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UNIVERSITY OF IBADAN,
IBADAN, OYO STATE, NIGERIA**

CSC 495: PROJECTS

**ADESUA OLUWATOSIN ADELEYE
MATRICULATION NUMBER: 165335**

**A DOCUMENTATION OF MY FINAL YEAR PROJECT
TITLED:**

**“ONLINE VOTING SYSTEM WITH BIOMETRIC
AUTHENTICATION FOR UI ELECTIONS”**

**SUPERVISED BY:
DR. O.F.W ONIFADE**

**IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR
THE AWARD OF A BACHELOR OF SCIENCE (B.Sc.)
DEGREE IN COMPUTER SCIENCE
(B.Sc. COMPUTER SCIENCE)**

JANUARY 2015

CERTIFICATION

I certify that this project work titled “ONLINE VOTING SYSTEM WITH BIOMETRIC AUTHENTICATION FOR UI ELECTIONS” was carried out and written by ADESUA OLUWATOSIN ADELEYE of the department of Computer Science, University Of Ibadan under My Supervision

DR. A.B. ADEYEMO

Head, Computer Science Department

.....

Date and Signature

DR. O.F.W ONIFADE

Supervisor

.....

Date and Signature

DEDICATION

This project and indeed the success of undergraduate program is dedicated solely to Jesus Christ - my ever present helper and lifter up of my head. The ONE who scripted my path in life from the foundations of eternity and who has guided me through all bends and curves in life's journey. I RETURN ALL THE GLORY TO HIM

ACKNOWLEDGEMENT

I would like to acknowledge and appreciate my family for being there for me all through the journey: Dad and Mom, Mike, Mercy, Faith and yes, Oluwatamilore, for being a source of inspiration to me. You kept me focused all the way while nudging me still to reach for more. You all are the best!

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To the Computer Science Academia, the H.O.D – Dr. A.B. Adeyemo, Dr. S.O. Akinola, Dr. (Mrs.) B. Oladejo, Dr. Akinkunmi, Dr. (Mrs.) Folajimi, Mrs. C.N. Woods, Mrs. Ogunseye and to all staff who have imparted on my life during my course. I say a BIG THANK YOU.

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ABSTRACT

The proposed online voting system with biometric authentication is an electronic voting system which seeks to make use of the uniqueness of the minutiae of the human fingerprint to further enhance the level of trust and confidentiality of the voters in the system as well as making the actual process as universally accessible as possible which would be achieved through the deployment on the Internet. It is expected to solve the two critical issues facing staff elections conducted within the University of Ibadan community which serves as the project case study.

For the voter registration and authentication processes which are performed on the desktop module, the voter is expected to have his or her fingerprints captured and the minutiae extracted that is stored on the database. This is done to prevent the occurrence of multiple registrations or identity. Thus, during the authentication period, voters are expected to undergo a matching verification of their fingerprint samples against the values stored in the database which is identified through the use of a unique voter identification number assigned during registration

The project was able to achieve a high success rate in the use for conducting elections as it was able to stamp multiple registrations by voters through the combined use of both the unique voter identification number and their unique fingerprints. This effectively solved all questions that may arise on eligibility of voters and accreditation hiccups. Voters can thus proceed to the online module of the project to cast their votes through any internet – connected device using the voter identification number, security answer keyed in during the registration process as well as a token key that was generated automatically for each voter per election on the online module. The token is sent by the administrator to each voter through his or her associated email. Worthy to note is that though voting is now done ubiquitously, it must be carried out during the stipulated period as contained in the email message sent to the voters.

Conclusively, the University of Ibadan Online Voting System with biometric authentication project, has been able to deliver an electronic voting system that solves all the highlighted challenges of the traditional system of conducting staff elections within the University of Ibadan, offering voters a trusted and credible means of exercising their franchise with great ease. It is therefore recommended to be deployed fully in subsequent staff elections.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In a democratic system of governance, election is very crucial and the integrity of the electoral process is sacrosanct. Election is a repetitive operation that occurs every specified period of time. Adding to that is the fact that there are different types of elections and/or different scopes of elections and the need to support multiple elections.

Democracy thus encourages individual freedom according to the rule of law, so that people may behave and express themselves as they choose. This not only gives people a chance to choose their leaders, but also to freely express their views on issues.

Voting through an election forms an important part of democracy and for democracy to be sustainable, the voter's participation is a key consideration. Apart from voters being encouraged to exercise this democratic right, the election that facilitates the function must be credible, watertight and free of bias. In addition to providing for the orderly transfer of power, it also cements the citizen's trust and confidence in an organization or government when it operates efficiently. Society is becoming more and more web / collaboration oriented, and citizens, used to the high degree of flexibility in the services provided by the private sector and in the Internet in particular, are now beginning to set demanding standards for the delivery of services by governments using modern electronic delivery methods.

The key concerns of elections and essence of a voting system is Transparency: ordinary voters should be able to understand and observe the vote casting and counting process, even with relatively nominal education as well as Trust.

The implementation of electronic voting would allow increased access to the voting process for millions of potential voters. Higher levels of voter participation will lend greater legitimacy

to the electoral process and should help to reverse the trend towards voter apathy that is fast becoming a feature of many democratic societies. It is also recognized that more traditional voting methods will exist for some time to come, so a means is needed to make these more efficient and integrate them with the newer electronic methods. (*The Oasis View*)

Online voting is an electronic way of choosing leaders via a web driven application. The advantage of online voting over the common “queue method” is that the voters have the choice of voting at their own free time within the stipulated election voting period and there is no need to queue up. It also minimizes on errors of vote counting. The individual votes are submitted into a database which can be queried to find out who of the aspirants for a given post has the highest number of votes.

This system is geared towards increasing the credibility and ease of the voting procedure of staff elections in the University of Ibadan since it has been noted that with the old voting method (the Queue System), the voter turnout has been a wanting case.

1.2 STATEMENT OF THE PROBLEM

In any instance of an election involving the academic staff of the University of Ibadan, it has been observed that there are primarily two major issues that are usually sources of problems to the voting population.

Firstly, it is usually commonplace that dispute over the issue of Eligibility or otherwise of the staff voters arises a lot. This is partly due to the varying staff levels on the academic ladder and also due to the time difference between dates of promotion to the next level.

Secondly, there are always incidences of staff voters been required to wait on long queues during election period thus leading to a situation where they are tired before they get the chance

to cast their vote and also due to the presence of the queue, aspirants and their campaign teams often exploit the situation to coerce voters into voting for them since all parties in the election are physically present.

The above factors combined to create a situation whereby any staff election is deemed not credible, and fair. Thus, there exists a vacuum for a system with features that would curb the inefficiencies of the current system

1.3 AIM/OBJECTIVES

The aim is to develop an application that seeks to use various stages of security authentication to enhance the electioneering process for staff elections using the case study, i.e. the University of Ibadan, ultimately providing an online platform which enables all eligible voters to exercise their franchise from any location during the election period.

The objectives are:

1. To create a secured online voting platform where authenticity of votes and voters are ensured with the use of mechanisms such as fingerprints registration and one – time password
2. To improve Voter's identification since biometric features cannot be shared
3. To ease the problem of queuing during voting period on elections

1.4 JUSTIFICATION

This project would leverage on the foundation built by a previous e-voting system that was developed and makes use of fingerprint identification during the registration process. It seeks to add the ability to access the voting application universally, that is, eligible voters are not

restricted by physical location as well as the use of a time-limited One – Time Password generated after the voter initiates the voting process to increase the security of the voting system.

1.5 SIGNIFICANCE OF STUDY

This study would help increase the level of trust in the entire staff electioneering process as well as ease the different difficulties previously clogging the system such as long queues, general time wasting and lack of credibility. It also ensures early availability of results and reduction of the overall cost of conducting an election. This would enhance the willingness of voters to participate in the elections and ultimately lead to the conduct of a credible election.

1.6 METHODOLOGY

The methodology of choice is Rapid Application Development (RAD); this is because the objectives of RAD include high speed, high quality and lowered cost. RAD emphasizes the use of special techniques and computer tools to speed up analysis, design and implementation phases. Tools include Computer Assisted Software Engineering (CASE) tools, Joint Application Design (JAD) and fourth generation programming languages. All of which are inline and essential to the proposed system.

The RAD methodology goes through the following phases:

Phase 1: Requirements Planning: refers to a review of the areas immediately associated with the proposed system. Areas associated with the proposed system include:

- Mode of user voting
- Mode of voter authentication

- Mode of data collection and verification
- Mode of data communication

1. User Voting: The proposed system would schedule elections by going through the following:

- Voters access the online voting portal and logs on with their personal Voter's Identification Number, in order to view to the voting page.
- On submission of the login request, the system checks to see if the specific voter is eligible to vote in the particular election and performs appropriate actions based on the result status returned from the check.
- If ineligible to vote, the system displays a corresponding message to the voter (staff) that he/she is not permitted to vote. If on the other hand, the voter is eligible to vote – an OTP (One – Time Password) is sent to the voter's registered phone and email. The OTP is then required to be entered on the appropriate screen after which the voter is shown the voting screen to select their choices for the given election.

2. Voter Authentication: This achieves our objective of ensuring a secured method of validating voters before they are allowed to cast their votes. Voters would be authenticated by verifying the unique identity details possessed by them. A common and easily implemented mode of verification is by OTP (One Time Password) combined with the unique personal Voter's Identification Number.

3. Data Collection and Verification: Before voters (staff) can be verified, there's a need for pre-recorded data in the memory i.e. database of the system. Consequently, the data of every prospective voter (staff) needs to be collected to allow verification. Data of currently employed University of Ibadan Staff would simply be obtained from the University's ITeMS unit after

all permissions required are granted. This includes all necessary details needed to effectively create an election ID for them as well as enable the proposed system to determine their eligibility for various elections.

4. **Data Communication:** The proposed system would operate on an internet. This allows all voters to have access regardless of location as well as increase their ability to use a range of devices to cast their votes. This is a network only accessible by members of a particular organization. In this case, the university information would be sent over this network, from the hall. This information is not necessarily complex, but simply a list of students permitted to exit the campus from the hall. Essential additional information about the student may be sent. Other information concerning destination name of host, need not be sent. This information is simply required in the hall as this is the current requirements, to take a leave. At points of exits, precisely the school gate, information required is whether or not you have been cleared at your residential hall to exit school.

Phase 2: User Design: This stage would use various software modelling tools to illustrate the system's data and processes and to build a visual representation of critical system components. Also, the programming tools chosen to implement the proposed system were stated. A key milestone of this proposed system is to make it a much user friendly and easy to use.

1.7 SCOPE OF PROJECT

The scope of this project revolves around the developing of an online voting system that employs fingerprint registration as well as the use of a one-time password generated for each voter per election, which will allow voters to participate in the elections regardless of their physical location.

Academic Staff Elections in the University of Ibadan has been adopted as the case study for the system to be developed.

1.8 PROJECT OUTLINE

This work is divided into five chapters, carefully organized as follows:

Chapter one of this project gives an introduction to the project, explaining the purpose, scope, and, approach of the project.

Chapter two, the literature review, gives an explanation of concepts, theories, and protocols employed in the course of the project.

Chapter three give analysis and a step by step guide to the design of the Online Voting System with Biometric Authentication for UI Election.

Chapter four goes over the process of implementing and testing of the Online Voting System for UI Elections, detailing key hardware and software requirements for a successful deployment.

Chapter five gives a summary of the entire project and conclusions drawn up at the end of the project as well as recommendations.

1.9 CHAPTER SUMMARY

This chapter contains the introduction to the project and research area. It also contains the major problems to be solved by the project i.e. the aims and objectives. The chapter as well contains the scope to be covered during the project and the methodology used during development.

CHAPTER TWO

LITERATURE REVIEW

2.1 ELECTIONS (DEFINITION, TYPES AND HISTORY)

An election is a formal decision-making process by which a population or society chooses an individual to hold a political office. Elections have been the usual mechanism by which modern representative democracy operates that predates to as early as the 17th Century.

Elections are conducted both by public entities such as the government as well as private and business organizations, for example, choosing representatives for the Board of Directors of a company, professional club leadership and even, used in voluntary associations.

Types

In most democratic political systems, there are several types or categories of elections that are held which corresponds to the different layers of public governance or geographical jurisdiction. Common types of election categories thus include

- Presidential Elections
- Parliamentary Elections
- Governorship Elections
- Local Government Elections

Considering our given domain, that is, within the university political sphere, there are also various types of elections that are conducted based on several criteria that help in delineating the staff of the university into categories such as Academic or Non – Academic, Senior Staff, Cooperative Union, to mention a little.

The various ethnic groups in Nigeria also have different methods of electing their rulers (e.g. Obas, Emirs, Igwes, etc.) and/or key office holders in their traditional kingdoms.

2.2 VOTING SYSTEMS

There are two (2) categories under which voting systems can be classified, namely:

- Traditional or Paper – Ballot Voting Systems
- Electronic Voting Systems

2.3 PAPER-BALLOT VOTING SYSTEMS

The paper-based voting system can be described as the traditional means of voting that has been in used over the ages. It is also the default method of conducting elections in Nigeria as well as other countries around the world.

It operates by issuing paper ballots to eligible voters who present themselves at the polling unit on the day of the election. The voter is authenticated by searching for and ticking his or her name on the voters register for that particular polling unit. Indelible ink is used to mark an authenticated voter by dropping the ink on the voter's left thumb fingernail.

The voter is then expected to proceed to a secret booth to vote a candidate by pressing his right thumb into an ink stamp and placing the inked fingerprint in front of the chosen candidate on the ballot paper given and subsequently required to drop the ballot paper into a ballot box placed in an open place within the polling unit.



Figure 2.1: *A traditional means of voting by paper*

After the close of polls or voting for the election, the election ballot box for the polling unit is opened by the polling officer, the ballots are counted by the various election judges such as election agents and election officials and the total vote results are reported and entered onto the election results sheet which is also required to be signed by all election judges as well as observers present thus giving authenticity to the declared results.

2.3.1 Challenges of Paper-based Voting Systems

The use of paper ballot comes with its own set of challenges as enumerated below:

- **LOW RELIABILITY:** It is easily breached at times due to the multiple avenues that exists for the voters to make error. Paper ballots constitute a single point of failure if lost or damaged, as ballots or choices cannot be copied without loss of fidelity. It also depends a lot of human judgment to ascertain “Voter intent” and not neglecting the fact that paper is essentially an analogue medium.

- **POOR SECURITY:** It can be seen that no checksum or encryption is possible as data must be presented in clear text. Paper ballot can thus be manipulated by hand even by the least of technical personnel and cases of Ballot Box stuffing during and after elections are often rampant. Voters are often at the mercy of political thugs and security personnel.
- **HIGH COSTS:** There are often high cost incurred during the printing of various election materials, purchase of paper-handling equipment as well as the cost needed to store and transport the materials.
- **VOTER INTIMIDATION:** There has been cases of harassment of voters during elections, voter coercion and issues of ballot counting discrepancies
- **QUEUEING:** In cases of high voter turnout, there is usually a high probability that queues would be formed by voters often subject to the unpredictable weather conditions such as rains or scorching sun.

2.4 ELECTRONIC VOTING SYSTEMS

The Council of Europe recommendations defined electronic voting (e-Voting) as “the use of electronic means in at least the casting of the vote” (Krimmer, *et al.*, 2007). Electronic voting is a term encompassing several different types of voting, embracing both electronic means of casting a vote and electronic means of counting votes.

Electronic voting systems are complex distributed systems, whose components range from general-purpose PCs to optical scanners and touch-screen devices, each running some combination of commercial off-the-shelf components, proprietary firmware, or full-fledged operating systems.

It is a fundamental demand of countries to enhance their election system. Now due to rapid emergence of technologies in computer and telecommunication world e-Voting based systems are to be introduced that lessens all the traditional manual election systems' problems. With the introduction of e-Voting systems our elections processes and social lives are going to be easy, efficient and low-cost. Now in this system voters can cast their votes from anywhere in world. E-voting system must meet security requirements such as confidentiality, integrity, fairness, forgery attack, verifiability and so on. This is because E-voting system is more vulnerable than traditional voting due to the nature of digital processing of election data which can be easily manipulated, hence may result in widespread fraud and corruption. Voting is getting to be seen a next generation approach of election in almost all countries. The ultimate aim of e-Voting is to provide voters a good environment so that voters can cast their votes with minimum cost and efforts on the internet.

Up to now there are so many properties have been proposed to make the e-Voting secure process, among them some are the below given must be satisfied.

1. Eligibility: Only eligible voters are permitted to cast their ballots.
2. Privacy: There is no association between voter's identification and a marked ballot.
3. Uniqueness: No voter can cast his ballot more than once.
4. Completeness: No one can forge a valid ballot and a voter's ballot cannot be altered, the valid ballots are counted correctly.
5. Fairness: No one can falsify the result of voting.
6. Verifiability: Voters can verify that their ballots are counted correctly.
7. Uncoerciability: No voter can prove what he voted to others to prevent bribery.
8. Efficiency: The computations can be performed within a reasonable amount of time.
9. Mobility: The voter can vote anytime and anywhere through internet. (*Kashif H.M et al, 2011*)

2.4.1 Components of E-Voting Systems

The components of an electronic voting system are:

- DRE - Direct Recording Electronic voting machine - is a device to record the voter's choices. The DRE is usually a touch-screen device where the voter casts his/her vote.
- VVPAT - Voter-Verified Paper Audit Trail - is a paper-based record of the choices selected by the voter. The VVPAT printer is hooked to the DRE and the paper record is viewable by the voter, but it is under a transparent cover so that it cannot be modified other than through the normal voting process.
- EMS - Election Management System - is the system responsible for the initialization of the components that collect the votes and also for the final tallying of the votes. The EMS is usually located at election central and it is often implemented as software running on a commodity PC.
- Optical Scanner - is an optical reader that counts votes cast on paper ballots. There is usually one scanner at each polling site and one at election central (e.g., for the counting of absentee ballots¹).
- DTD - Data Transport Device - is a storage device to transfer data between different components of the systems. These devices are used to transport ballot information to the DREs and optical scanners at the polling site and to transport voting results to the EMS. (*Davide Balzarotti, et al, 2010*)

2.4.2 Types of Electronic Voting Systems

There are two types of e-voting systems: On-Line and Offline. On-line, e.g. via Internet, and offline, by using a voting machine or an electronic polling booth. Authentication of Voters,

Security of voting process, Securing voted data are the main challenge of e-voting (*Alaguvel R., et al, 2013*).

It should be noted that the main focus of this proposed project is the Online E-Voting System (Internet Voting) and it is x-rayed in the next section

2.4.3 Internet Voting System

Internet voting is defined as an election system that utilizes the internet to ensure access to a website or domain which makes use of electronic ballots. In this regard, the electronic ballots allow voters to transmit their voted ballot to election officials over the Internet.

It is a secure system that allows for eligible voters to cast their votes from any (remote) location.

Features include:

- Highly secure platform
- Supports multiple languages
- Simple and user-friendly voting interface.
- Support multiple voting channels: web browsers; mobile phones and PDAs

Types of Internet Voting

- **Poll-site Internet voting:** This system allows voters to cast their ballots from any designated polling station. Voting is done in a controlled environment offered by the polling site; this tends to curb some security risk. This type of internet voting system offers more convenience and efficiency than the conventional voting systems.

- **Kiosk Internet voting:** This is similar to poll-site internet voting, but voting machines are placed away from traditional voting locations and could be set up in convenient places like schools, libraries, and malls. Like poll-site voting, kiosk voting would make it possible to manage some security risks by controlling the physical environment.
- **Remote Internet voting:** This type of internet voting allows voters to cast ballots from anywhere in the world as long as they are connected to the internet. This offers immense convenience but exposes the system to security risks on the internet. This is because the voting environment is not controlled. It is also possible that issues of intimidation and voter impersonation arise (*O.M. Olaniyan, et al, 2011*).

2.4.4 Merits of E-Voting Systems

- **Electronic Ballots**

Electronic voting systems may use *electronic ballots* to store votes casted in computer memory. Systems which use them exclusively are called DRE Voting Systems. When electronic ballots are used, exhaustion of supplied ballots never arise. Additionally, the need to print paper ballots are eliminated which is often a major chunk of the costs incurred. When administering elections in which ballots are required by law to be offered in multiple languages, electronic ballots can be programmed to provide the ballots in multiple languages for a single machine with ease

- **Lower Costs**

A major edge over the paper – based voting systems, electronic voting systems save money by reducing personnel expense, management overheads and the overall costs incurred. It should be noted though that the initial cost of building the electronic voting system may be high but it is on the long term cheaper as it is only built once in a stark

contrast to the paper – based voting system where ballots would have to be printed for every elections even if the elections were cancelled as seen in the recent cancellation of the Nasarawa State Governorship Bye – Election as scheduled based on a court judgment, with less than 2 weeks to the election. Thus it has rendered all the paper ballots printed totally useless and the costs incurred on logistics all wasted.

- **Convenience and Accessibility**

With a well – designed and user – centered Electronic Voting System, the voters can be guaranteed to cast their votes with ease and minimal technical skills needed. It is also possible to design a variety of ballot question formats to suit the different categories of voters that might use the system. It can also be fitted with adaptive technologies in order to provide accessibility for the voters with a form of disability. And voter participation would be increased as a direct result of enhancing the ease of use and accessibility of the voting system.

- **Efficient Results Collation**

With an electronic voting system, results of an election can be counted and displayed immediately. And it is particularly useful in the event that there is a very large amount of votes to be counted, which can be very tedious, error-prone and time – consuming if the ballots are counted by hand. The time used to collate and declare results is reduced significantly using electronic means.

- **Elimination of Duplicate or Multiple Voter Registrations**

The deployment of biometric integration, specifically fingerprint recognition, which leverages on the fact that no two persons possess the same features for a given biometrics characteristics, can be used to eliminate multiple voter registration and laid the foundation for the enshrinement of the One Man One Vote rule.

2.5 REQUIREMENTS OF ELECTORAL SYSTEMS

In general terms, the success of any democratic system in the world depends upon the faith of the voters in the system itself. Therefore, any voting system or technology must address and adhere to the electoral requirements. In this regard, it is the responsibility of legislative or administrative bodies to set up the requirements of an electoral process. They must make sure that requirements are scientific and do not create unfairness. The fundamental qualities should be maintained. Once a suitable set of fundamental system requirements are agreed upon, the unsettling vulnerabilities of the conventional elections systems will become apparent. The importance of electoral requirements is to minimize present and future risks. The requirements are as follows:

1. **Accessibility:** This seeks to accommodate all eligible voters in terms of ensuring that they all have access to a user-friendly system.
2. **Fairness:** All eligible voters should be counted in the final tally.
3. **Timeliness and accuracy:** Timeliness is based on the need to ensure that information is recorded and available results released as quickly as possible, while accuracy focuses on the ability to ensure that each individual's vote is recorded and counted.
4. **Secrecy and privacy:** All participants must be permitted to vote in secret. It must also discourage both vote-buying and coercion. Voters' privacy must also be protected in such a way that no one can discover how someone has voted except by a court order. Moreover, this will prevent electoral authorities from selling votes of the voters.
5. **Security:** Usually, human beings operate computer machines. Therefore, it may be easy for them to manipulate and interfere with the whole system. In essence, it guards against manipulation and interference, using the following mechanisms: Personal identification number (PIN) or password, encryption, digital signature, biometric identifiers (like fingerprints).

6. **Authentication and verification:** With regard to authentication, it should be ensured that individuals cannot be impersonated during voting. The need for verification emphasizes that the e-voting system must be able to independently verify that all voters have been correctly counted in a system (*Akinyemi A.E., 2014*).

2.6 SECURITY IN E-VOTING SYSTEMS

Security is at the heart of e-voting process. Therefore the necessity of designing a secure e-voting system is very important. Usually, mechanisms that ensure the security and privacy of an election can be time-consuming, expensive for election administrators, and inconvenient for voters. There are different levels of e-voting security. Therefore serious measures must be taken to keep it out of public domain. Also, security must be applied to hide votes from publicity. There is no measurement for acceptable security level, because the level depends on type of the information. An acceptable security level is always a compromise between usability and strength of security method. The authenticating voters and polling data security aspects for e-voting systems are discussed here. It ensures that vote casting cannot be altered by unauthorized person. The voter authentication in online e-voting process can be done by formal registration through administrators and by entering OTP Certificate. In Offline e-voting process authentication can be done using facial recognition, fingerprint sensing and RFID (smart cards) which enables the electronic ballot reset for allowing voters to cast their votes (*Alaguvel R., et al, 2013*).

The main goal of a secure e-voting is to ensure the privacy of the voters and accuracy of the votes.

A secure e-voting system satisfies the following requirements:

- Eligibility: only votes of legitimate voters shall be taken into account
- Un-reusability: each voter is allowed to cast only one vote

- Anonymity: votes are set secret
- Accuracy: cast ballot cannot be altered. Therefore, it must not be possible to delete ballots nor to add ballots, once the election has been closed
- Fairness: partial tabulation is impossible
- Vote and go: once a voter has casted their vote, no further action prior to the end of the election
- Public verifiability: anyone should be able to readily check the validity of the whole voting process (*Alaguvel R., et al, 2013*).

2.7 BIOMETRICS

The term “Biometrics” originally comes from the two Greek words: *bios* and *metrikos*, meaning life and metric (measure) respectively (*Bolle et al., 2003*).

Biometrics is the science and technology of measuring and analyzing biological data of human body, extracting a feature set from the acquired data, and comparing this set against to the template set in the database.

A biometric is a physical or behavioural feature or trait that can be measured. It is often used as a means of proving an individual’s identity, assign certain rights as well as validating people’s identities.

Authors in (*A. F. Thompson, et al, 2010*) as well, define biometric as the most secure and convenient authentication tool that relies on the automated identification or verification of an individual. It cannot be borrowed, stolen, or forgotten and forging one is practically impossible.

Biometrics measure individual's unique physical (physiological characteristics refer to inherited traits that are formed in the early embryonic stages of human development) or behavioural characteristics (not inherited, but learned) to recognize or authenticate their identity.

Biometric systems can be categorized into two.

i. **Unimodal Biometric Systems**

Unimodal biometric system uses only a single biometric characteristic. This system is usually more cost-efficient than a multimodal biometric system. However, it may not always be applicable in a given domain because of unacceptable performance and inability to operate on a large user population.

Examples are: face recognition, fingerprint matching, Hand Geometry, Palm Prints.

ii. **Multimodal Biometric Systems**

Multimodal Biometric system combines multiple sources of biometric traits. This can be accomplished by fusing multiple traits of an individual, or multiple feature extraction and matching algorithms operating on the same biometric. These multimodal systems, can improve the matching accuracy of a biometric system while increasing population coverage and deterring spoof attacks. (*A. F. Thompson, et al, 2010*)

A human feature can be used for biometrics recognition or validation if it possess the following parameters:

1. **Universality:** Everyone should have it (it is present in every human being)
2. **Uniqueness:** No two individuals should have the same value for the biometric characteristics or feature.
3. **Permanence:** It should be invariant over a given period of time (that is, it should be the same most or all of the lifetime of the individual).
4. **Performance:** It should give accuracy, speed and robustness.
5. **Measurability:** It must be easy to measure.

6. **Circumvention:** How easy it is to cheat the system by the use of a substitute.

2.7.1 Biometric Features

Biometric features are properties that are common to all human beings and can be used for the authentication and validation.

Biometric features are broadly classified into;

1. Physiological (e.g. Face, Fingerprint, Iris, Retina, Hand Geometry, Ear etc.)
2. Behavioral (e.g. Voice, Dynamic Signature)

As a primary advantage, biometric features are typically unique and therefore cannot be misplaced or forgotten since there are inherently associated with human beings.

A brief description is given about some of the biometric features mentioned above:

- **FINGERPRINT**

It looks at the friction ridges or the pores in the skin of the ridges that cover the fingertips and classify patterns of minutiae, such as branches and end points of the ridges.

- **IRIS**

The iris pattern contains a large amount of randomness, and appears to have many times the number of degrees of freedom of a fingerprint. It is formed between the third and eighth month of gestation, and (like the fingerprint pattern) is phenotypic in that there appears to be limited genetic influence; the mechanisms that form it appear to be chaotic. So the patterns are different even for identical twins (and for the two eyes of a

single individual), and they appear to be stable throughout life.

- **Retinal Scanning**

This method of personal authentication uses the vascular patterns of the retina of the eye. In healthy individuals, the vascular pattern in the retina does not change over the course of an individual's life. The patterns are scanned using a low-intensity (e.g., near-infrared) light source. It requires the user to look into a device and focus on a given point.

The image acquisition involves cooperation of the subject, entails contact with the eyepiece.

- **Face**

The human face is also a feature that can be used by biometric systems by analyzing the size and position of different facial features is being pushed for use at several airports to increase security. Another possible approach is to make infrared recordings and analyze the resulting facial thermo gram.

- **Ear**

It has been suggested that the shape of the ear and the structure of the cartilaginous tissue of the pinna are distinctive. The ear recognition approaches are based on matching the distance of salient points on the pinna from a landmark location on the ear. The features of an ear are not expected to be very distinctive in establishing the identity of an individual.

- **Voice**

A more behavioural individual aspect of humans are their voices. Everybody has a special mode and tone while speaking. Voice recognition tries to analyze these features and use them to identify a person.

- **Signature**

Another behavioural aspect of a person usable by biometrical analyses is the signature. Not only the form but also the dynamic aspects can be seen as a set of unique features of a person. Other possible movable biometric input could be the rhythm and pattern of a person's walk.

- **Hand or Palm geometry**

In this biometric system the entire hand is used as an individual identifier. This method relies on devices that measure the length and angles of individual fingers. Hand geometry uses a camera to capture a silhouette image of the hand. The hand of the subject is placed on the plate, palm down and guided by five pegs that sense when the hand is in place. It is more user-friendly than retinal scans but it is also cumbersome.

2.7.2 Mode of operation for Biometrics – based systems

Most biometric technology systems use the same basic principles of operation. First, a person must be registered, or enrolled, on the biometric system.

1. **Enrollment:** The process by which a user's biometric data is initially acquired, accessed, processed, and stored in the form of a template for ongoing use in a biometric system is called enrollment. Subsequent verification and identification attempts are conducted against the template(s) generated during enrollment.

2. **Presentation:** it is a process by which user provides biometric data to an acquisition device-the hardware used to collect biometric data. Depending on the biometric system, presentation may require looking in the direction of a camera, placing a finger on a platen, or reciting pass phrase.
3. **Biometric data:** The biometric data users provide in an unprocessed image or recording of a characteristic. The unprocessed data is also referred to as raw biometric data or as a biometric sample. Raw biometric data cannot be used to perform biometric matches. Instead, biometric data provided by the user during enrollment and verification is used to generate biometric templates, and in almost every system is discarded thereafter. Thus Biometric systems do not store biometric data-systems use data for template creation. Enrollment requires the creation of an identifier such as a username or ID. This identifier is normally generated by the user or administrator during entry of personal data. When the user returns to verify, he or she enters the identifier, and then provides biometric data. Once biometric data has been acquired, biometric templates can be created by a process of feature extraction.
4. **Feature extraction:** The automated process of locating and encoding distinctive characteristics from biometric data in order to generate a template as called feature extraction. Feature extraction takes place during enrollment and verification-any time a template is created. The feature extraction process includes filtering and optimization of images and data in order to accurately locate features. For example, voice-scan technologies generally filter certain frequencies and patterns, and finger-scan technologies often thin ridges present in a fingerprint image to the width of a single

pixel. Since quality of feature extraction directly affects a system's ability to generate templates, it is extremely important to the performance of a biometric system.

Table 2.1: Comparisons of Various Biometric Features (Alina, 2010)

FEATURE	CRITERIA					
	Universality	Uniqueness	Performance	Measurability	Permanence	Circumvention
Fingerprint	Medium	High	High	Medium	High	Medium
Hand Geometry	Medium	Medium	Medium	High	Medium	Medium
Face	High	High	Low	High	Medium	High
Iris	High	High	High	Medium	High	Low
Voice	Medium	Low	Low	Medium	Low	High
Retina	High	High	High	Medium	Medium	Low
Ear	Medium	Medium	Medium	High	High	Medium

2.7.3 Fingerprints Recognition and Authentication

Every human in the world has a unique Fingerprint so it is impossible to steal or lose so there is no need to remember fingerprints like if individual passwords or personal identification numbers (PINs) in card technology to keep systems secure. Besides, every finger has distinctive characteristics because fingerprints of every finger of a person are different (*Altun A.A. et al, 2008*). Fingerprint recognition or fingerprint authentication refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of

biometrics used to identify individuals and verify their identity. A fingerprint looks at the patterns found on a fingertip. There are a variety of approaches to fingerprint verification. Some emulate the traditional police method of matching pattern; others use straight minutiae matching devices and still others are a bit more unique, including things like moiré fringe patterns and ultrasonic. A greater variety of fingerprint devices are available than for any other biometric. Fingerprint verification may be a good choice for in e-voting systems, where you can give users adequate explanation and training, and where the system operates in a controlled environment (Alaguvel R., et al, 2013). It is not surprising that the work-station access application area seems to be based almost exclusively on fingerprints, due to the relatively low cost, small size, and ease of integration of fingerprint authentication devices that will be implemented is shown in the figure below

Fingerprints Enrollment and Verification Process

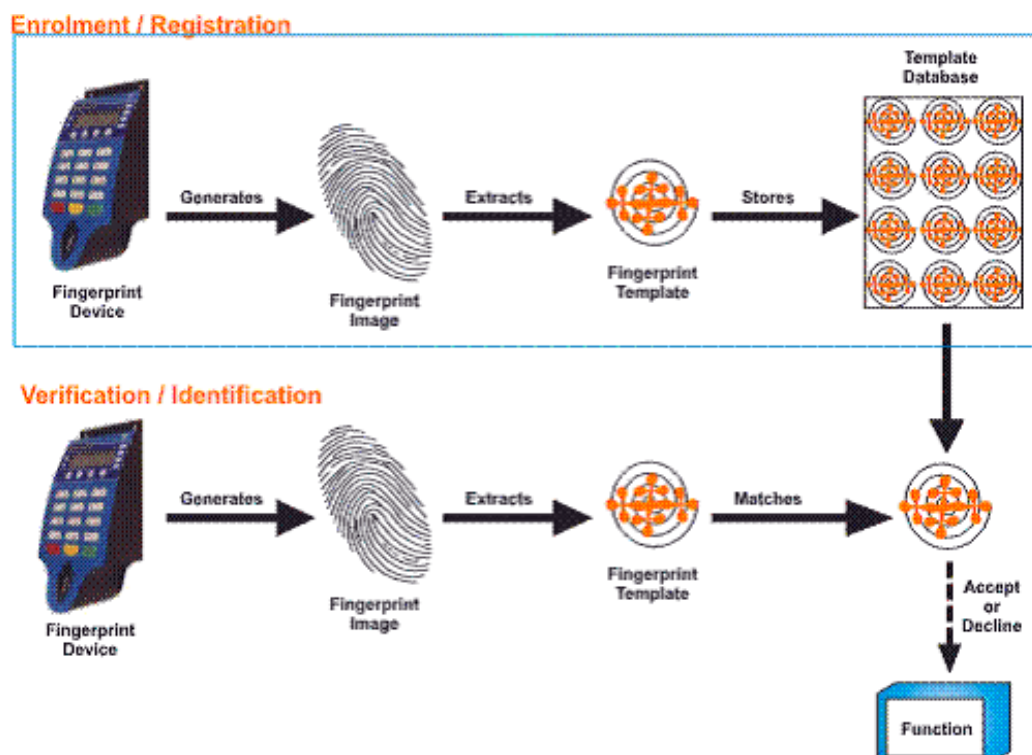


Figure 2.2: Fingerprints Enrollment and Verification Process. (Alaguvel R., et al, 2013)

2.8 RELATED WORKS

In this section I examine some electronic voting systems and software that are similar to the proposed system. During the course of my research a majority of such systems were found to be implemented in various organizations and countries. This section discusses the most closely related with my system.

1. **Fair Vote – University of Ibadan:** is an intranet-based system for conducting student elections within the university and it has been used successfully across various departments as well as halls of residence. This system was created to replace the previous paper-based system. This system records votes using computers connected on the dedicated intranet and accessing the e-voting URL. Users are expected to obtain their one-time password at the polling venue after the verification of their identity against the record available in the voters register and thus combined with their matriculation number, gain access to cast their votes for their candidates. It provides instant results computation. It reduces the use of paper by eradicating the ballot paper, reduces costs of administering student elections and enhances the voting process. Limitations include:

- Users are always required to be physically present at the polling venue which is often centralized
- Occurrences of missing or inaccurate voter details in the physical voter register
- Long time required to manually feed the voters' details into the e-voting system
- High Likelihood of long queues forming when turnout of voters is much as there is usually the constraint of a limited number of computer systems being deployed on the intranet

2. **Biometrics Based E-Voting System – University of Ibadan:** This voting system makes use of a biometric feature (fingerprint) to authenticate users of the system. Fingerprint recognition hardware is integrated with the system so as to solve the problem of the existing system. The new system operates in an identification mode and performs the following:

- Captures fingerprints, extracts the features and stores it in the database.
- Verifies the identity of the voter at login time by comparing the fingerprint that has been pre-stored in the database with the fingerprint being supplied at login.
- Provides an interface for the user to cast votes if a match is found.
- Provides an interface for viewing the results of the election.

Limitations include:

- System only works on a single computer thus giving rise to inefficient use of time as it cannot successfully serve all the teeming voters
- Restricted by physical location, that is, all voters must come to a central location.
- Prone to long queues as the system is tightly-coupled, i.e. both the voter's and admin's login button are on the same interface thus rendering concurrent access impossible (*Akinyemi A.E, 2014*)

2.9 CHAPTER SUMMARY

This chapter contains a literature review that summarizes and generally overviews the major aspects of the project which include elections and its types, security and ergonomics challenges facing the conduct of elections, a brief review of biometrics and human biometrics features as well as their individual peculiarities.

CHAPTER THREE

REQUIREMENTS ANALYSIS AND SYSTEM DESIGN

3.1 INTRODUCTION

A requirement is a statement of desired behaviour. It deals with objects or entities of a system, the states the objects can be in, and the functions that are performed to change states or objects characteristics. The goal of the requirements gathering and analysis phase is to understand a customer's problems and needs which forms the basis of their expectations from the proposed new system. It involves a proper study of the project problem statement, elicitation of the requirements from the intended users and other stakeholders, to produce a requirements definition document and analyzing the requirements thus gathered to determine the specifications of the proposed new system.

3.2 ANALYSIS OF THE EXISTING UI ELECTIONEERING SYSTEM

The existing system used in the conduct of staff election within the University of Ibadan currently is still being operated manually. The staff members who vote are expected to converge at a specified location, get themselves accredited by initially verifying their eligibility from the election officials and subsequently queue up in order to exercise their franchise. At the end of the voting exercise in the day, votes casted are tallied by manual counting of the ballot papers and results announced.

The analysis of the manual system was looked into and the following benefits and demerits were identified.

3.2.1 Benefits of the Manual System

The benefits of the existing system are:

1. Voters must be physically present.
2. Results are available immediately after the voting process.
3. Familiarity of faces aids voter identification.
4. Prevention of fraud in polling stations and during the transmission and tabulation of results by reducing human intervention with the use of the University security outfit.
5. Physical use of Staff records.

3.2.2 Limitations of the Existing System

The current electoral process, though with the promises of transparency and reliability of the system, is not without its defects. Following are the observations which call for modification in the way this whole process carries itself:

1. Low percentage of voting
2. Long distance between polling booth and the voter.

3.3 ANALYSIS OF THE PROPOSED SYSTEM

The new system makes use of a biometric feature (fingerprint) to authenticate users of the system. Fingerprint recognition hardware is integrated with the system so has to solve the problem of the existing system.

The new system operates in an identification mode and performs the following:

1. Captures fingerprints, extracts the features and stores it in the database.

2. Verifies the identity of the voter at login time by comparing the fingerprint that has been pre stored in the database with the fingerprint being supplied at login.
3. Provides an interface for the user to cast votes if a match is found.
4. Provides an interface for viewing the results of the election.

3.3.1 Design Goals for the Proposed System

Some of the overall design goals of the new Online Voting System are listed below:

1. Voter secrecy: No one should know what the voter voted
2. Voter authentication: Voters should be who they claim they are
3. Verifiability of votes: Internal tracking of votes, to assure all ballots are registered to a voter.
4. Accuracy of voter turnout. Each voter is tracked to completion, so voter data is available at any time.
5. Safe transfer of votes from user's computer to the server
6. Safety of casted votes: Proper security process and user registration can guarantee ballot assurance.
7. Uniqueness of casting – A person can cast only one vote
8. Permitting the voter to vote for as many candidates for an office as the voter is lawfully entitled to vote for without exceeding the limit
9. Empty ballot box at the start of voting
10. Voter should be able to verify the vote before it is cast
11. User manuals should be provided for voters several days before election

3.3.2 Functional Requirements of the Proposed System

Functional requirements are the capabilities of the system and domain specific.

The Online Voting System (UIBOVS) would have the following functional requirements:

1. The system must provide the voters with accurate data
2. The system must supply standard reports for decision making
3. Audit trails of who made changes to the database must be maintained
4. The system should allow voting administrators to make updates to the voter information database
5. The system must provide standard error checking
6. The system must provide data integrity checks to ensure data remains consistent and updated.
7. The system should provide documentation to inform users of system functionality and any change to the system.
8. Ease of GUI use that can be accessed via web browser must be established

3.3.3 Non – Functional Requirements of the Proposed System

Non – functional requirements are constraints on the functional requirements or quality requirements.

The non-functional requirements of the system include:

1. The system must be working at 100% peak efficiency during the voting process.
2. All voting is done in one day
3. Voting is carried out from many computers using the internet
4. Backup data restore capabilities should be granted
5. The system must conform to the requirements of the University authorities

3.3.4 Security Requirements

The Online Voting System with Biometric Authentication would be required to enforce the following security rules or requirements in order to fully satisfy and build the trust of the voting populace in the system.

The security requirements are listed below:

1. The voting system should include controls to prevent deliberate or accidental attempts to replace code such as unbounded arrays and strings
2. The system should have zero-tolerant with regard to compromising
3. Election process should not be subject to any manipulation including even a single vote manipulation
4. The system should provide accurate time and date settings
5. The system should not allow improper actions by voters and election officials
6. The system should not allow unauthorized users to download votes to infer how voters have voted
7. The system should provide means for protecting and securing recounts of ballots cast in elections

3.4 DESIGN OF THE PROPOSED SYSTEM

Having defined the requirements of the proposed system, I now present the system's design which will include the use of software modelling tools to structure requirements. Structuring requirements help us to understand requirements thoroughly. It is important to have standard notations for modelling, documenting, and communicating decisions.

In looking at the functionality of the proposed online voting system with biometrics authentication system - use case models, data flow diagrams, entity – relationship models and hierarchy chart plus input, process, and output (HIPO) diagram would be used to specify the functionality and non-functionality of the system in this project work.

It can be seen highlighted below

3.4.1 Data Flow Diagrams (DFDS)

Data-flow diagram is a model that shows the graphical flow of data through an information system, the relationships among the data flows, and how data come to be stored at specific locations. Data-flow diagrams also show the processes that change or transform data. Data-flow diagram focuses on the movement of data between processes, called process models.

CONTEXT DATA FLOW DIAGRAM

The Context (or Level 0) Data Flow Diagram is an overall overview of the main entities, process and data flow of the system being modelled. It does not show a data store.

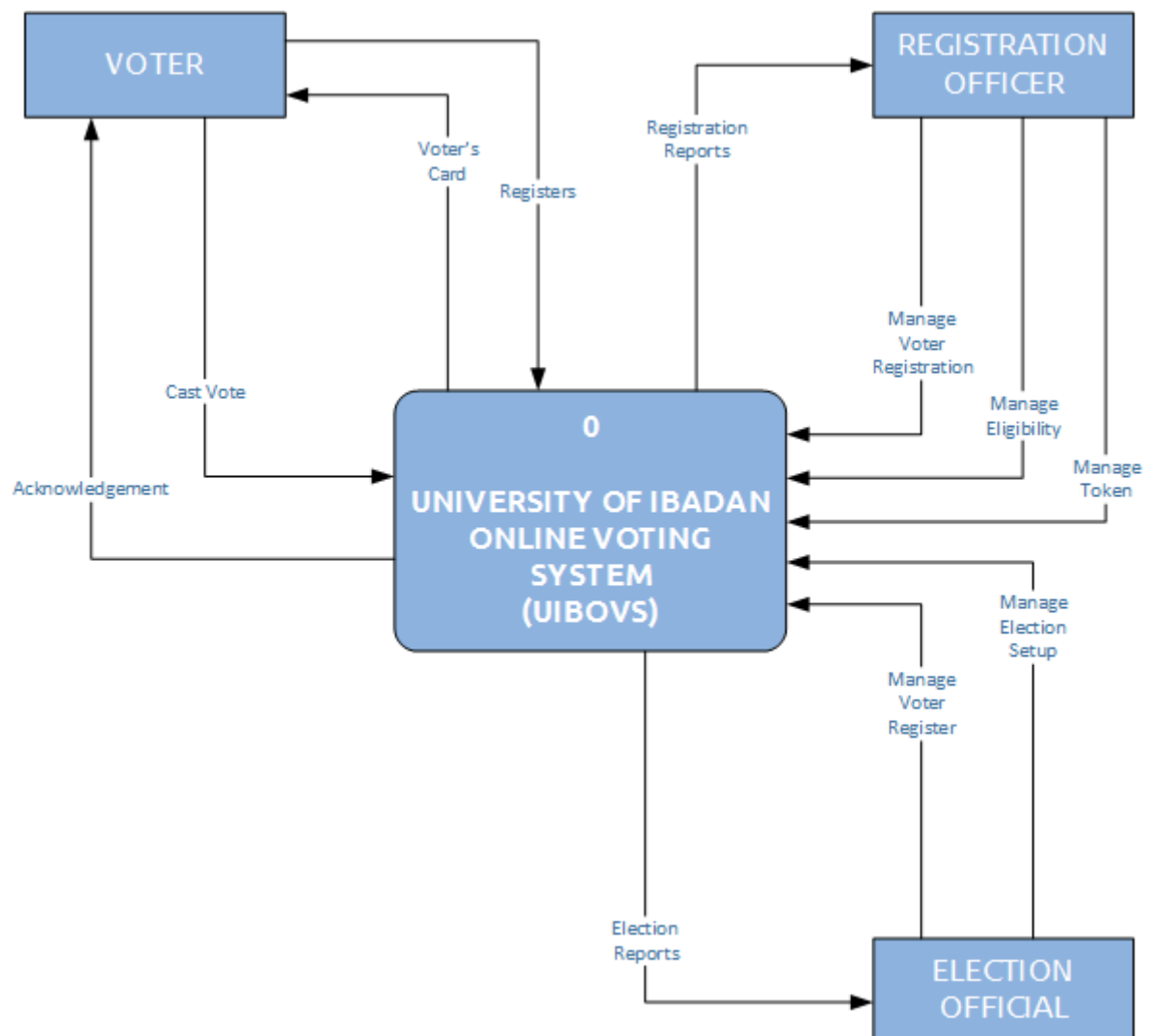


Figure 3.1: The Context (Level – 0) Data Flow Diagram of UIBOVs

LEVEL 1 DIAGRAMS OF OFFLINE (DESKTOP) SUB-MODULE

The Offline (Desktop) module of the University of Ibadan Online Voting comprises of two major activities, which are the Voter Registration and Enrollment Process as well as the Voter Verification Process.

Their respective Data Flow Diagrams are shown below:

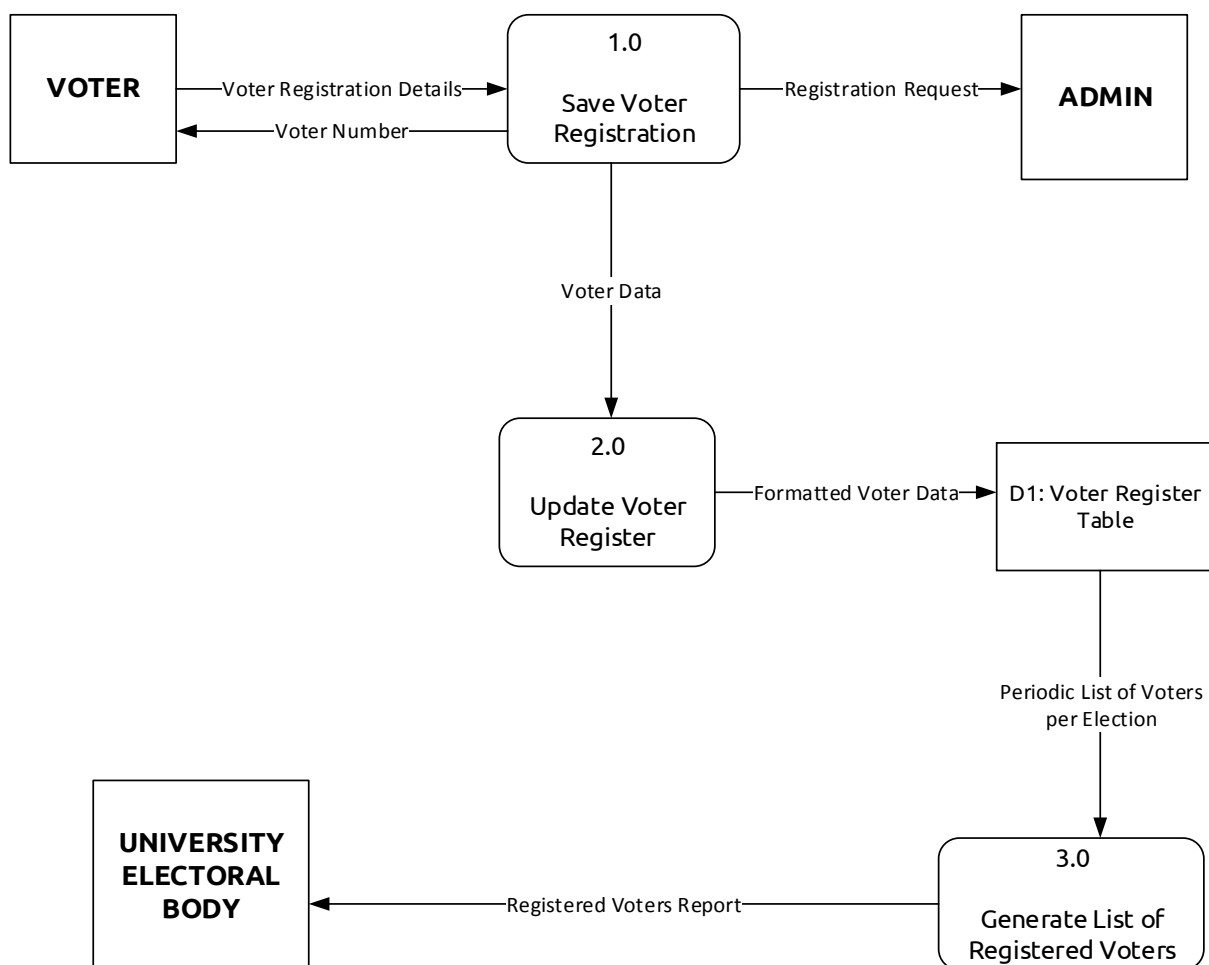


Figure 3.2: Level 1 DFD Diagram for the Voter Enrollment Process on the Desktop Module

**BREAKDOWN OF PROCESS 1.0 – SAVE VOTER REGISTRATION – IN THE
DATA FLOW DIAGRAM ABOVE**

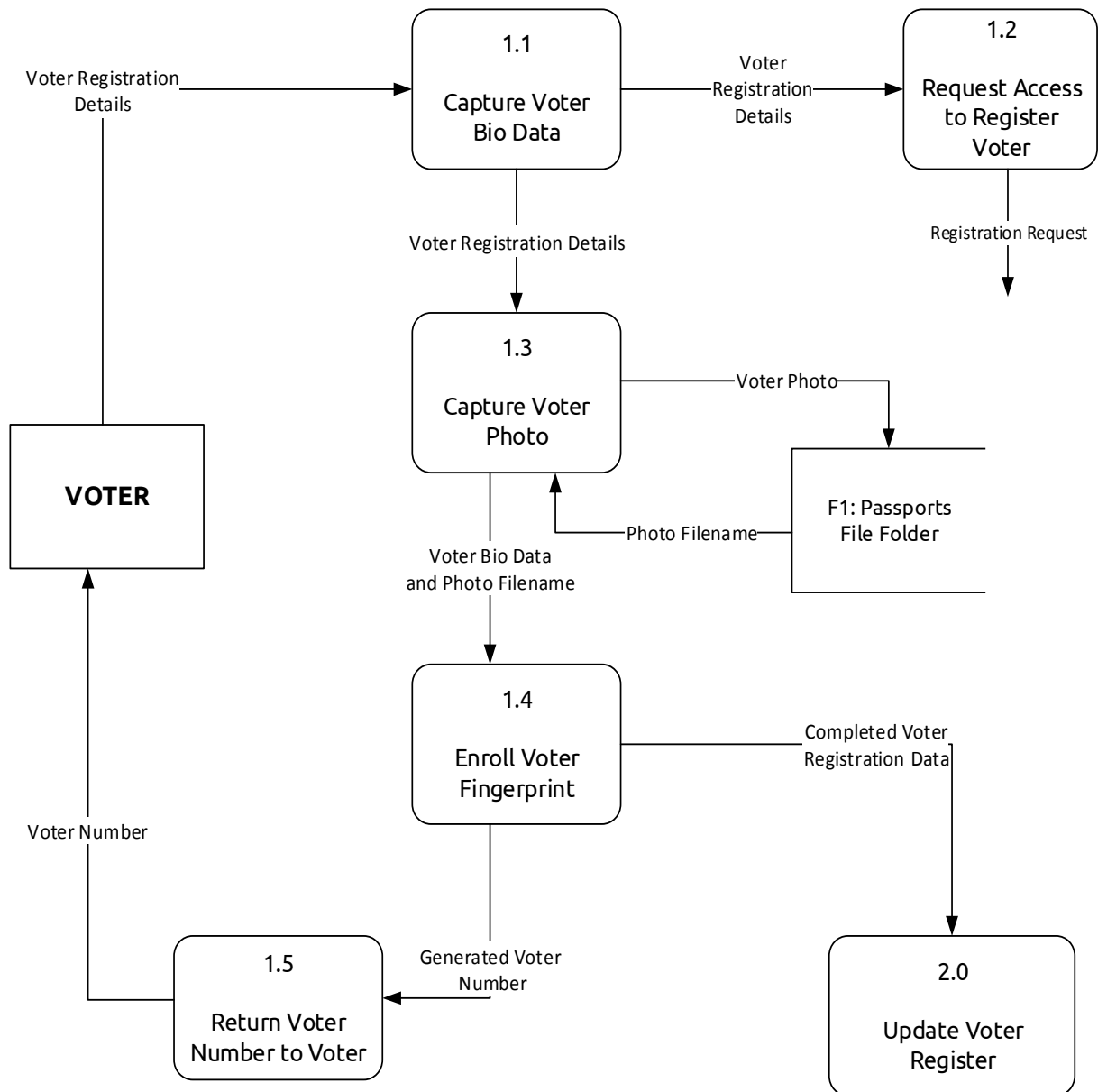


Figure 3.3: Level 2 DFD Diagram for the Breakdown of the Process 1.0 (Save Voter Registration) under the Voter Enrollment Process Flow on the Desktop Module

BREAKDOWN OF VOTER VERIFICATION PROCESS FLOW

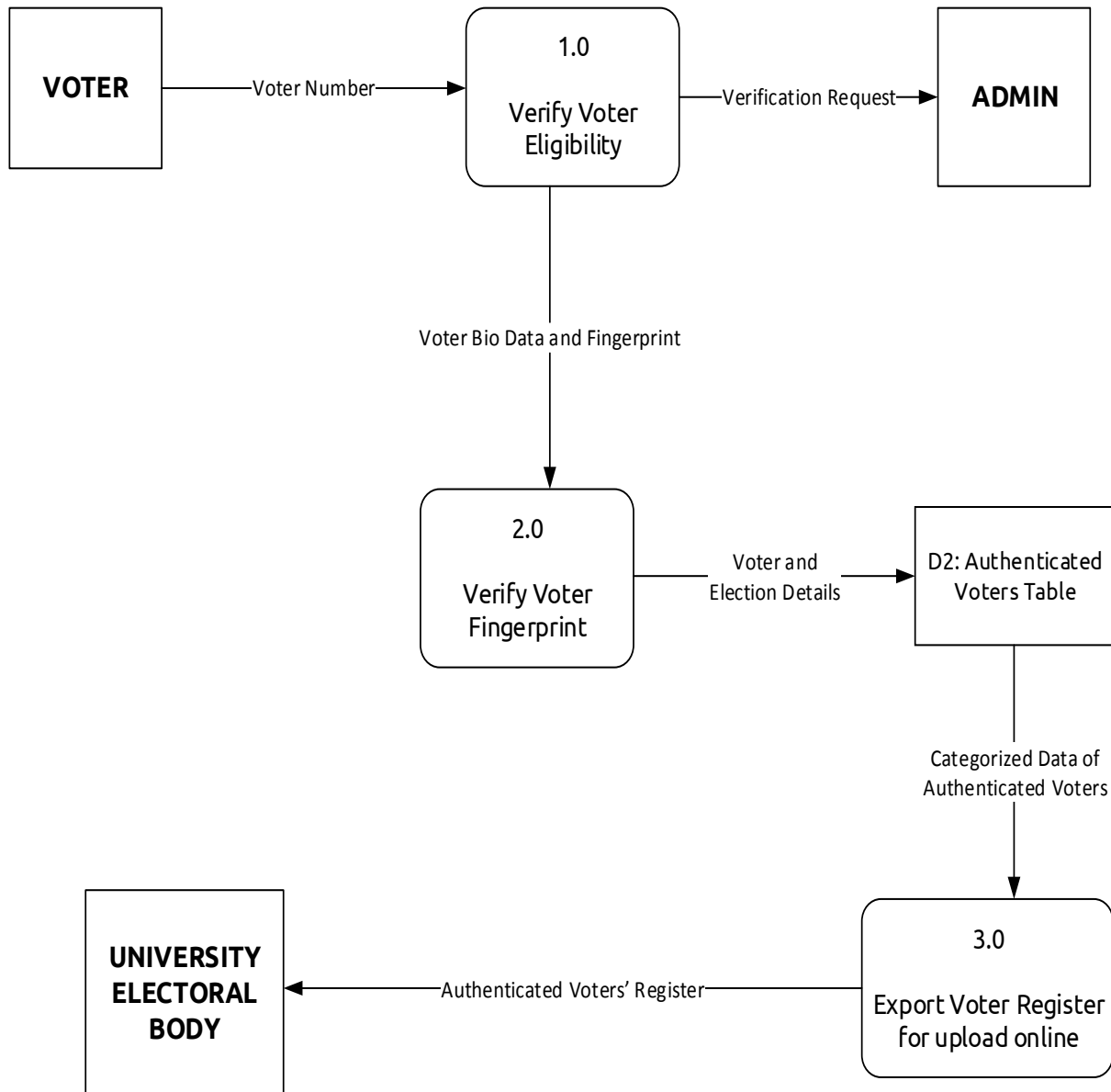


Figure 3.4: Level 1 DFD Diagram for the Voter Verification Process on Desktop Module

BREAKDOWN OF THE ONLINE VOTING PROCEDURE DATA FLOW

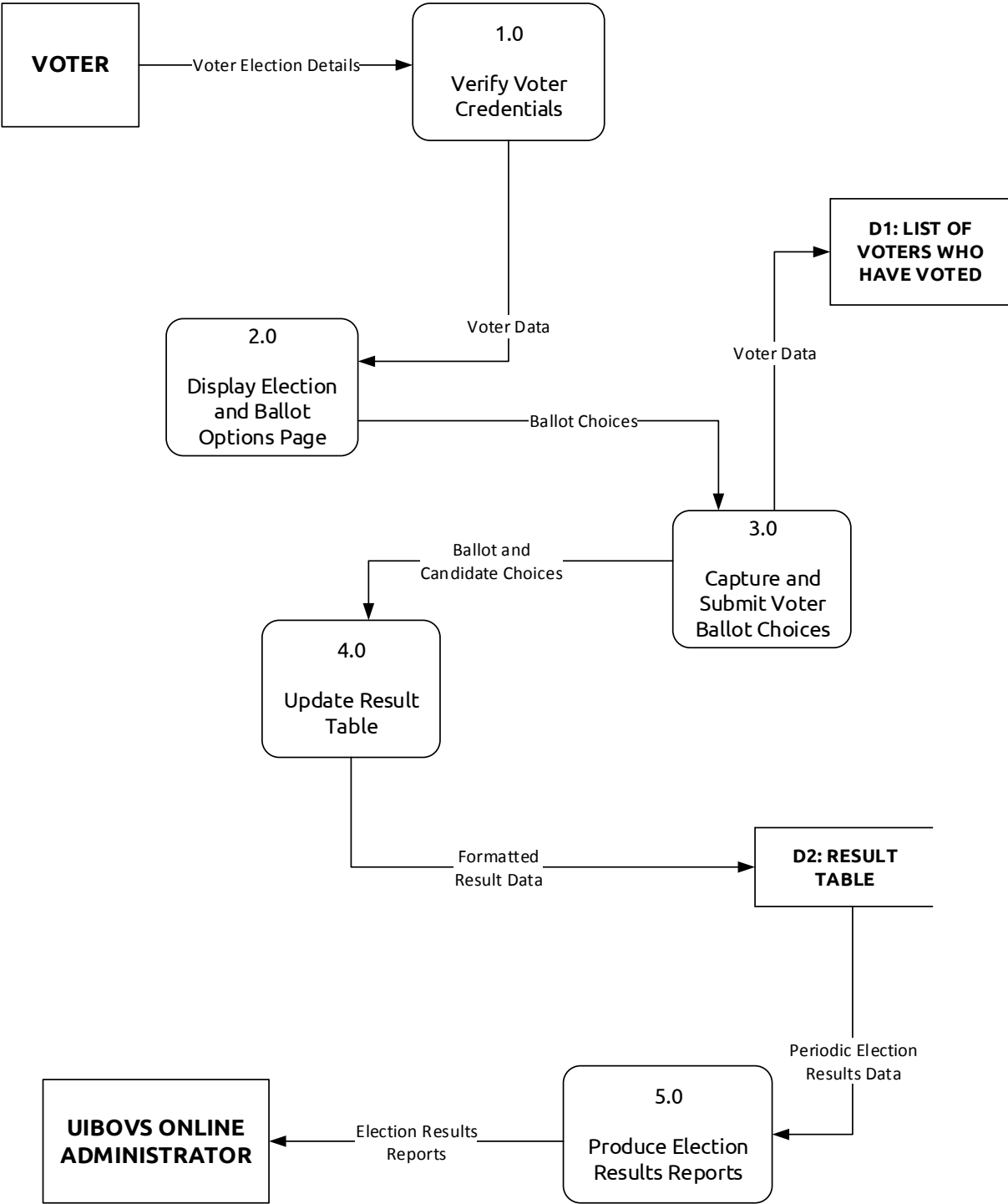


Figure 3.5: UIBOVS Online Module – Level 1 DFD Diagram for Online Voting Process

3.4.2 Use Cases Diagram

The Use case diagram is a graphic that is used to define the core elements and processes that make up a system. The key elements are termed as "*actors*" and the processes are called "*use cases*." It shows which actors interact with each use case.

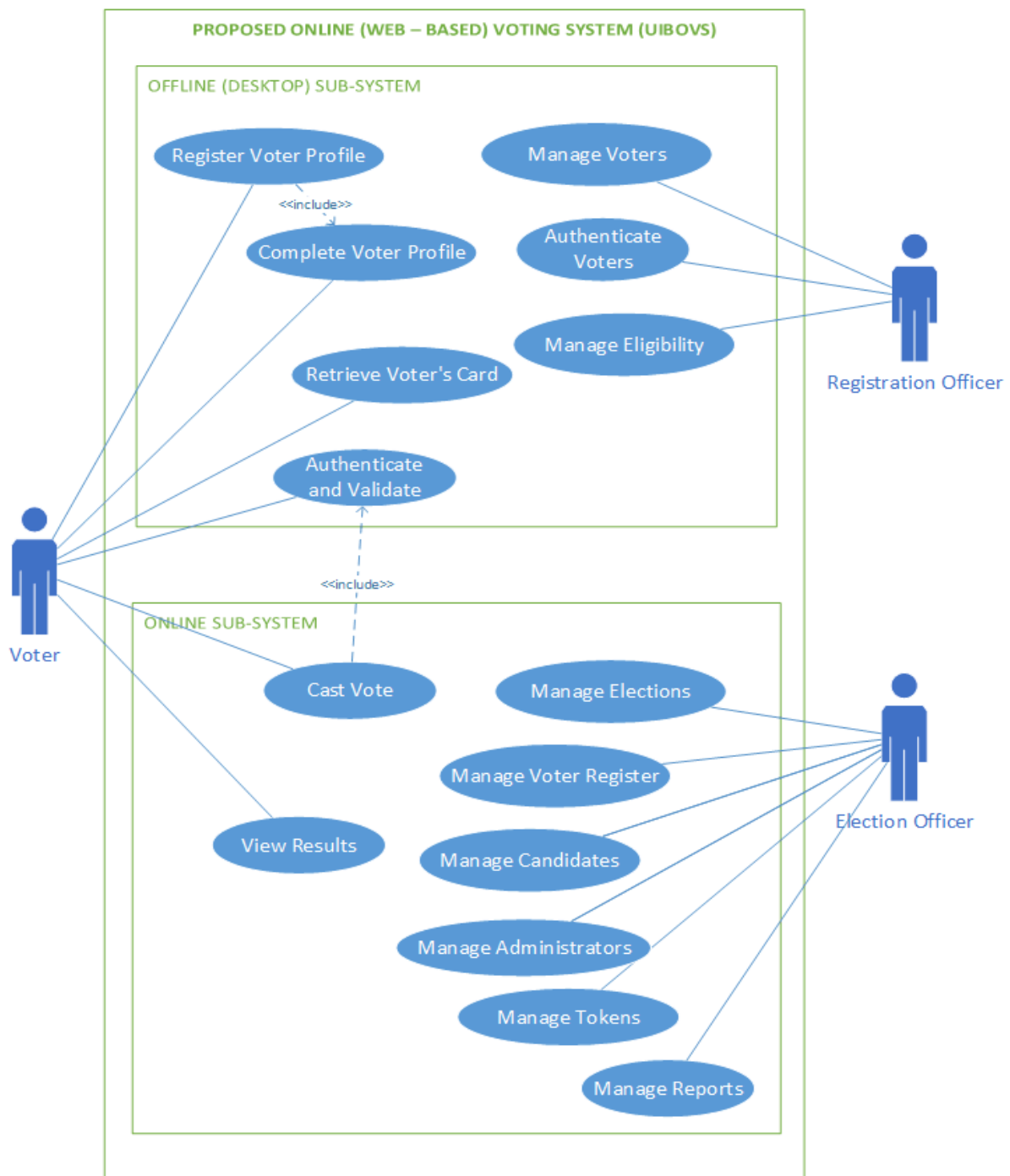


Figure 3.6 Overall Use-Cases Diagram for the Online Voting System

Following below are the breakdown of the individual Use Cases. Each showing the Actors, Input and Output respectively:

ACTORS AND THEIR USE CASES

ACTOR: VOTER

USE CASES:

1. **Register Profile:** This is a major functional requirement of the system. Here the voter's details as well as fingerprint template is enrolled on the system and stored in the database.
2. **Complete Profile:** The voter whose fingerprint template has not been enrolled as a result of pre-loading his data, is expected to enroll only his or her fingerprint template, in order to have a complete voter profile and obtain a voter identification number.
3. **Authenticate and Validate:** This is a functional requirement of the system. It entails the capturing of the voter's identification number and fingerprint image for verification against the template already stored on the database during the registration enrollment process. It does a comparison of the fingerprint templates, detecting the minutiae points and matching them. If successful, the voter's id is stored on the list of authenticated voters for the particular election.
4. **Cast Vote:** The voter is able to exercise their franchise and choose their preferred candidate for any ballot or post in an election.
5. **Retrieve Voter Card:** The voter can request for the reprint of his or her voter registration receipt or card.
6. **View Result:** The voter can view the results of all elections that have been closed and stopped

ACTOR: REGISTRATION OFFICER

The registration officer is an administrator who manages the operation of the Offline (or Desktop) module of the University of Ibadan Online Voting System.

USE CASES:

- 1. Manage Voters:** This is a major functional requirement of the system. The registration officer is the user responsible for enrolling the various voters as well as update or delete their registration details in the University of Ibadan Online Voting System. Key functions include capturing the voters' photograph as well as enrolling the voters fingerprint template, which is stored on the file system and the database, respectively.
- 2. Authenticate Voters:** This is the responsibility of the registration officer to verify the eligibility of a voter by entering the voter's unique identification number and if eligible, carry out the Fingerprint template verification to determine the true identity of the voter. If a voter is properly matched, the voter records as well as the election for which the voter was authenticated for, would be saved into the list of authenticated voters.
- 3. Manage Eligibility:** The registration officer is authorized to create, edit, and delete eligibility criteria for any election that is created on the system and for which, voters would be require to be authenticated for. Eligibility criteria management is a critical functional requirement of the University of Ibadan Online Voting System project.

ACTOR: ELECTION OFFICER

The Election officer is an administrator who manages the operation of the Online Voting module of the University of Ibadan Online Voting System.

USE CASES:

1. **Manage Elections:** This is a major functional requirement of the system. The election officer is required to create new election as well as manage their lifecycle. A direct sub – function of creating elections on the system is the operation to create ballots or offices or posts for which candidates would be able to contest for.
2. **Manage Voter Register:** Here the voter register which is the output of the University of Ibadan Online Voting System desktop module, is uploaded into the database online. Thus all the authenticated voters for any election have their details auto – entered into the voter register online based on the election for which they were authenticated.
3. **Manage Candidates:** This allows the election officer to create candidates for any forthcoming election which has been registered on the online voting module.
4. **Manage Administrators:** This is a function that allows new administrators to be created on the system.
5. **Manage Tokens:** After the successful uploading of any voter register containing the list of authenticated voters for any election, the election officer is expected to send out tokens which are auto – generated during voter register upload to all voters on each register using the email address field of the respective voter. It also involves a functionality whereby individual voter token can be retrieved and sent to the voter.
6. **Manage Results:** This involve the printing of the completed election results which can also be saved as a pdf file.

3.4.3 Entity Relationship (E-R) Diagram

An entity-relationship diagram is a data modeling technique that creates a graphical representation of the entities, and the relationships between entities, within an information system. It depicts a visual representation of different data using conventions that describe how these data are related to each other. It has three notations which are: Entity, Relationship and Cardinality.

EER DIAGRAM OF DESKTOP MODULE

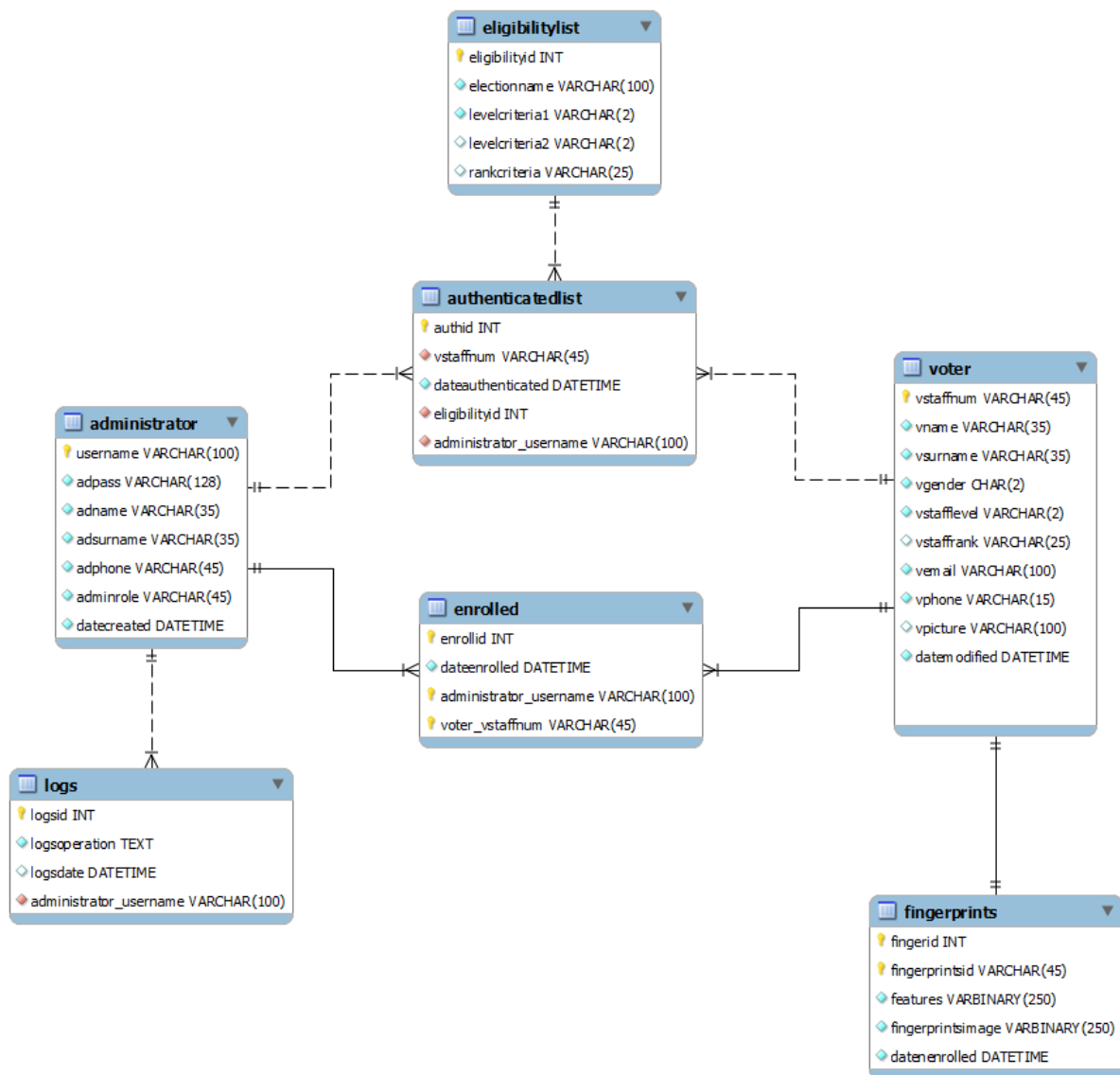


Figure 3.3: EER of the Offline (Desktop) Sub-Module

EER DIAGRAM OF ONLINE MODULE

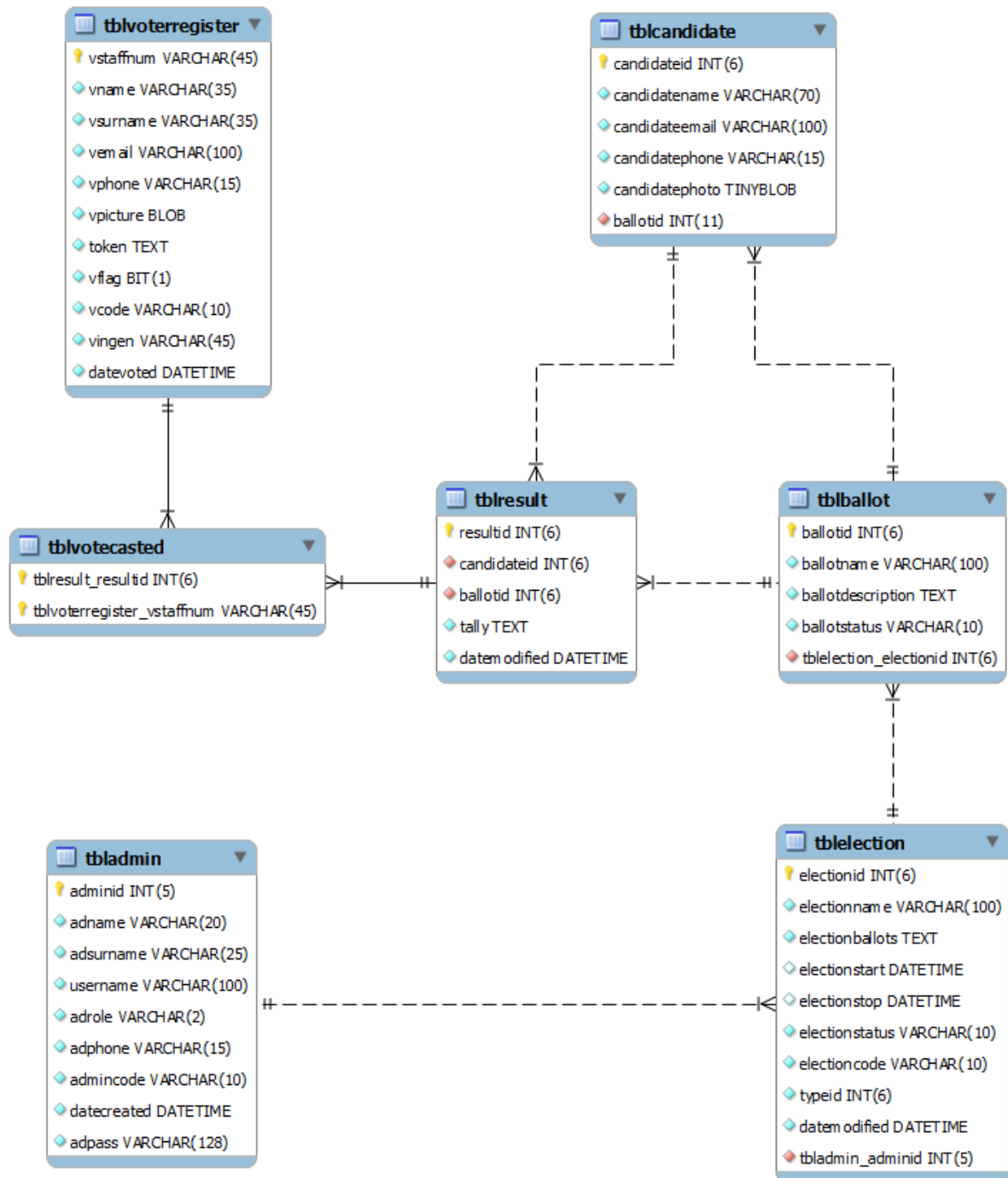


Figure 3.4: EER of the Online Sub-Module

ER DIAGRAM OF DESKTOP MODULE

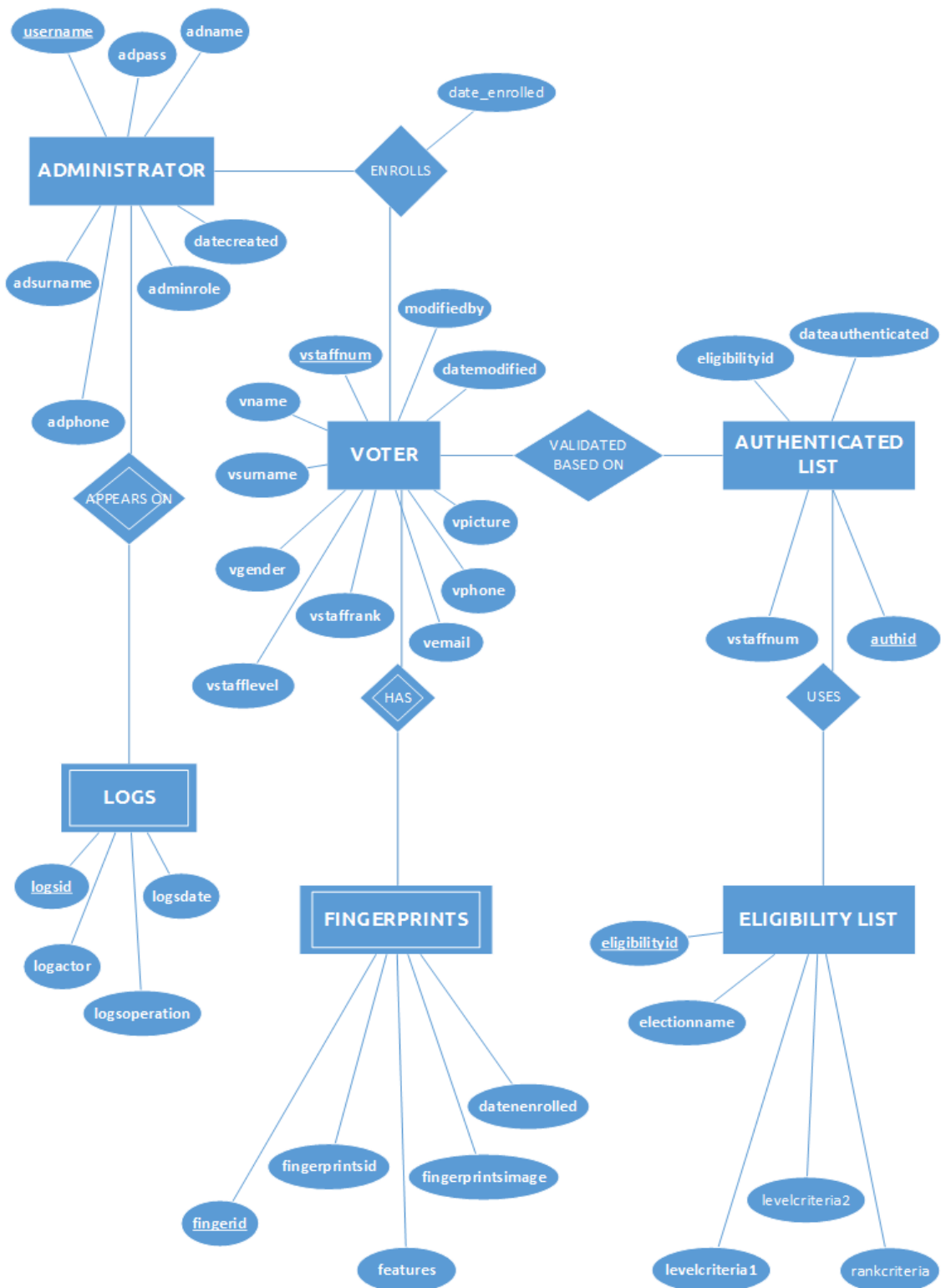


Figure 3.5: ER Diagram of the Offline (Desktop) Sub-Module

ER DIAGRAM OF DESKTOP MODULE

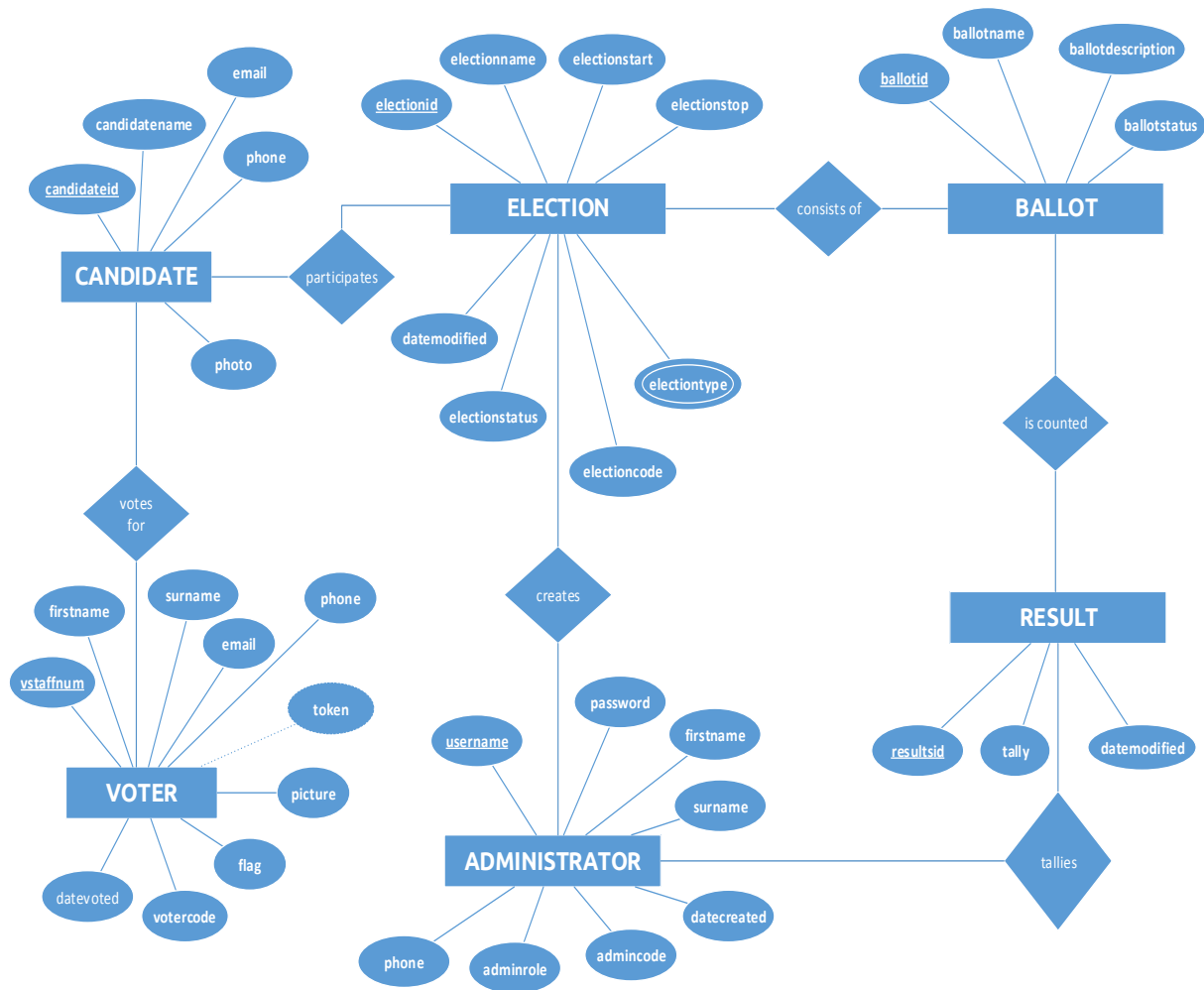


Figure 3.6: ER Diagram of the Online Sub-Module

3.5 THE FINGERPRINT MODULE

This module is used to capture the fingerprints of users. There are different types of fingerprint readers with their corresponding Software Development Kits, provided by several vendors. The fingerprint reader that would be used in the proposed new system is the *DigitalPersona U.are.U 5000* reader.

The above fingerprint reader has the following specifications as seen in the table below:

Table 3.1 The DigitalPersona U.are.U 5000 reader specifications

Sensor Type	Optical
Resolution	512 PPI
Image size	355x390 pixels
Image Capture Area	14.6mm width at 18.1mm length
Colors	8-bit grayscale (256 levels of gray)
Device Connection	USB 1.0, 1.1 and 2.0 Full Speed
Supported OS	Windows 7/Vista/XP/2003/2000



Figure 3.7: Digital Persona U.are.U 5000 Scanner

3.6 HIERARCHICAL (HIPO) DIAGRAM

HIPO is a graphic technique that can be used to describe a system. The HIPO (Hierarchy plus Input-Process-Output) technique is a tool for planning and/or documenting a computer program. A HIPO model consists of a hierarchy chart that graphically represents the program's control structure and a set of IPO (Input-Process-Output) charts that describe the inputs to, the

outputs from, and the functions (or processes) performed by each module on the hierarchy chart.

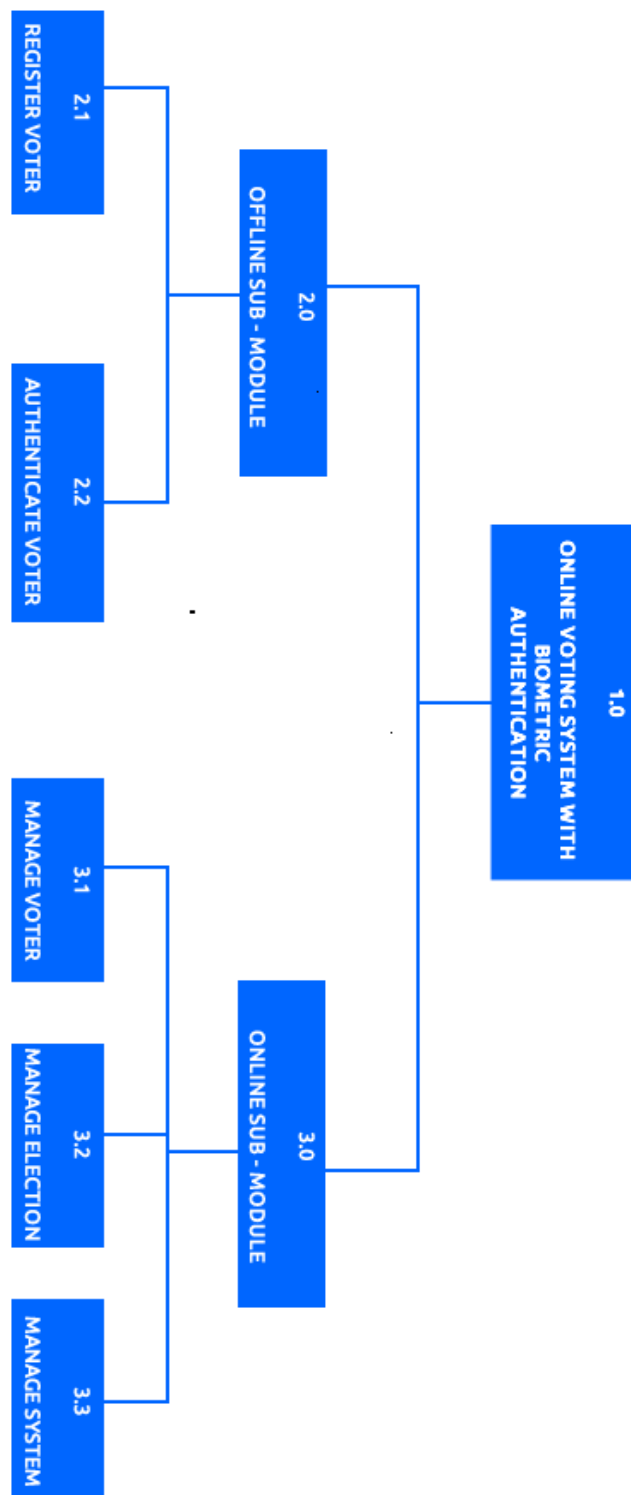


Figure 3.8: HIPO diagram for the overall system

HIERARCHICAL INPUT-PROCESS-OUTPUT DIAGRAM SHOWING THE OFFLINE MODULE OF THE UIBOVS DESKTOP MODULE

It shows the logical connection of the various processes that can be carried out on the Offline module; the vital two activities are the Registrattion and Authentication of voters respectively

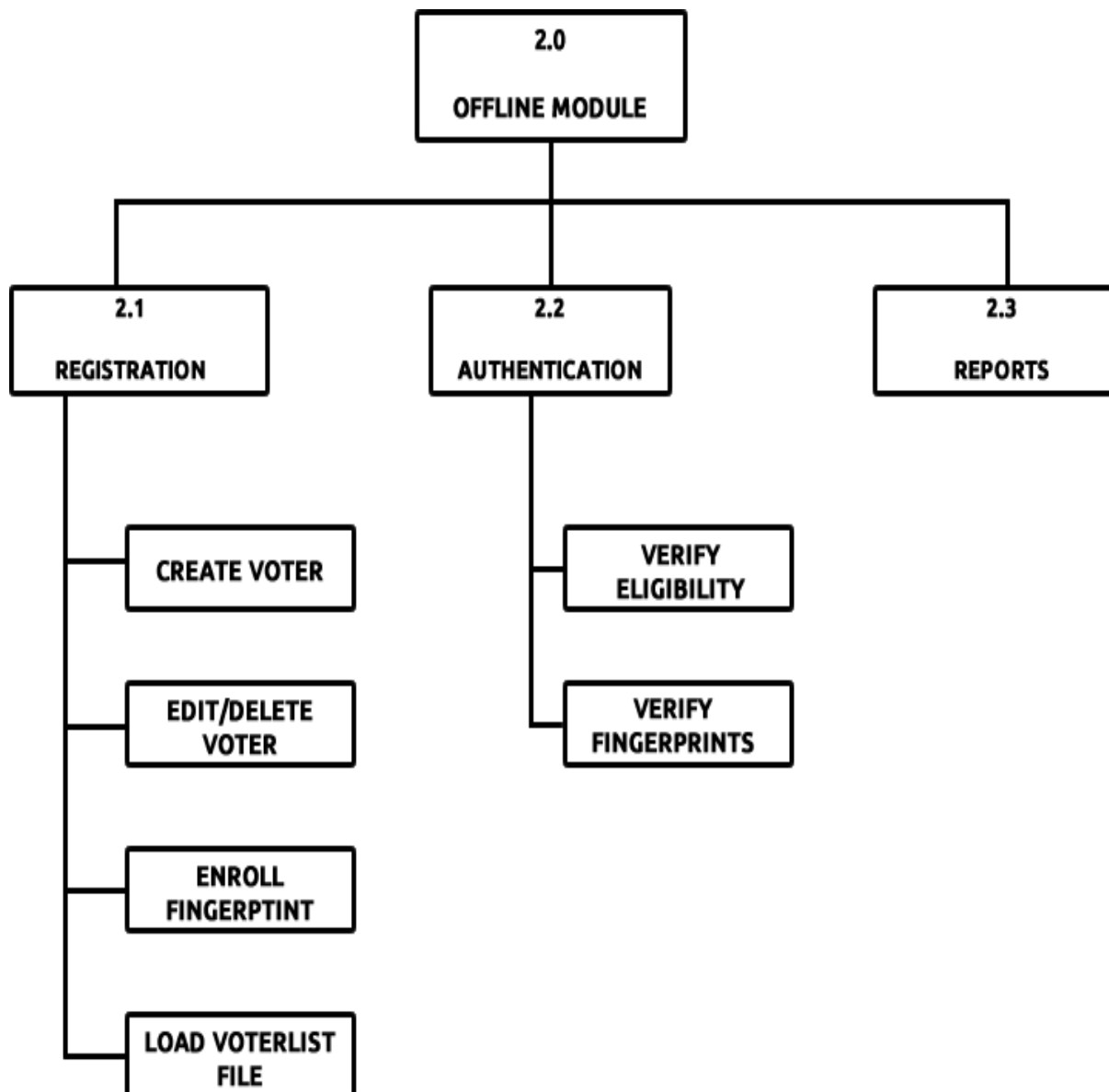


Figure 3.9: HIPO diagram for the Offline (Desktop) Module

HIERARCHICAL INPUT-PROCESS-OUTPUT DIAGRAM SHOWING THE ONLINE MODULE OF THE UIBOVS DESKTOP MODULE

It shows the logical connection of the various processes that can be carried out by the two major entities on the Online module, that is, the Voter and the Administrator

It is worthy to note that both system users (voter and administrator) have different interfaces from which they gain access into the system

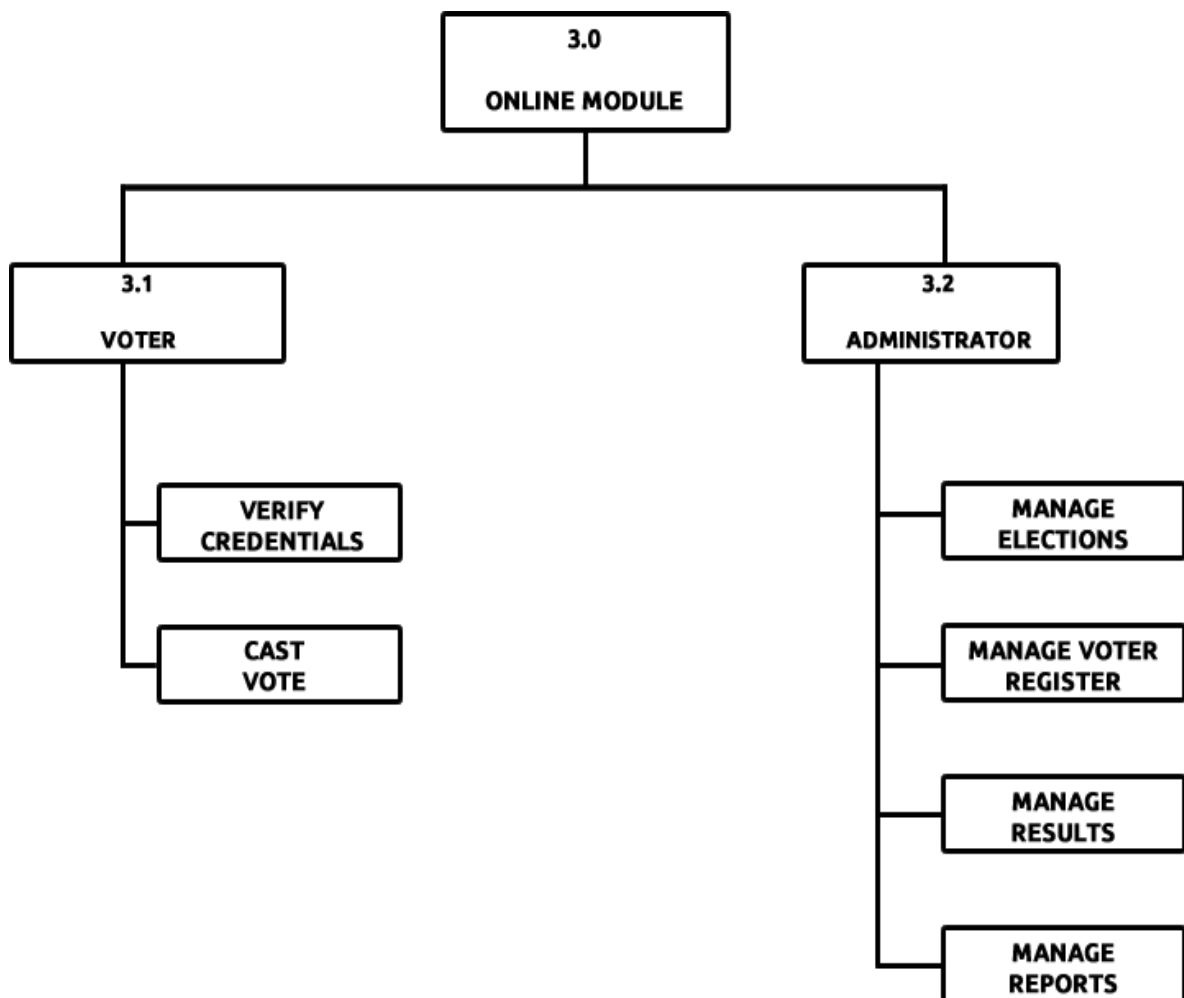


Figure 3.10: HIPO diagram for the Online Module

3.7 WORK-FLOW CHARTS FOR FINGERPRINTS PROCESSING

FINGERPRINT ENROLLMENT

Fingerprint enrollment is the initial process of collecting fingerprint data from a person (enrollee) and storing the resulting data as a fingerprint template for later comparison. The following procedure describes typical fingerprint enrollment.

Enrollment Workflow Procedure

1. Obtain the enrollee's voter identification number (Subject Identifier).
2. Capture the enrollee's fingerprint using the fingerprint reader.
3. Extract the fingerprint feature set for the purpose of enrollment from the fingerprint sample.
4. Repeat steps 2 and 3 until you have enough fingerprint feature sets to create a fingerprint template, typically four times.
5. Create a fingerprint template.
6. Associate the fingerprint template with the enrollee through the Subject Identifier, such as a user name.
7. Store the fingerprint template, along with the Subject Identifier, for later comparison.

Fingerprint templates can be stored in any type of repository that you choose, but for this project – a local database is used.

FINGERPRINT VERIFICATION

Fingerprint verification is the process of comparing the fingerprint data to the fingerprint template produced at enrollment and deciding if the two match. The following procedure describes typical fingerprint verification.

Verification Workflow Procedure

1. Obtain the Voter Identification Number of the person to be verified.
2. Capture a fingerprint sample using the fingerprint reader.
3. Extract a fingerprint feature set for the purpose of verification from the fingerprint sample.
4. Retrieve the fingerprint template associated with the Subject Identifier from your repository.
5. Perform a one-to-one comparison between the fingerprint feature set and the fingerprint template, and make a decision of match or non-match.
6. Act on the decision accordingly.

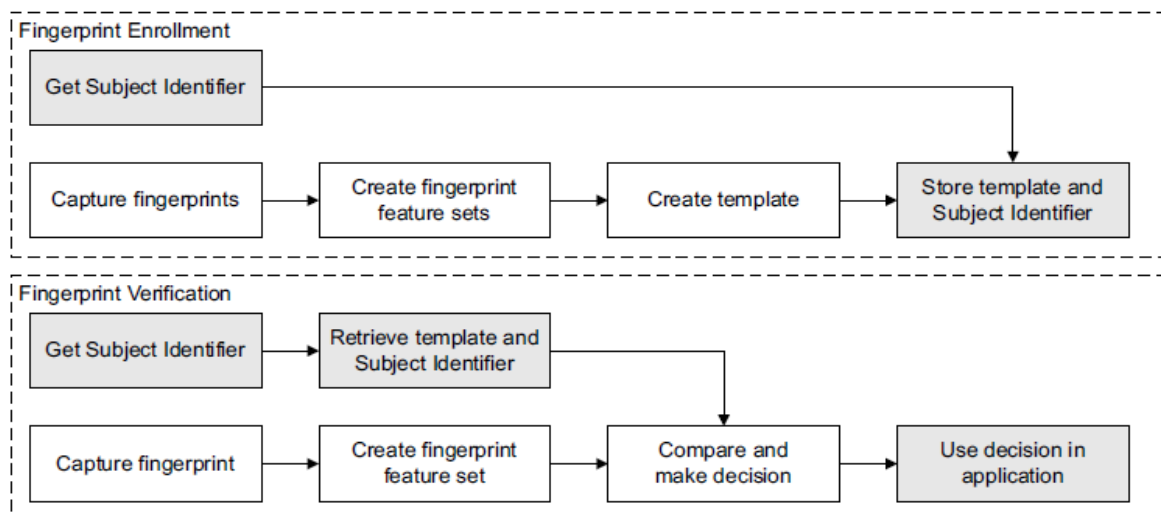


Figure 3.11: Work Flow Chart for Voter Fingerprint Enrollment and Verification

3.8 SYSTEM ARCHITECTURAL DESIGN

The University of Ibadan Online Voting System's architectural design is a diagram that defines the relationship between major structural elements of the software, the design patterns that can be used to achieve the requirements defined for the system and the constraints that affect the way in which architectural design patterns can be applied.

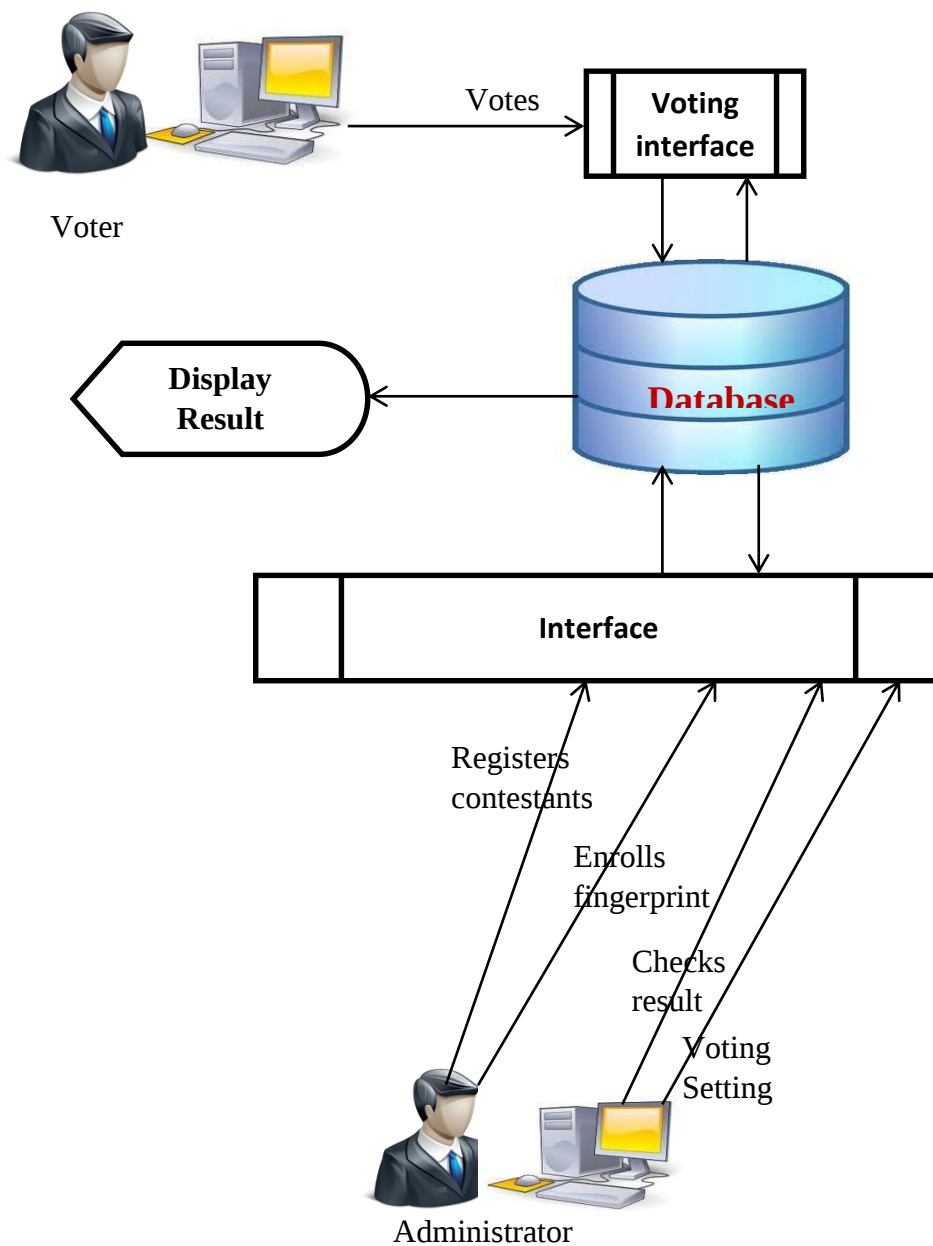


Figure 3.12: System Architectural Diagram for the UIBOVS System

3.9 PROCESS FLOW – CHARTS

3.9.1 Flowchart for Voter Verification and Authentication

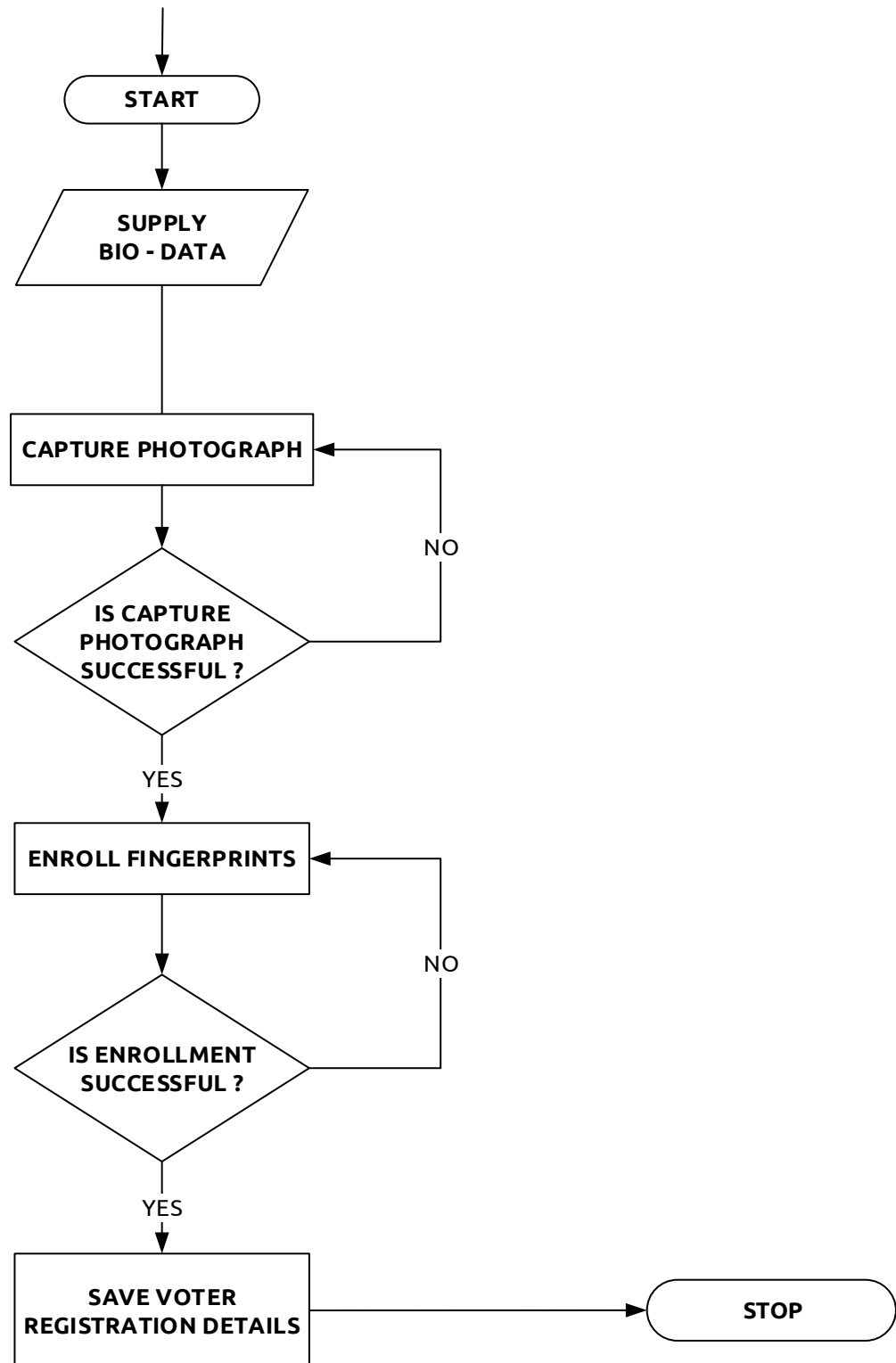


Figure 3.13: Flow Chart for the Voter Registration and Enrollment Process

3.9.2 Flowchart for Voter Verification and Authentication

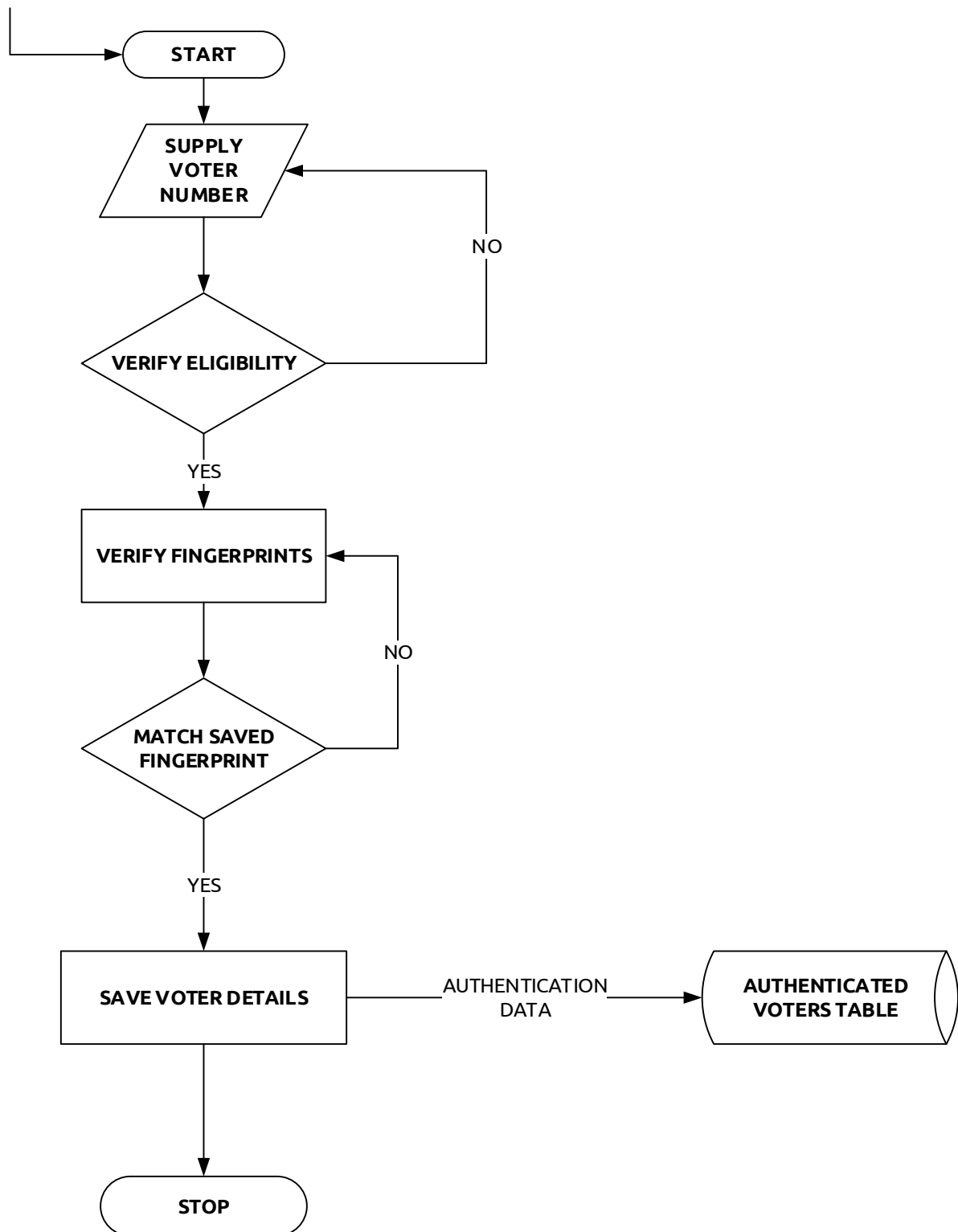


Figure 3.14: Flow Chart for the Voter Verification and Authentication Process

3.10 DATABASE DESIGN

The database design depicts the various relations that have been formalized from the entity – relationship diagram earlier developed for the project. It refers to the organization of data and essentially captures the entities after normalization and includes all their properties as well as the constraints that exists on the relationships between the entities. A RDBMS, specifically MySQL Server, is used to implement the database design formulated.

Some of the relations that were used are shown below:

TABLE UIBOVSD.ADMINISTRATOR

COLUMN NAME	DATA TYPE
USERNAME	VARCHAR(100)
ADPASS	VARCHAR(128)
ADNAME	VARCHAR(35)
ADSURNAME	VARCHAR(35)
ADPHONE	VARCHAR(45)
ADMINROLE	VARCHAR(45)
DATECREATED	DATETIME

TABLE UIBDRS.AUTHENTICATEDLIST

COLUMN NAME	DATA TYPE
AUTHID	INT(11)
VSTAFFNUM	VARCHAR(45)
DATEAUTHENTICATED	DATETIME
ELECTIONREF	VARCHAR(20)

TABLE UISEVS.TBLVOTECAST

COLUMN NAME	DATA TYPE
VOTECASTID	INT(5)
VOTERCODE	VARCHAR(10)
ELECTIONVOTED	VARCHAR(10)
DATEVOTED	DATETIME

TABLE UIBOVSD.VOTER

COLUMN NAME	DATA TYPE
VOTERID	INT(10)
VINUMBER	VARCHAR(45)
VFIRSTNAME	VARCHAR(35)
VSURNAME	VARCHAR(35)
VGENDER	VARCHAR(10)
VSTAFFLEVEL	VARCHAR(2)
VSTAFFRANK	VARCHAR(25)
VEMAIL	VARCHAR(100)
VPHONE	VARCHAR(15)
VPICTURE	VARCHAR(250)
VFINGERS	BLOB
VSECURITYQUESTION	TEXT
VSECURITYANSWER	TEXT
DATEMODIFIED	DATETIME
VSTATUS	VARCHAR(10)

TABLE UIBOVSD.ELIGIBILITYLIST

COLUMN NAME	DATA TYPE
ELIGIBILITYID	INT(11)
ELECTIONNAME	VARCHAR(100)
ELECTIONREF	VARCHAR(20)
MINIMUMVOTERLEVEL	VARCHAR(2)
MAXIMUMVOTERLEVEL	VARCHAR(2)
RANKCRITERIA	VARCHAR(25)

Other relations/tables can be found in the appendix.

3.11 CHAPTER SUMMARY

The chapter contains the system design overview and justification of the proposed system, the methodology, requirements analysis of the proposed system which includes the functional and non-functional requirements of the system.

CHAPTER FOUR

IMPLEMENTATION, TESTING AND DOCUMENTATION

4.1 INTRODUCTION

This chapter presents the implementation and testing overview of the application: it starts with the program implementation details of the system and then proceeds to give a more top –level view of the application and subsequently wraps up with steps and requirements for deploying the application

4.2 CHOICE OF PROGRAMMING LANGUAGES

JAVA was used to implement the desktop (Offline) sub-system of this application. JAVA has a wealth of data structures and methods in its development kit or library such as the swing package which the graphical user interface of this application leverages on; also, the language is highly portable which means that it can run on any hardware architecture and it is robust as well as being highly secured.

PHP was used to implement the online sub-system of this application. PHP as a language is now object – oriented thus it can serve the purpose of developing this application very well. Also, it is cheaper to deploy online, with a vast array of technical support as well as the open-sourced nature of the language.

MySQL is deployed as the database engine for both the Offline and Online module of the University of Ibadan Online Voting System (UIBOVS) project. It is currently open-sourced and can be gotten freely online. MySQL has been proven with a high performance rating as well as optimal query operations

4.3 SYSTEM REQUIREMENTS

The system requirements under the headings of the hardware, and software requirements would be discussed below

4.3.1 Hardware Requirements

The hardware requirements of the application includes the following:

1. **A Fingerprint Reader:** A DigitalPersona U.are.U 5000 fingerprint reader was used during the development of this application.
2. **A Compatible Computer:** The application should be run on a computer with at least the following configurations:
 - a. 4 GB RAM
 - b. 2.20 GHz Dual-Core CPU Processor
 - c. 500 GB HDD

4.3.2 Software Requirements

The software requirements of the application are as follows:

1. Windows 7/8/8.1 32/64-bit Operating System
2. MySQL Server
3. JAVA Development Kit
4. Fingerprint SDK license
5. A compatible browser, for accessing the online module

4.3.3 Personnel Training

It is necessary for the personnel that would be handling the offline and online subsystems to be well trained on how to properly and ethically use the application. They would need to be conversant with both the User Manual as well as the various modules of the application.

4.4 DEVELOPMENT TOOLS

Listed below are the various development tools used during the project.

1. NETBEANS 8.0.1 IDE
2. DREAMWEAVER CC IDE
3. WAMP SERVER 2.4E

4.5 SYSTEM SCREENSHOTS

The images below show the screenshots of the application from both the voters' and administrator perspective or account.

4.5.1 DESKTOP MODULE LOGIN SCREEN

This is the screen that first displays when the Offline (Desktop) module of the Project (UIBOVS) is launched. The administrator is expected to supply his/her login credentials.

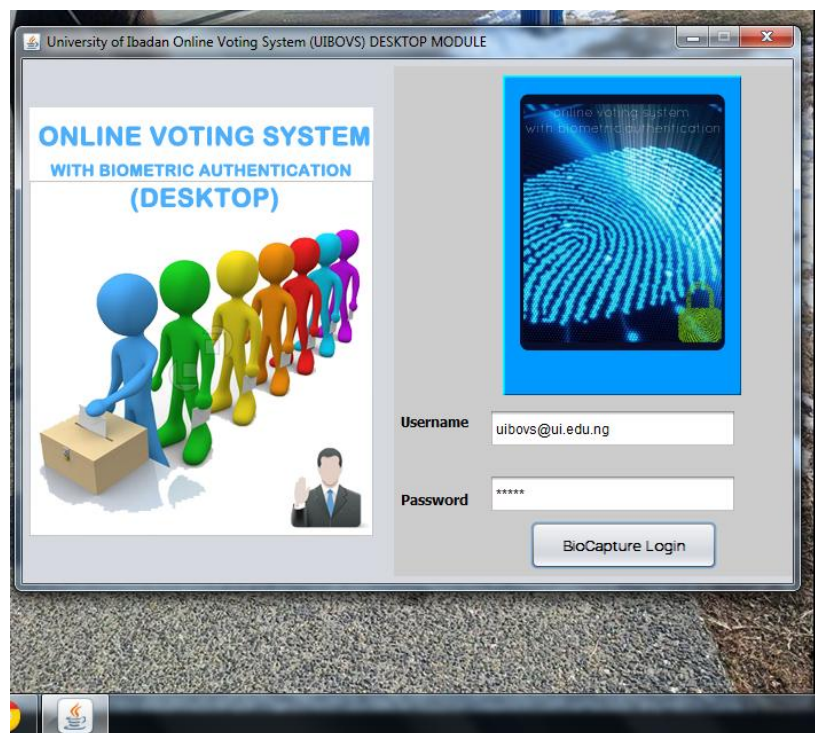


Figure 5.1: The UIBOVS Desktop Module Login Screen Interface

4.5.2 DESKTOP MODULE MAINSCREEN

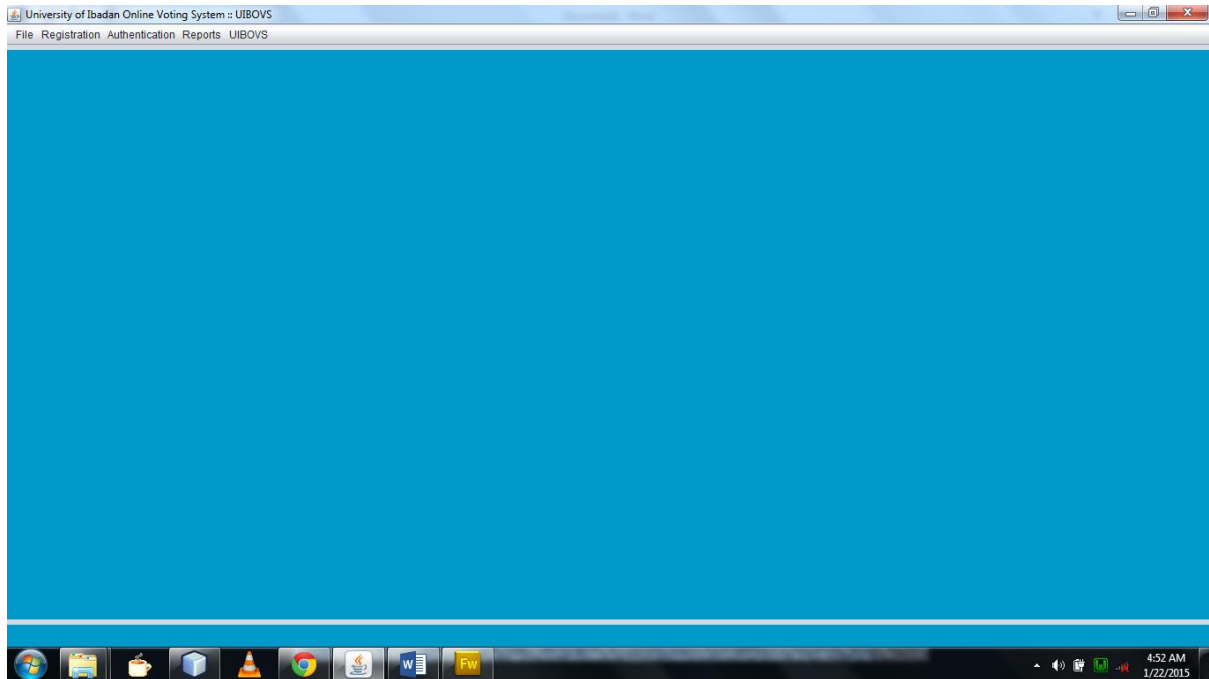


Figure 5.2: The UIBOVs Desktop Module Home Interface or Main Screen

4.5.3 DESKTOP MODULE ADD VOTER FORM SCREEN

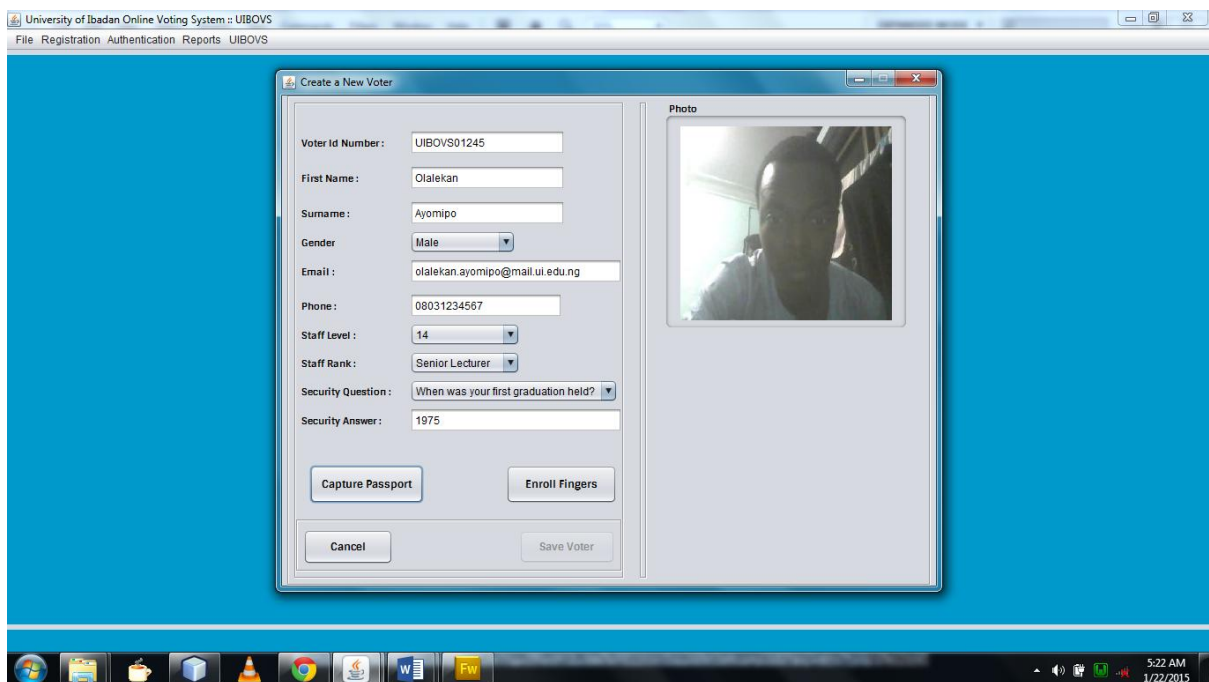


Figure 5.3: A Voter Interface during an ongoing voting process

4.5.4 DESKTOP MODULE AUTHENTICATE VOTER SCREEN

Multiple screens showing the various sub steps involved in verifying the eligibility and thus, authentication of a voter for a forthcoming election

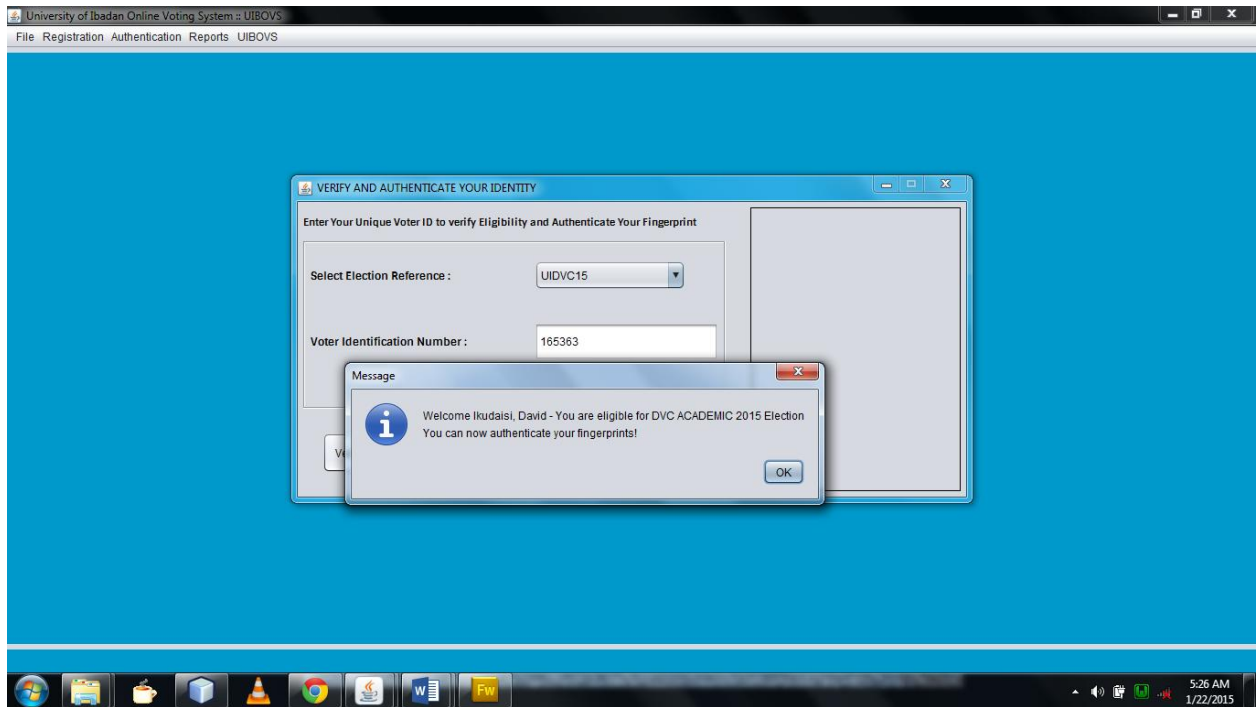


Figure 5.4: The Verify Voter Interface during voter authentication for an election

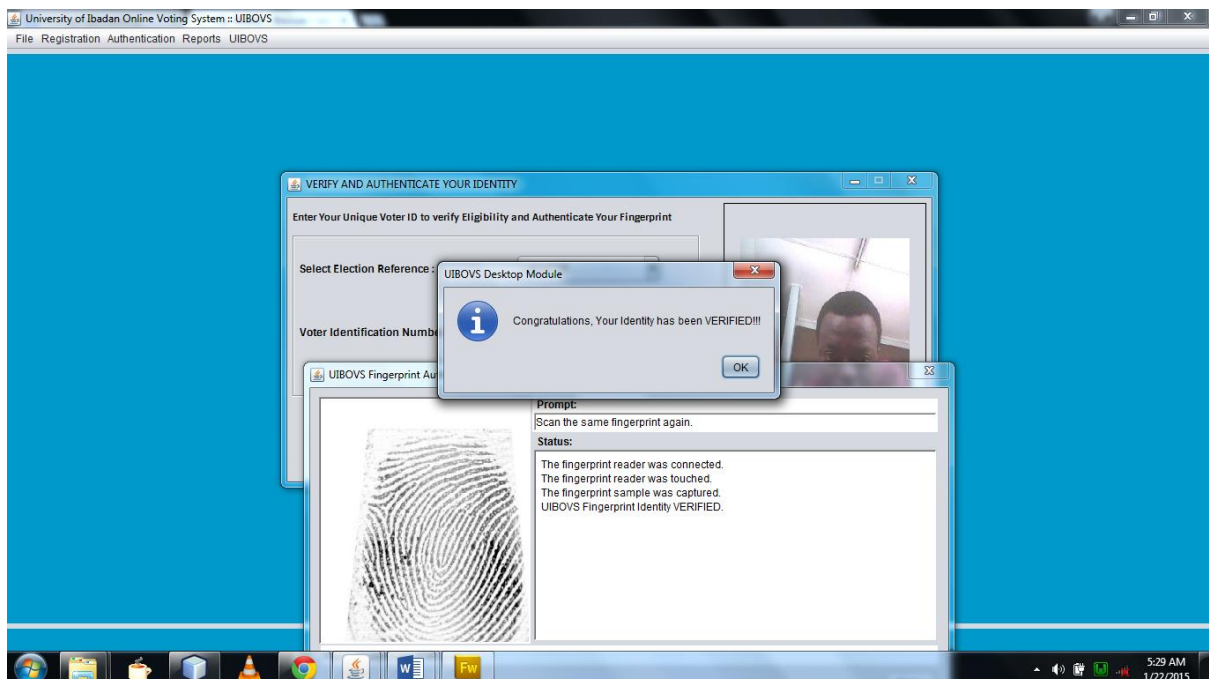


Figure 5.5: Interface to show a successful authentication process

4.5.5 DESKTOP MODULE CREATE OR EDIT ELIGIBILITY SCREEN

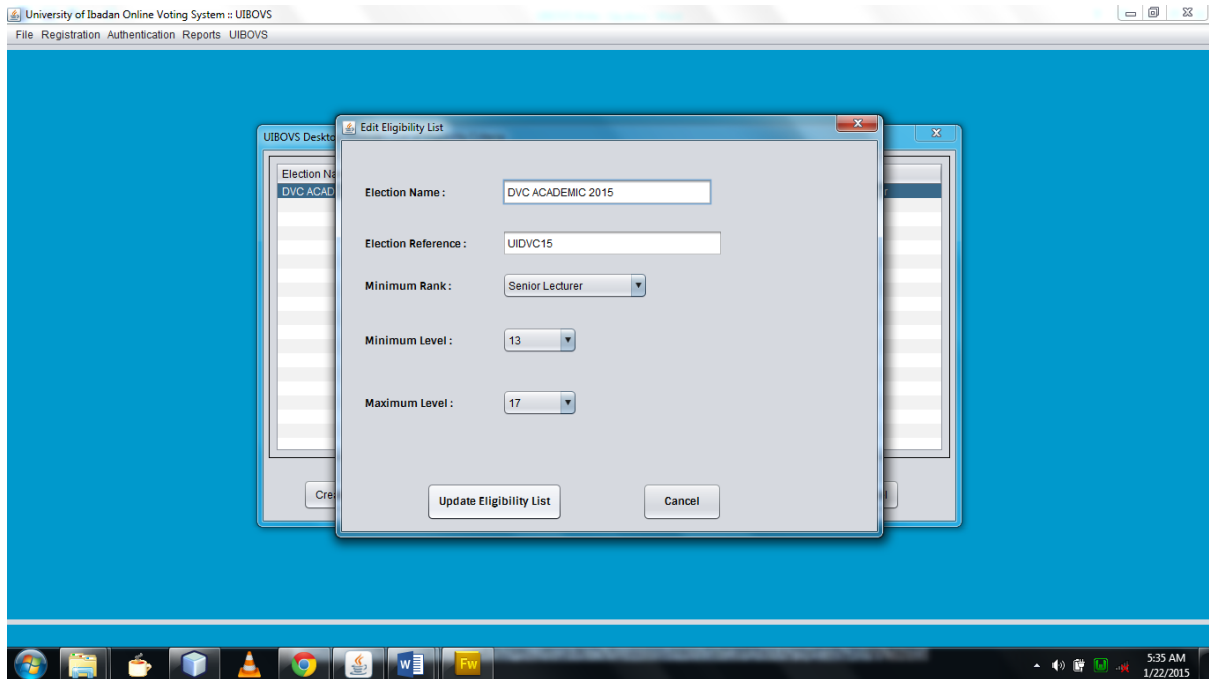


Figure 5.6: The Create/Edit Election Eligibility interface before an election

4.5.6 DESKTOP MODULE AUTHENTICATED VOTERS LIST SCREEN

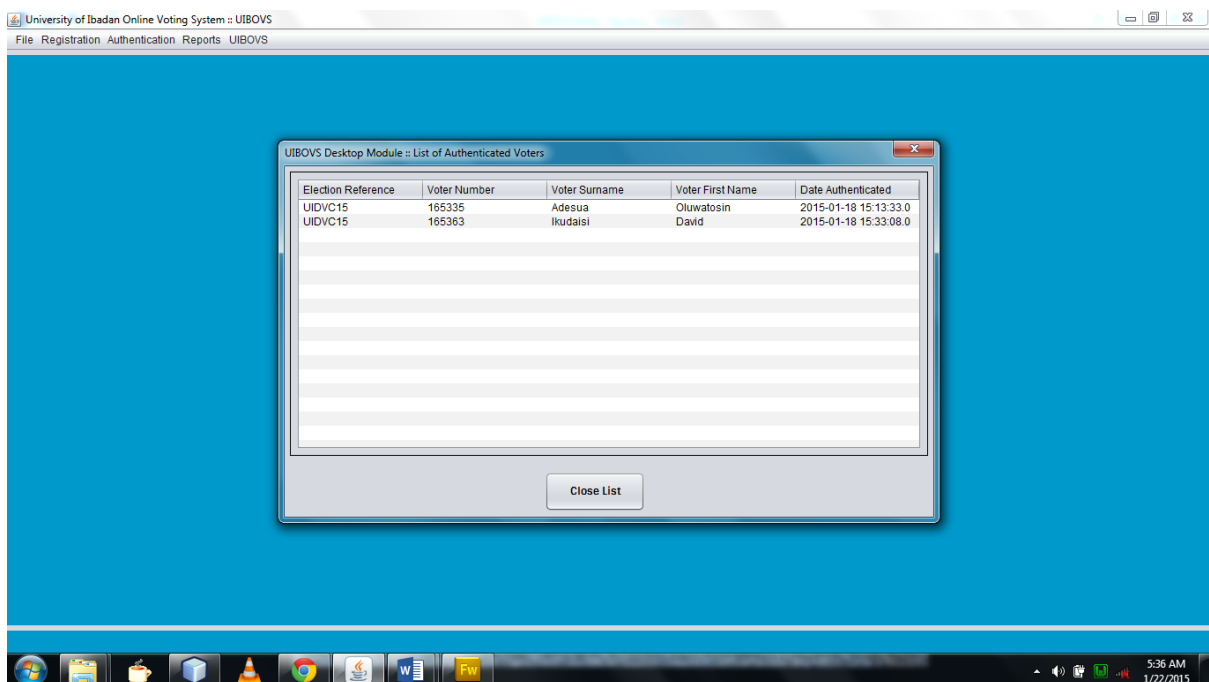


Figure 5.7: Interface showing the list of Authenticated voters for an election

4.5.7 DESKTOP MODULE EXPORT AUTHENTICATED VOTERS LIST SCREEN

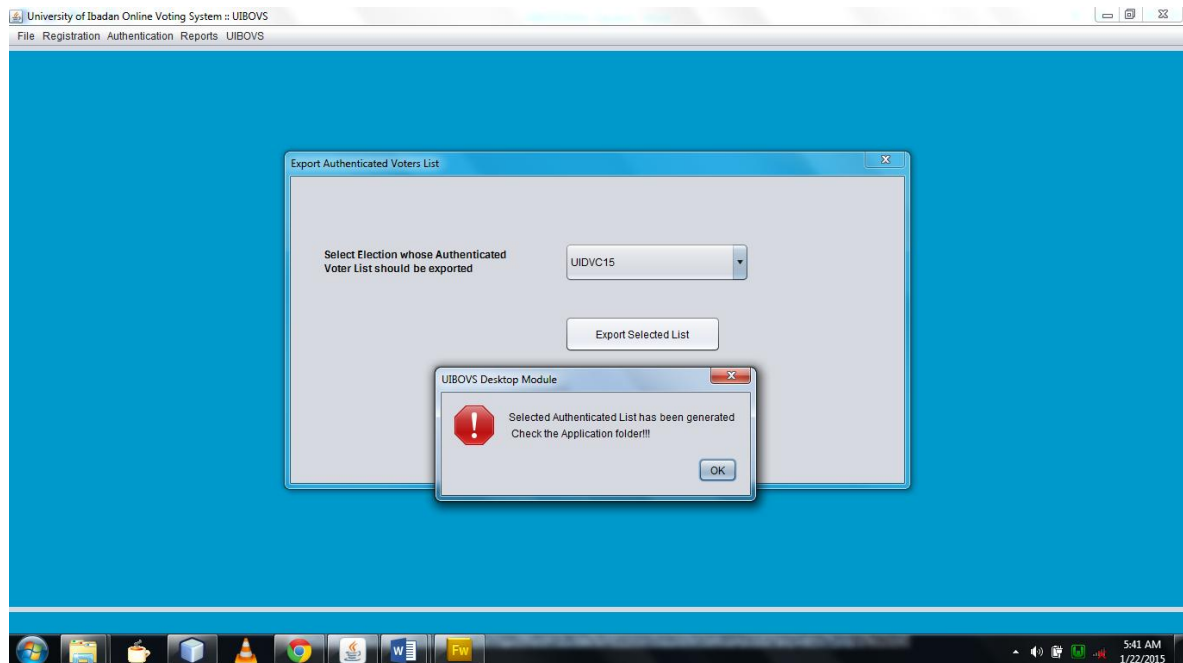


Figure 5.8: The Export Authenticated Voters List Interface which creates the Voter Register which is uploaded on the UIBOVs Online Module per Election

4.5.8 DESKTOP MODULE CREATE OR EDIT ADMINISTRATOR SCREEN

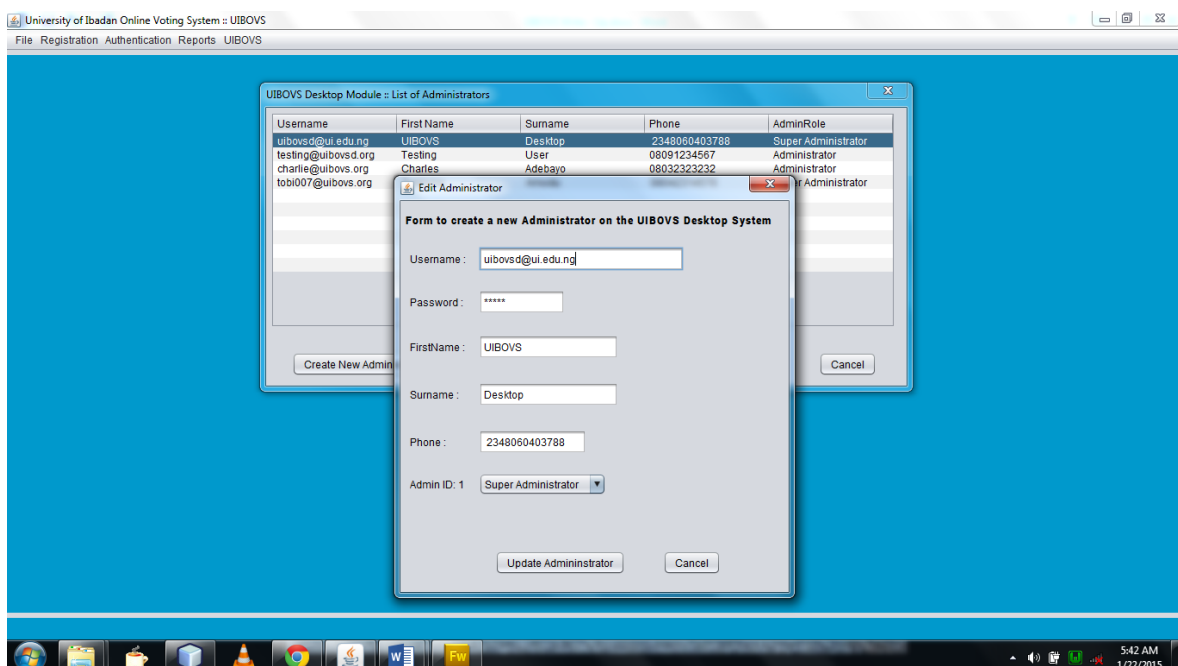


Figure 5.9: The UIBOVs Desktop Module used to either Create/Edit an Administrator

4.5.9 ONLINE MODULE VOTERS HOME PAGE



Figure 5.10: The Home page of the UIBOVs Online module

4.5.10 ONLINE MODULE VOTING LOGIN SCREEN

Voters can use the form as shown to gain access to the election, they were authenticated for.

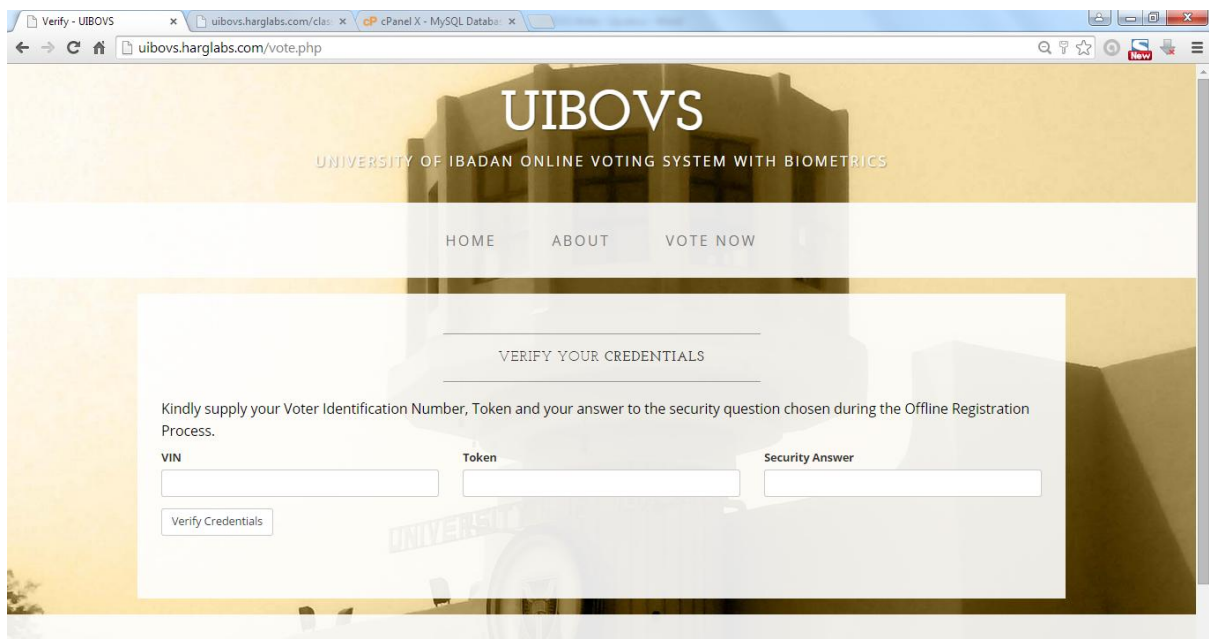


Figure 5.11: The Interface that allows a voter's credentials to be verified before voting

4.5.11 ONLINE MODULE ELECTION VOTING PAGE

The screenshot shows a web browser window with the URL `uibovs.harglabs.com/voting.php?r=verifiedok`. The page header features the UIBOVs logo and the text "UNIVERSITY OF IBADAN ONLINE VOTING SYSTEM WITH BIOMETRICS". The navigation menu includes "HOME", "ABOUT", "VOTE NOW", "OBTAIN RECEIPT", and "CONTACT". The main content area is titled "CAST YOUR VOTE" and contains the following form elements:

- A heading: "Choose your preferred candidate for each office and submit at the end of the form."
- Three input fields: "Election Name:" (containing "UI DVC Academics"), "Election Day:" (containing "2015-01-19"), and "Election Period:" (containing "8 AM to 4 PM").
- A section titled "Office of the Deputy Vice Chancellor - Academics" with two radio button options: "Professor Gbemisola Oke" and "Professor Ade Olayinka".
- A "Cast Your Vote" button.

The browser's taskbar at the bottom shows the time as 2:42 PM on 1/22/2015.

Figure 5.12: A Voter Interface during an ongoing voting process

4.5.12 ONLINE MODULE POST – VOTING SCREEN

The screenshot shows a web browser window with the URL `uibovs.harglabs.com/vote.php?r=votingsucc`. The page header features the UIBOVs logo and the text "UNIVERSITY OF IBADAN ONLINE VOTING SYSTEM WITH BIOMETRICS". The navigation menu includes "HOME", "ABOUT", and "VOTE NOW". The main content area is titled "VERIFY YOUR CREDENTIALS" and contains the following form elements:

- A heading: "Kindly supply your Voter Identification Number, Token and your answer to the security question chosen during the Offline Registration Process."
- Three input fields: "VIN", "Token", and "Security Answer".
- A "Verify Credentials" button.
- A confirmation message: "You have successfully voted. Thanks".

The browser's taskbar at the bottom shows the time as 2:44 PM on 1/22/2015.

Figure 5.13: An Interface showing that a Voter has successfully cast a vote

4.5.13 ONLINE MODULE ADMINISTRATOR DASHBOARD SCREEN

The dashboard or index page of the UIBOVs Online Administrator. It serves as a link to other pages and functions within the application



Figure 5.14: The Login Screen of the UIBOVs Online Administrator Control Panel

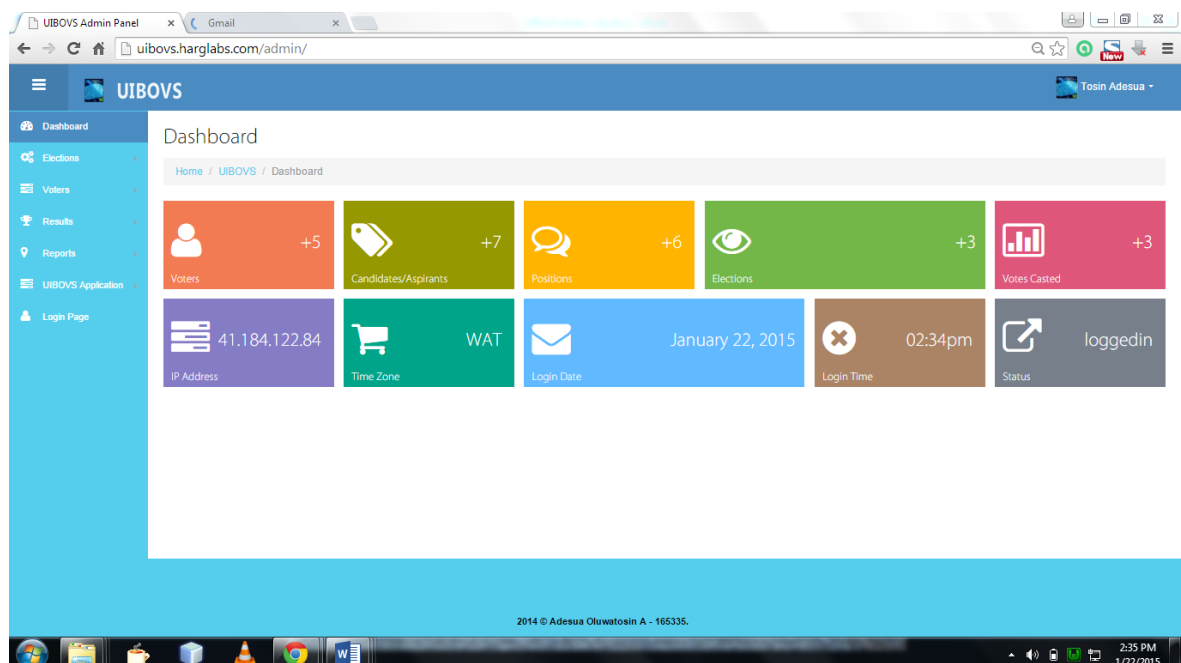


Figure 5.15: The Dashboard of the UIBOVs Online Administrator Control Panel

4.5.14 ONLINE MODULE ADD ELECTION SCREEN

Verify - UIBOVS x Create Elections x cPanel Login x Settings x

uibovs.harglabs.com/admin/create_election.php

UIBOVS

Home / Elections / Create Election

Dashboard

Elections

- Add Election
- Manage Elections
- Add Ballot
- Manage Ballots
- Add Candidate
- Manage Candidates

Voters

Results

Reports

UIBOVS Application

Create Election

Elections List

Create Election

All fields are required

Election Name

Number of Ballots

Election Day

Election Starts

Election Stops

Status

Create Election

2014 © Adesua Oluwatoshin - 165335.

2:30 PM 1/21/2015

Figure 5.16: The Add Election Interface

4.5.15 ONLINE MODULE ADD BALLOT SCREEN

Verify - UIBOVS x Create Ballots x cPanel Login x Settings x

uibovs.harglabs.com/admin/create_ballot.php

UIBOVS

Home / Ballots / Create Ballot

Dashboard

Elections

- Add Election
- Manage Elections
- Add Ballot
- Manage Ballots
- Add Candidate
- Manage Candidates

Voters

Results

Reports

UIBOVS Application

Create Ballot

Ballots List

Create Ballot

All fields are required

Election

Ballot Name

Ballot Description

Status

Create Ballot

2014 © Adesua Oluwatoshin - 165335.

2:32 PM 1/21/2015

Figure 5.17: The Add Ballot Interface

4.5.16 ONLINE MODULE ADD CANDIDATE SCREEN

The screenshot shows the 'Create Candidate' page in the UIBOVS application. The left sidebar contains a menu with options: Dashboard, Elections, Add Election, Manage Elections, Add Ballot, Manage Ballots, Add Candidate, Manage Candidates, Voters, Results, Reports, and UIBOVS Application. The main content area has a header 'Create Candidate' and a breadcrumb 'Home / Candidates / Create Candidate'. Below this are two buttons: 'Create Candidate' (blue) and 'Candidates List' (pink). The 'Create Candidate' form is active, showing a message 'All fields are required'. The form fields are: 'Office Voted For' (dropdown menu showing 'UI DVC ACADEMICS - Depu'), 'Candidate Name' (text input with 'Professor Gbemisola Oke'), 'Candidate Email' (text input with 'gbemisola.oke@mail.ui.edu.ng'), and 'Candidate Phone' (text input with '08081234567'). A 'Create Candidate' button is at the bottom of the form. The footer of the application shows '2014 © Adesua Oluwatosin - 165335'.

Figure 5.18: The Add Candidate Interface

4.5.17 ONLINE MODULE LOAD VOTER REGISTER SCREEN

The left screenshot shows the 'Load Voter Register' page in the UIBOVS application. The left sidebar is the same as in Figure 5.18. The main content area has a header 'Load Voter Register' and a breadcrumb 'Home / Voters / Load Voter Register'. Below this are two buttons: 'Load Voter Register' (blue) and 'Voter Register' (pink). The 'Load Voter Register' form is active, showing a message 'All fields are required'. The form fields are: 'Voter Register's Election' (dropdown menu showing 'UI DVC ACADEMICS'), 'Voter Register' (text input with 'Select Register File'), and a 'Load Voter Register' button. The footer of the application shows '2014 © Adesua'.

The right screenshot shows the same 'Load Voter Register' page, but with a success message at the bottom: 'The uploaded file was successfully loaded on the system.' The 'Load Voter Register' button is now disabled (greyed out).

Figure 5.19: The Interface that is used to Load Voter Register(s) which are exported from the UIBOVS Desktop Module

4.5.18 ONLINE MODULE SENDTOKEN SCREEN

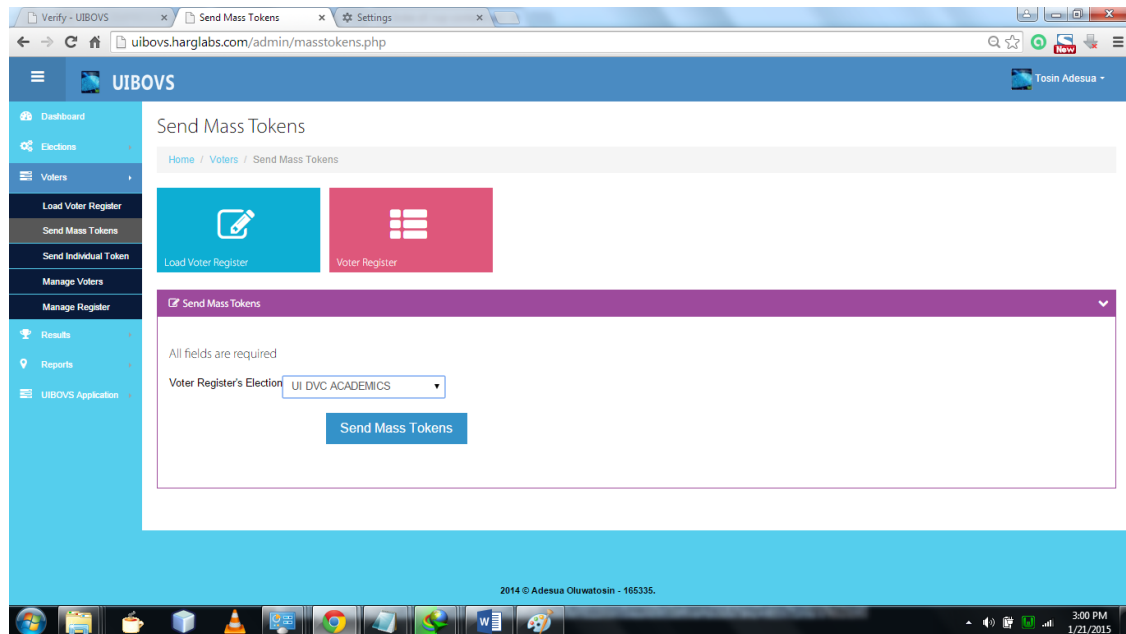


Figure 5.20: Interface used to send out tokens to all voters

4.5.19 ONLINE MODULE VOTER TOKEN AS SEEN IN EMAIL RECIEVED

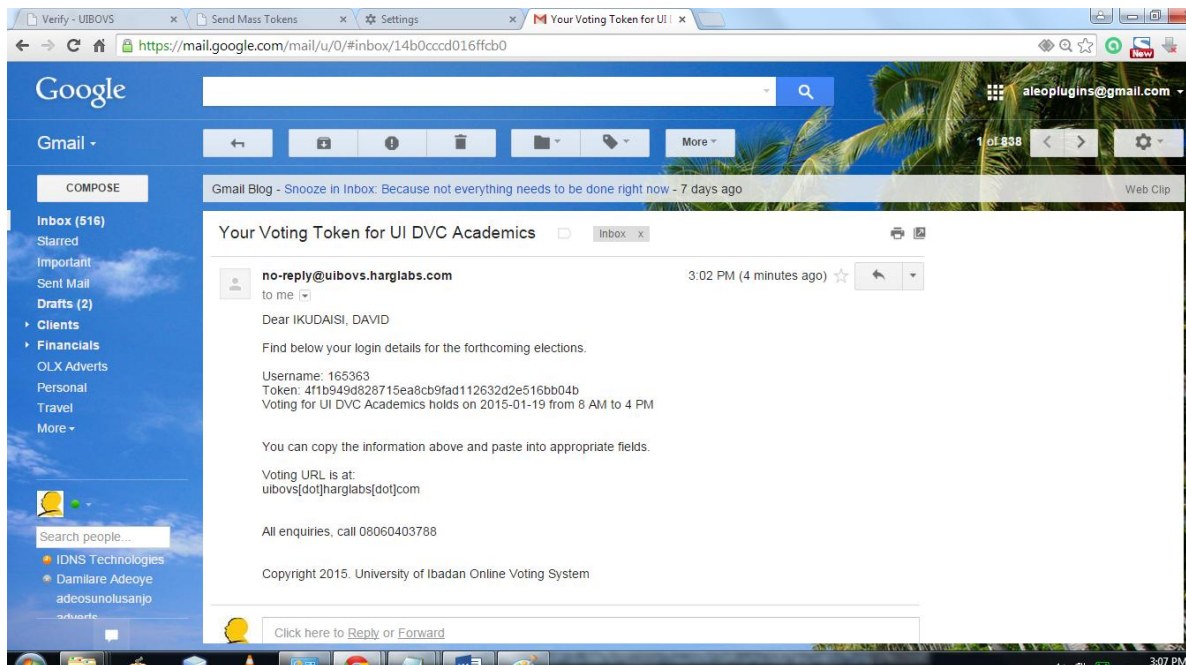


Figure 5.21: Email showing a copy of the Voting Token received as sent by the UIBOVS

4.5.20 ONLINE MODULE RESULT DISPLAY SCREEN

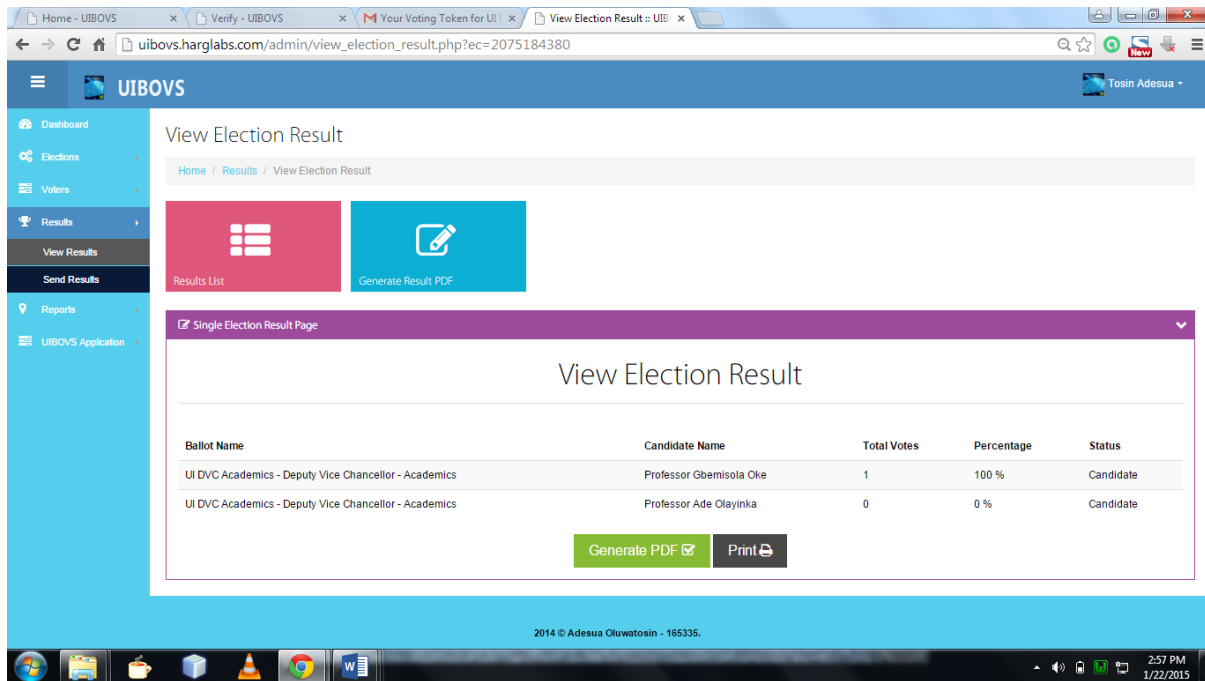


Figure 5.22: The Result Overview Interface showing a breakdown of election results

4.6 SYSTEM TESTING

Testing of the software is necessary in order to check the existence of fault in the software so as to make changes that will remove the faults. Testing is necessary to prevent system failure.

The major testing done include

Unit testing: breaks down the software into components and verifies the functionalities of each individually within the programming environment. Also known as component testing, it tests if each component works as it is supposed to, why it gets the required input and returns the required output.

Integration Testing: this was done after successfully testing each module of software. Testing is done by creating interfaces between components and making sure that they communicate efficiently and that necessary input and output is transferred for the overall efficient functioning of the system.

Acceptance Testing: Acceptance testing was done after the implementation of the system. The acceptance testing will check if the system works correctly in the user environment and if all user specified functionalities are present. It also tests if the system adheres to the policies and qualities standard.

4.7 CHAPTER SUMMARY

This chapter provides the information about how the application needs to be set – up in order to function optimally as well as highlighting steps needed to be followed by all users of the application. It gives a documentation brief for the users and also gives information on testing procedures implemented on the application.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

This project was designed to implement a system that will be used for election process using the staff elections of the University of Ibadan as case study. With trust, credibility and voter apathy challenges constantly cropping up in the traditional manual way of elections within the staff community of the University of Ibadan, the development of this online voting system with biometric authentication – specifically the use of the voter fingerprints – will be a welcome innovation to the staff voting electorate.

It has also helped to restore belief and encourage more staff members to always participate and have their say in how they are governed administrative by fully exercising their voting rights or franchise.

This project delivers an efficient Online Voting System with Biometric Authentication for University of Ibadan Staff Elections to reduce, if not eradicate, the problem of eligibility, wrong voter information as well as centralized and stressful voting location.

5.2 CONCLUSION

This project was designed to implement a system that will be used for election process using the staff elections of the University of Ibadan as case study.

The integration of biometric authentication within the system will provide an efficient way to cast votes, free of fraud, and make the system more trustable, economic and fast as well as enabling the voters to cast their votes from any location as a result of the online voting module which can be accessed from any device with internet connectivity. The use of fingerprint

recognition deepens the process of ensuring that the voting mantra – one man, one vote – is fully enforced.

The project is of immense benefits to the University as it protects and secures the integrity of the university's staff elections, reduces administrative work, and improves the staff election's creditability rating which subsequently strengthens internal democracy and trust among the staff.

5.3 RECOMMENDATIONS

A lot of improvements can be made to this project, to enhance the usability and human-computer interaction as listed below:

1. Facial Capabilities could be added to this application to enhance the security
2. The application could be made to function in a distributed network mode such that once the voter comes to authenticate at the various polling centers, the application opens a new window for the voter to cast their votes immediately without going online – subsequently upgrading the project to an enterprise application.
3. The Online module of the application can be further secured by the purchase and use of a Secure Socket Layer protocol certificate. This would increase the ability of the system to withstand intrusion attacks on its file system.

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APPENDIX

CODE LISTINGS

Listing 1: eligibilitydao.java

```
/**
 * @author Oluwatosin Adesua
 * @matric 165335
 * @project University of Ibadan Online Voting System
 * @version UIBOVS 1.0.0
 * @since 2014
 */

package com.adesua.uibovs.dao;

import com.adesua.uibovs.to.EligibilityTO;
import com.adesua.uibovs.utils.DBConnection;
import java.sql.Connection;
import java.sql.PreparedStatement;
import java.sql.ResultSet;
import java.sql.Statement;
import java.sql.SQLException;
import java.text.SimpleDateFormat;
import java.util.Date;
import javax.swing.JOptionPane;

public class EligibilityDAO
{
    // The Class EligibilityDAO
    /*

    username, adpass, adname, adsurname, adphone, adminrole, datecreated

    CREATE TABLE `eligibilitylist` (
    `eligibilityid` int(11) not null default '1',
    `electionname` varchar(100) not null,
```

```

`electionref` varchar(20),
`minimumvoterlevel` varchar(2) not null,
`maximumvoterlevel` varchar(2),
`rankcriteria` varchar(25),
PRIMARY KEY (`eligibilityid`)
) ENGINE=InnoDB DEFAULT CHARSET=utf8;

private int eligibilityid;
private String electionname;
private String electionref;
private String minimumvoterlevel;
private String maximumvoterlevel;
private String rankcriteria;
private ResultSet resultSet;
*/

protected static final String FIELDS_INSERT = "electionname, electionref, minimumvoterlevel, maximumvoterlevel,
rankcriteria";

protected static final String FIELDS_RETURN = "eligibilityid," + FIELDS_INSERT;

protected static final String INSERT_SQL = "INSERT INTO eligibilitylist (" + FIELDS_INSERT +
")VALUES(?,?,?,?,?)";

protected static final String SELECT_SQL = "SELECT " + FIELDS_RETURN + " FROM eligibilitylist WHERE
eligibilityid=?";

protected static final String UPDATE_SQL = "UPDATE eligibilitylist SET
electionname=?,electionref=?,minimumvoterlevel=?,maximumvoterlevel=?,rankcriteria=? WHERE eligibilityid=?";

protected static final String UPDATE_ELIG_SQL = "UPDATE eligibilitylist SET
electionname=?,electionref=?,minimumvoterlevel=?,maximumvoterlevel=?,rankcriteria=? WHERE eligibilityid=?";

protected static final String DELETE_SQL = "DELETE FROM eligibilitylist WHERE electionref=?";

protected static final String SELECT_ALL_SQL = "SELECT " + FIELDS_RETURN + " FROM eligibilitylist";
protected static final String SELECT_SOME_SQL = "SELECT " + FIELDS_RETURN + " FROM eligibilitylist ";
protected static final String SELECT_AUTH_SQL = "SELECT electionref FROM eligibilitylist";
protected static final String GETID_SQL = "SELECT eligibilityid WHERE VALUES=?";

public int create(EligibilityTO eligibleTO)throws SQLException,ClassNotFoundException
{
    int eligibilityid = 0;
    Connection connection = null;
    ResultSet resultSet = null;

```

```

try
{
    connection = DBConnection.getConnection();
    PreparedStatement prepStatement = null;
    prepStatement = connection.prepareStatement(INSERT_SQL);
    int i = 1;
    prepStatement.setString(i++,eligibleTO.getElectionName());
    prepStatement.setString(i++,eligibleTO.getElectionRef());
    prepStatement.setString(i++,eligibleTO.getMinVoterLevel());
    prepStatement.setString(i++,eligibleTO.getMaxVoterLevel());
    prepStatement.setString(i++,eligibleTO.getRankCriteria());
    //prepStatement.executeUpdate();
    int rowCount = prepStatement.executeUpdate();
    JOptionPane.showMessageDialog(null, "New Eligibility List created", "UIBOVS Desktop Module",
JOptionPane.OK_OPTION);
    //System.out.println("Created");
}
catch(Exception e)
{
    e.printStackTrace();
    //return 1001;
}
finally
{
    connection.close();
}
return 0;
}
// end of create
public EligibilityTO findAllAuth()
{
    EligibilityTO eligibleTO = null;
    PreparedStatement prepStatement = null;
    ResultSet resultSet = null;
    Connection connection = null;

```

```

try
{
    connection = DBConnection.getConnection();

    PreparedStatement prepStatement =
connection.prepareStatement(SELECT_AUTH_SQL,ResultSet.TYPE_SCROLL_INSENSITIVE,ResultSet.CONCUR
_READ_ONLY);

    eligibleTO = new EligibilityTO();
    resultSet=prepStatement.executeQuery();
    if(resultSet.first())
    {
        eligibleTO.setResultSet(resultSet);
    }
    else
    {
        System.out.println("No Eligibility Lists yet");
        eligibleTO.setResultSet(resultSet);
    }
}
catch(Exception e)
{
    e.printStackTrace();
}
return eligibleTO;
}

public void delete(String elgRef)throws SQLException,ClassNotFoundException
{
    Connection connection=null;
    PreparedStatement prepStatement=null;

    try
    {
        connection = DBConnection.getConnection();
        prepStatement = connection.prepareStatement(DELETE_SQL);

        prepStatement.setString(1, elgRef);
        prepStatement.executeUpdate();
    }
}

```

```

        JOptionPane.showMessageDialog(null, "Selected Eligibility List has been deleted", "UIBOVS Desktop Module",
JOptionPane.OK_OPTION);

    }
    catch(Exception e)
    {
        e.printStackTrace();
    }
    finally
    {
        prepStatement.close();
        connection.close();
    }
} //End of delete

}

```

Listing 2: loginscreen.java

```

/**
 *
 * @author Oluwatosin Adesua
 * @matric 165335
 * @project University of Ibadan Online Voting System
 * @year 2014
 * @version UIBOVS 1.0.0
 *
 */
package com.adesua.uibovs.view;

import com.adesua.uibovs.utils.DBConnection;
import com.adesua.uibovs.dao.AdminDAO;
import com.adesua.uibovs.to.AdminTO;
import com.digitalpersona.onetouch.ui.swing.*;
import com.digitalpersona.onetouch.ui.swing.sample.Enrollment.*;
import java.awt.Color;

```

```

import javax.swing.JOptionPane;
import java.sql.SQLException;
import java.util.logging.Level;
import java.util.logging.Logger;

public class LoginScreen extends javax.swing.JFrame {

    /**
     * Creates new form LoginScreen
     */
    public LoginScreen() {
        initComponents();
        this.setBackground(Color.white);
    }

    /**
     * This method is called from within the constructor to initialize the form.
     * WARNING: Do NOT modify this code. The content of this method is always
     * regenerated by the Form Editor.
     */
    @SuppressWarnings("unchecked")
    // <editor-fold defaultstate="collapsed" desc="Generated Code"> //GEN-BEGIN: initComponents
    private void initComponents() {

        LoginRightPanel = new javax.swing.JPanel();
        jTxtUsername = new javax.swing.JTextField();
        jLblUsername = new javax.swing.JLabel();
        jLblPassword = new javax.swing.JLabel();
        jPasswordField = new javax.swing.JPasswordField();
        jBtnLogin = new javax.swing.JButton();
        jPanel1 = new javax.swing.JPanel();
        jLblMainLogo = new javax.swing.JLabel();
        jLabel1 = new javax.swing.JLabel();

        setDefaultCloseOperation(javax.swing.WindowConstants.EXIT_ON_CLOSE);

```

```

setTitle("University of Ibadan Online Voting System (UIBOVS) DESKTOP MODULE");
setBackground(new java.awt.Color(0, 102, 255));
setBounds(new java.awt.Rectangle(350, 150, 0, 0));
setName("loginFrame"); // NOI18N
setResizable(false);

LoginRightPanel.setBackground(new java.awt.Color(204, 204, 204));
LoginRightPanel.setPreferredSize(new java.awt.Dimension(350, 0));

jLblUsername.setFont(new java.awt.Font("Tahoma", 1, 12)); // NOI18N
jLblUsername.setText("Username");

jLblPassword.setFont(new java.awt.Font("Tahoma", 1, 12)); // NOI18N
jLblPassword.setText("Password");

jBtnLogin.setFont(new java.awt.Font("Roboto", 1, 12)); // NOI18N
jBtnLogin.setText("BioCapture Login");
jBtnLogin.addMouseListener(new java.awt.event.MouseAdapter() {
    public void mouseClicked(java.awt.event.MouseEvent evt) {
        jBtnLoginMouseClicked(evt);
    }
});

/* Create and display the form */
java.awt.EventQueue.invokeLater(new Runnable() {
    public void run() {
        new LoginScreen().setVisible(true);
    }
});
}

public void login(){
    //String username = jTxtUsername.getText();
    //String password = String.valueOf(jPasswordField.getPassword());

```

```

String username = LoginScreen.jTxtUsername.getText();
char[] password = LoginScreen.jPasswordField.getPassword();
String pword = new String (password);
//String quote = "";
String whereClause = " WHERE username = '" + username + "'";
//whereClause += whereClause + " AND " + " password = " + quote + password + quote;
whereClause += " AND " + " adpass = '" + pword + "'";

AdminDAO adminDAO = new AdminDAO();
AdminTO adminTO = adminDAO.findSome(whereClause);

try {
    if(adminTO.getResultSet().first() == true)
    {
        // Send the user to the destination Screen
        // based on the user's access role level
        MainScreen uibovsMain = new MainScreen();
        uibovsMain.setVisible(true);
        this.dispose();
    }
    else
    {
        JOptionPane.showMessageDialog(null,"Wrong Login Credentials");
    }
} catch (SQLException ex) {
    Logger.getLogger(LoginScreen.class.getName()).log(Level.SEVERE, null, ex);
}

}

// Variables declaration - do not modify//GEN-BEGIN:variables
private javax.swing.JPanel LoginRightPanel;
private javax.swing.JButton jBtnLogin;
private javax.swing.JLabel jLabel1;
private javax.swing.JLabel jLblMainLogo;
private javax.swing.JLabel jLblPassword;

```

```

private javax.swing.JLabel jLblUsername;

private javax.swing.JPanel jPanelI;

public static javax.swing.JPasswordField jPasswordField;

public static javax.swing.JTextField jTxtUsername;

// End of variables declaration//GEN-END:variables

}

```

Listing 3: *votingcontroller.php*

```

<?php

//      Author:           Adesua Oluwatosin

//      Project:  Online Voting System with biometric authentication

//      An Voting Controller File that controls operations on the Voting Object


// Import the votingformmodel class
include_once("class.VotingForm.php");


//      Start a new session if not started by now
if(!isset($_SESSION)){
    session_start();
}


//      Logic to verify credentials supplied by the voter
if(isset($_POST['btnVerify']) && $_POST['btnVerify']=="VerifyVoter")
{
    // Create a new instance of the Voting object
    $nVoting = new VotingForm();


    //      Save the passed parameters
    $votnumber = $_POST['vin'];
    $vottoken = $_POST['token'];
    $votanswer = $_POST['sanswer'];


    //      Call the Voting->verifyVoter method

```

```

//      Logic to create a new Election entry in the system
if(isset($_POST['btnVote']) && $_POST['btnVote']=="CastVote")
{
    // Create a new instance of the Voting object
    $nVoting = new VotingForm();

    //      Save the passed parameters
    $elcode = $_POST['electcode'];
    $vc = $_SESSION['voters']['votercode'];
    date_default_timezone_set('Africa/Lagos');
    $dte = date("Y-m-d\TH:i:s");

    //      Generate the Tally
    $vtally = hash("sha1", $vc.$dte);

    $fuv;
    $fu;

    if (!$nVoting->retVotingStatus($vc))
    {
        try
        {
            //      Iterate through the values in the POST array and get each ballot code and
its corresponding candidate code
            foreach($_POST as $ballotcode => $candcode)
            {
                $bcd = "";
                $ccd = "";

                if (!$ballotcode == "electcode") && !$ballotcode == "btnVote")
                {
                    $bcd = $ballotcode;
                    $ccd = $candcode;

                    //      Save each entry into the database

```

```

        $fuvr = $nVoting->updateVotingResult($bcd, $ccd, $vtally);
    }
}
$nVoting->updateVoterFlag($vc);
$fuvc = $nVoting->updateVoteCasted($vc, $elcode, $dte);
}
catch (exception $ex)
{
    echo $ex->getMessage();
    echo $ex->getLine();
    echo "Technical Failure of the desired operation";
}
} else { $fuvc = "failed"; }

if ($fuvc == "success")
{
    unset($_POST);
    //      Call the Voting Destructor method to close the database access
    $nVoting->__destruct();

    //      Redirect the voter back to the same page with a status message
    header("location:vote.php?r=votingsucc");
} else {
    unset($_SESSION);
    header("location:vote.php?r=votingfailed");
}
}
//      End of logic to create a new Election entry in the system

?>

```

For want of space, the reader should please refer to the Compact Disc attached to this document for the full listing of all the source codes as well as libraries used.