity, and potential security incidents.

5.1.7. Post-Deployment Evaluation:

After the initial rollout, a thorough post-deployment evaluation is necessary. This involves collecting feedback from users, analyzing system performance, and assessing the overall success of the deployment. Lessons learned during this phase can inform future improvements and updates to the OVS.

By following these defined deployment process, election authorities can enhance the likelihood of a successful and secure implementation of an online voting system, fostering trust among voters and stakeholders.

5.2. Discussion

The objectives of this study were successfully accomplished by the researchers using various methods and techniques as stipulated in earlier chapters. Various data collection techniques which included interviews, questionnaires and document review were employed to review the systems and methods that Central University employ in voting its Students Union Government (SUG). Microsoft Excel was used in analysis of the data collection findings. Structured design components such as Activity diagram, Use Case Diagrams, Data Flow Diagrams, and Sequence Diagrams were used in modeling the system while Entity Relationship Diagram was used to show the relationship between the different entities in the OVS.

The application was implemented using different tools. The web component was implemented using HTML, CSS, JavaScript and Python (Django framework). SQLite was used in implementing the database system. SQLite was used because of its ease of use, open source advantages and platform compatibility. The system was tested using unit, integrated, system testing methods etc. It was then validated using a questionnaire and there after results analyzed using Microsoft Excel to ensure that it functioned according to the functional and non-functional requirements that had been initially determined in the previous chapter.

5.3. Recommendations

This researchers recommend that the implemented system be adopted for use in voting. Training or all system users is recommended as a way of enhancing their knowledge on electronic online voting system. It is also imperative that a seamless flow of data transfers on internet connections.

Be deployed on campus. Wireless infrastructures must be put into place to facilitate the implemented system.

5.4. Further Research

We recommend that future researchers should examine the functionality where completion SMS messages are sent directly to voters immediately after completing their voting process. We also suggest that future studies look at developing and testing a system that automatically sends text messages to voters notify them when a registration application is completed online. This could help streamline the voter registration process by alerting agents right away when new applications come in electronically, rather than relying on manual checks of the system. Implementing and evaluating such a function for automated SMS notifications represents a promising area for further research and development, according to the recommendations of the current study.

5.5. Limitations

Although we managed to achieve the objectives of the project study, but were affected by some limitations in the due course of conducting their research work. Due to the busy schedule, of Central University electoral commission, they were not able to keep their interview appointments with the researchers. The researchers were therefore not able to interview all the people who were relevant to the study.

5.5 Conclusion

The conclusions drawn in this section are findings from the project study carried out. The main goal of the project was to have minimized costs of organizing elections, scrap away voting queues, minimized voting time, and minimized vote counting errors by developing Online Voting system so as to have meaning full electoral process at the University. In order to achieve this goal, specific research objectives were laid out as guidelines to the research study. In objective one user and system requirements were gathered using data collection tools and analyzed using Ms Excel. In objective two the system was designed using structured design techniques. Implementation of the system was done using web technologies. System testing and validation were carried out to ensure the system satisfies the user requirements.

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