Thesis submitted to the

UNIVERSITY OF MOHAMED BOUDIAF - MSILA

FACULTY OF MATHEMATICS AND COMPUTER SCIENCE

DEPARTMENT OF COMPUTER SCIENCE

OPTION : BUSINESS INTELLEGENCE AND OPTIMIZATION

In partial fulfillment of the requirements for the degree of

Master in Computer Science

By

Guersas Tayeb

Yahi Fedwa

Design and Implementation of a Digital Web Platform for Electronic Voting in Municipal Elections

Under the supervision of

Boudia Malika

Composition of the jury

Guesmia Salah	University of Msila	President
Boudia Malika	University of Msila	Reporter
Chalabi Baya	University of Msila	Examiner

June, 2025

الملخص

شهدت العمليات الانتخابية تطورًا كبيرًا على مر الزمن. ففي البداية، كانت الانتخابات تُجرى باستخدام الأساليب التقليدية التي تتطلب الحضور الفعلي والتصويت الورقي، مما كان يؤدي غالبًا إلى الاتهامات المتبادلة بالتزوير، والتأخيرعن اعلان النتائج، وصعوبات في عدّ الأصوات. ومع التقدم التكنولوجي، برز التصويت الإلكتروني كحل بديل يهدف إلى تعزيز الشفافية، وتسريع المعالجة، وتسهيل مشاركة المواطنين بشكل أوسع في العملية الانتخابية. وفي هذا السياق، يهدف هذا العمل إلى تصميم وتطوير منصة رقمية مخصصة لمتابعة سير الانتخابات على المستوى المحلي تُمكّن من إجراء عملية التصويت الإلكتروني بشكل آمن وفعّال.

الكلمات المفتاحية: التصويت الإلكتروني، الانتخابات البلدية، منصة رقمية، الأمان، الشفافية، المشاركة...إلخ

Abstract

Electoral processes have witnessed significant development over time. Initially, elections were conducted using traditional methods that required physical presence and paper-based voting, which often led to mutual accusations of fraud, delays in announcing results, and difficulties in vote counting. With technological advancement, electronic voting emerged as an alternative solution aimed at enhancing transparency, accelerating result processing, and facilitating broader citizen participation in the electoral process. In this context, the present work aims to design and develop a digital platform dedicated to monitoring the progress of elections at the local level. The platform enables the secure and efficient implementation of electronic voting..

Keywords: Electronic Voting, Municipal Elections, Digital Platform, Security, Transparency, Participation..etc

Dedication

To those who inherited the patience of Asiya, the loyalty of Khadija, the wisdom of Aisha, and the fortitude of Fatima… to those whose hearts overflow with compassion, vaster than the mightiest rivers on Earth.

To you, the luminous guide of our path, the sanctuary of our journey, and the longing of hearts aflame with devotion… To you, the quenchless thirst of the yearning soul… To the noblest mothers this world has known.

To those who taught us the endurance to learn, the tenacity to succeed, and the resilience to persevere you have been the beacon of our purpose and the essence of our achievements.

To those who reign sovereign over the realms of our hearts… To our beloved parents, who nurtured us with boundless care and shared with us life's sweetness and trials alike.

To our cherished siblings, and to every soul who illuminated our minds with even a single letter guiding us, step by step, from childhood's classroom to the halls of academia.

To all who loved us unconditionally, who offered the gifts of kinship and unwavering kindness though words fail to name each of you, know that your presence is etched indelibly upon our hearts.

To each of you, we dedicate this humble endeavor.

Fedwa Yahi

All praise is due to Allah, by whose grace all good things are accomplished. May peace and blessings be upon His noble Messenger, Prophet Muhammad (peace be upon him), whose life exemplified the highest values of knowledge, patience, and compassion.

To my family, whose unwavering love and support have been my constant source of strength, To every mentor, friend, and kind soul who offered encouragement, guidance, or simply believed in me throughout this journey.

To those who inspired me with their sincerity and perseverance .I dedicate this humble work with deep appreciation and heartfelt gratitude.

Hoping it may be of benefit and reflect even a fragment of the light I have received.

Tayeb Guersas

Acknowledgements

All praise and gratitude belong to Allah, the Almighty, the Omnipotent, the First and the Last, the Manifest and the Hidden, who has bestowed upon us innumerable blessings, sustained us with His boundless provisions, and illuminated our path. To Him alone is due all praise and the utmost gratitude.

He, the Most High, granted us the greatest of blessings by sending His servant and Messenger, Muhammad (peace and blessings be upon him), who conveyed the clear Qur'an, imparted knowledge of what we did not know, and inspired us to seek wisdom in all its forms.

We praise and thank Him for granting us the strength, patience, and perseverance to overcome the challenges faced in completing this humble endeavor.

We also express our profound appreciation to every educator who has enriched our intellect from the earliest stages of learning to the present. Our gratitude extends to all who have offered their support, near or far.

We are particularly indebted to the faculty and staff of the Department of Computer Science at Mohamed Boudiaf University of M'sila for their invaluable guidance and assistance.

In particular, we extend our heartfelt thanks to all the professors of the Computer Science Department, whose dedication and efforts have greatly contributed to our academic growth.

We are also especially grateful to the Dean of the Faculty and the Head of the Department for their continuous support and encouragement.

A special expression of sincere appreciation goes to our supervisor, **Dr. Boudia Malika**, whose valuable guidance, patience, and insightful feedback have played a pivotal role in the success of this project.

Finally, we humbly beseech Allah Almighty to bless us with righteousness, wisdom, moral fortitude, and contentment, and to count us among those who are rightly guided and who guide others

Contents

List of Tables

List of Figures

List of Acronyms

- **DRE**: Direct Recording Electronic
- **VVPAT**: Voter Verified Paper Audit Trail
- **ID**: Identity Document
- **COVID-19**: Coronavirus Disease 2019
- **OTP**: One-Time Password
- **TLS**: Transport Layer Security
- **KSI**: Keyless Signature Infrastructure
- **EVM**: Electronic Voting Machine
- **ROM**: Read-Only Memory
- **ANIE**: National Independent Authority for Elections
- **NIN**: National Identification Number
- **DNA**: National People's Assembly (Lower House)
- **CN**: Council of the Nation (Upper House)
- **RSA**: Rivest–Shamir–Adleman (encryption algorithm)
- **KOVS**: Kernel-based Online Voting System
- **CU**: Control Unit (of EVM)
- **BU**: Ballot Unit (of EVM)
- **UML**: Unified Modeling Language
- **LATEX**: Lamport TeX
- **HTML**: HyperText Markup Language
- **CSS**: Cascading Style Sheets
- **JavaScript**: JavaScript

- **PHP**: Hypertext PreProcessor
- **XAMPP**: Cross-platform Apache MariaDB PHP Perl
- **VS Code**: Visual Studio Code

General Introduction

1)Contextual:

The progressive digitization of administrative processes represents a salient development within contemporary public governance, fostering enhanced efficiency, transparency, and citizen engagement. Within this evolving landscape, the electoral process constitutes a pivotal domain wherein the integration of digital technologies offers substantive potential to modernize traditional voting mechanisms. Conventional paper-based electoral systems, while historically foundational to democratic practice, increasingly manifest operational limitations, including protracted vote tallying procedures, susceptibility to human error, and constrained accessibility for geographically dispersed and differently-abled populations.

Electronic voting (e-voting) systems emerge as an innovative solution poised to address these challenges by leveraging computational methodologies to streamline vote casting, collection, and tabulation. Beyond expediting electoral workflows, e-voting platforms can foster inclusivity by enabling remote participation and accommodating users with diverse abilities and technological proficiencies. Furthermore, such systems facilitate real-time dissemination of election outcomes, thus promoting transparency and timely access to results for stakeholders.

2)Problem Statement:

Despite the apparent advantages, the design and deployment of electronic voting systems necessitate a careful consideration of multifaceted challenges that extend beyond mere technological implementation. This study is framed by the overarching research question:
How can electronic voting platforms be systematically designed and developed to optimize usability, accessibility, and operational efficiency, thereby enhancing the democratic participation process?

This principal inquiry is further delineated through the following sub-questions:

- In what ways can user interface design principles be applied to ensure the platform accommodates individuals across a spectrum of digital literacy levels, including those with disabilities?
- How can system functionalities be architected to support both remote and in-person voting modalities, minimizing user error and maximizing ease of use?

- What mechanisms can be incorporated to enable transparent, real-time reporting of electoral outcomes that is accessible to all relevant stakeholders?
- How can system scalability and reliability be ensured to maintain consistent performance during periods of intensive usage typical of electoral events?
- Which evaluation methodologies are most appropriate for assessing usability and user satisfaction within the context of electronic voting platforms?

3)Objectives:

This investigation aims to conceive and implement an electronic voting system that prioritizes user-centric design and operational robustness. The specific objectives include:

- The development of an intuitive, accessible user interface that facilitates seamless navigation and voting for users of heterogeneous technological competencies and physical abilities.
- The integration of flexible voting modalities that enable both remote and onsite participation to broaden electoral inclusivity.
- The design and implementation of transparent vote aggregation and dissemination mechanisms, ensuring timely and clear communication of election results.
- The adoption of rigorous software engineering practices to guarantee platform reliability, scalability, and responsiveness under realistic electoral conditions.
- The application of empirical usability testing and iterative refinement based on comprehensive user feedback.

4)Thesis Structure:

This study is structured into three main chapters:

- **Chapter 1:** General presentation of electronic voting.
- **Chapter 2:** Design of our platform, with a particular focus on its modelling using UML diagrams.
- **Chapter 3:** Description of the tools used for the implementation of the platform, followed by a detailed explanation of its practical application with examples of the main interfaces developed.

In conclusion, this research aims to provide a comprehensive overview of the future of electronic voting in Algeria by highlighting ways to adapt this technology to the country's technological and legal framework, while ensuring electoral integrity and promoting broader citizen participation in democratic processes.

Chapter 1: Electronic Voting.

1.1 Introduction

The electoral process has witnessed significant transformation in the digital age, with electronic voting emerging as a modern alternative to traditional systems, aiming to enhance transparency, speed, and reliability. In this chapter, we will explore the concept, types, and importance of electronic voting. We will also examine the role of polling stations in managing the electoral process, as they serve as the central points where electoral procedures are executed and the integrity of the vote is safeguarded. Furthermore, international case studies both successful and unsuccessful will be analyzed to provide a critical perspective, concluding with suggested solutions to improve the performance and reliability of electronic voting systems.

1.2 The Evolution of Electronic Voting

Electronic voting has gradually developed over the decades in response to the need for improved efficiency, speed, and transparency in electoral processes. This evolution can be divided into three major phases:

- **First Phase: Mechanical Experiments (1960–1980):**

  The first phase of modernizing voting technology took place between 1960 and 1980 with the introduction of punch-card ballots[40]. These ballots were initially used in the early 1960s, notably during the 1964 primary elections in Fulton and DeKalb Counties, Georgia, and also in West Virginia's 1964 elections. The punch-card system significantly reduced vote-counting time from days to just hours [17] In 1965, Joseph P. Harris developed the Votomatic punch card system, which rapidly gained popularity; by 1966, approximately 37.3% of American voters used this system[37]. However, despite their efficiency, punch-card machines were prone to mechanical reading errors. This vulnerability became widely known during the 2000 U.S. presidential election, when issues with incomplete perforations commonly referred to as "hanging chads" led to significant controversy and challenges in accurately counting votes. As a result, the Help America Vote Act of 2002 was enacted, which effectively banned the use of pre-scored punch cards in American elections after 2006 to improve voting accuracy and reliability[11].

- **Second Phase: Direct Recording Electronic (DRE) Machines (1990–2000):**

  During the 1990s, Direct Recording Electronic (DRE) voting systems became increasingly popular. These systems used touchscreen interfaces to record votes digitally, eliminating the need for paper ballots and helping speed up both voting and counting processes while reducing human error. Brazil was the first country to implement DRE voting nationwide in 1996, followed by India in 2004, where over 400 million votes were cast electronically. The technology proved especially useful in managing large-scale elections efficiently, including in remote areas. However, DRE systems faced criticism for lacking a physical verification method, such as the Voter Verified Paper Audit Trail (VVPAT), which raised concerns about transparency and vote integrity. In response, some countries later introduced VVPAT systems to allow voters to confirm their choices and enable independent audits. This phase marked a major technological leap in electoral systems, but it also highlighted the need to balance innovation with robust verification mechanisms [14] [10].

- **Third Phase: Online Voting (2005–Present):**

  With the advancement of digital technology, some countries began exploring internet-based voting as a modern way to streamline elections.Estonia became the first country to implement online voting on a national level, using digital identity cards and encrypted electronic signaturesto enable secure remote voting. The system was first used in the 2005 municipal elections, with around 1.9% of voters participating online. By 2019, that number had grown to 44%, reflecting increasing trust and system reliability. Estonia's model is now seen as a leading example of digital democracy.

  However, online voting still raises important concerns, including:

  - Server security and the risk of cyberattacks.
  - Voter authentication, ensuring only eligible individuals vote.
  - Ballot confidentiality, particularly when voting occurs outside controlled environments.

  Due to these challenges, most countries remain cautious about adopting online voting, despite its potential to increase accessibility and reduce election costs. Estonia's experience, however, offers a glimpse into the future of secure and efficient digital elections [12] [9] [34].

The following timeline illustrates the historical evolution of electronic voting, highlighting the key milestones that have shaped its development and adoption over the years:

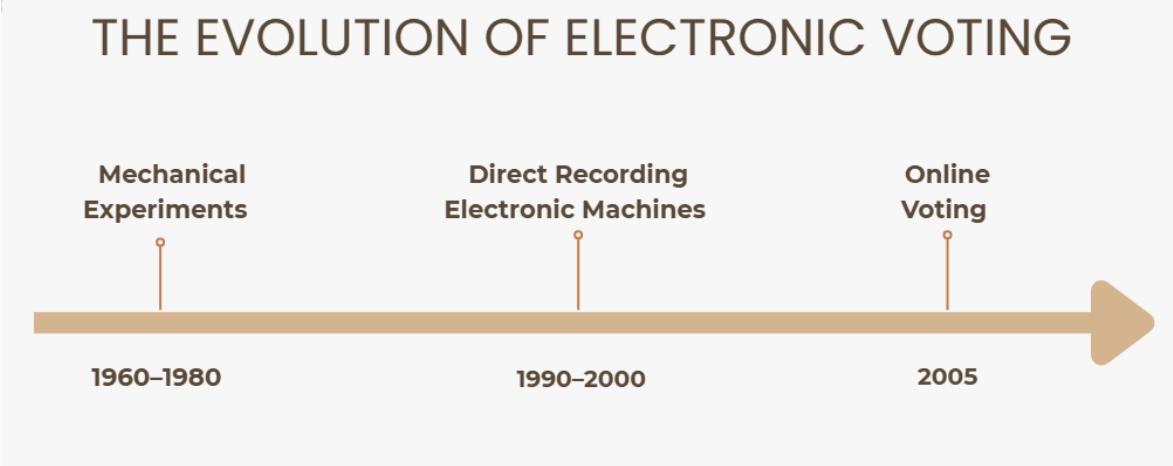


Figure 1.1: The Evolution of Electronic Voting.

1.3 Electronic Voting

Electronic voting is a modern system that relies on technology to enhance the voting process. In this section, we will address its definition, types, and significance.

1.3.1 Definition of E-voting

Electronic voting refers to any electoral system that uses digital technologies for the recording, transmission, or counting of votes. It may rely on dedicated electronic devices (DRE – Direct Recording Electronic) or online voting platforms. This voting method is characterized by its ability to convert electoral data into digital format, enabling automated processing. As a result, it helps to accelerate the electoral process and improve its reliability [1].

1.3.2 The Importance of E-voting

In an era of rapid technological progress, it has become essential to adopt modern mechanisms that ensure both the efficiency and transparency of electoral processes. Electronic voting emerges as one of the most promising solutions, offering significant advantages across multiple dimensions, as outlined below:

- **Increasing the efficiency of the electoral process:**

  Electronic voting makes the process faster in terms of casting votes and counting results. This significantly reduces the time required to announce election outcomes and increases the accuracy of the vote tally[16].

- **Enhancing Trust in Election Management:**
  If electronic voting is implemented properly and thoughtfully, it enhances the security of the voting process and reduces the chances of fraud or manipulation, thereby increasing the credibility of the elections[16] [19].

- **Facilitating Electoral Participation:**
  Electronic voting enables voters to cast their ballots with ease, especially individuals with special needs or citizens living abroad, by allowing them to vote remotely or through various electronic means[19].

- **Reducing Costs and Resources:**
  Electronic voting reduces the need for paper printing, cuts down on the costs of transporting and storing ballot papers, and decreases the requirement for a large number of election supervisors[19].

- **Improving Result Accuracy and Reducing Errors:**
  Electronic voting minimizes human and mechanical errors in vote counting and ensures that data is stored securely and accurately[19].

- **Supporting Transparency and Integrity:**
  By implementing strict technical and legal safeguards, electronic voting ensures the security of the electoral process and prevents double voting or fraud, thereby enhancing the integrity of elections[19].

- **Keeping Pace with Technological Advancement:**
  Electronic voting aligns with the demands of the digital age and helps countries modernize their electoral systems to meet the challenges of the 21st century especially under exceptional circumstances such as the COVID-19 pandemic[19].

In summary,electronic voting is a strategic tool for improving the electoral process in terms of speed, accuracy, transparency, and ease of participation. However, it requires careful planning and proper design to avoid challenges that could undermine trust in the electoral system[16][19].

1.3.3 Types of E-voting

With the rise of digital technologies, electronic voting systems have diversified to meet increasing demands for security, accessibility, and electoral efficiency.

Three main forms can be distinguished:

1. **Internet Voting:**
   Internet voting relies on a multi-layered technical architecture designed to ensure the integrity and confidentiality of the vote. These systems consist of three main layers:

   - **Authentication layer:** Uses digital ID cards or one-time passwords (OTP) to verify voter identity.
   - **Transmission layer:** Encrypts data via the TLS protocol.
   - **Storage layer:** Utilizes end-to-end encrypted databases.

   The Estonian system serves as a benchmark example, employing KSI Blockchain technology to ensure data traceability and tamper-proofing, thereby strengthening public trust in the electoral process[15].

2. **Electronic Voting Machines (EVMs):**
   Direct Recording Electronic (DRE) devices enable automated vote recording in a controlled environment. These machines consist of three main modules:

   - **Input module:** Uses a touchscreen or physical keyboard for voter interaction.
   - **Processing module:** Features an independent processor with secure ROM memory.
   - **Storage module:** Relies on an isolated smart card to securely retain voting data.

   The Indian model exemplifies this approach, functioning offline without internet connectivity and employing 256-bit encryption to ensure high data security[1].

3. **Hybrid Voting:**
   Hybrid systems combine the advantages of paper ballots and electronic voting to optimize electoral processes. These systems integrate:

   - **Optical scan paper ballots:** Such as Egypt's DS200 system.
   - **Direct electronic voting:** Enables digital recording of voter preferences.

   Studies show that these systems significantly reduce tallying errors, with an average error rate of 0.1%, compared to 1.5% in purely manual systems, making them an efficient and reliable intermediate solution[25].

1.4 Polling Station

A polling station is a designated location where voters cast their ballots during elections. In this section, we will discuss its definition, functions, and structure.

1.4.1 Definition of Polling Station

A polling station is the fundamental organizational unit in the electoral process where registered voters go to cast their votes. It is supervised by a chairperson and appointed members, and all voting procedures take place there, starting from verifying the voter's identity and handing them the ballot paper, ensuring the secrecy of the vote, and ending with the counting of votes and announcing preliminary results. The polling station serves as the place where the electoral process is conducted in an organized and transparent manner, aiming to guarantee the integrity and fairness of the election [4].

1.4.2 Organizational Structure of Polling Station

The organizational structure of polling stations represents a critical framework for ensuring the orderly conduct of electoral operations. It is based on a hierarchical and systematic distribution of roles and responsibilities, aimed at upholding legal and procedural standards. The structure typically includes:

- **Station President:** Appointed official responsible for overall station management and regulatory compliance.
- **Deputy President:** Provides administrative and procedural support to the Station President.
- **Station Members:**Field staff who assist with voter management, ballot handling, and procedural tasks.
- **Accredited Observers:**Authorized individuals or organization representatives who monitor the electoral process (when present).
- **Security Personnel:**Ensure safety, order, and integrity of the process, preventing disruptions or violations.

Such a framework contributes significantly to administrative discipline and operational transparency within polling stations, thereby enhancing the overall credibility of the electoral process and reinforcing institutional trust among voters and electoral stakeholders.
The organizational structure of of polling station is illustrated in the figure 1.2 below:

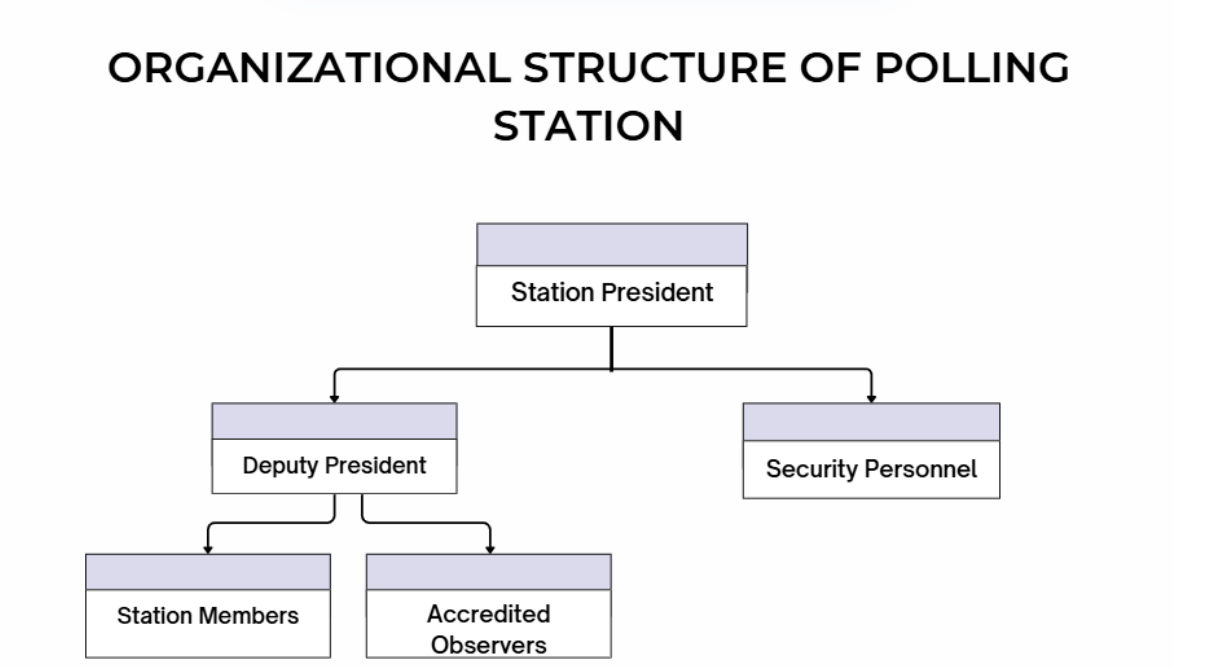


Figure 1.2: Organizational Structure of polling station

1.4.3 Core Functions of Polling Station

The core functions of polling stations constitute a fundamental component of the electoral process, ensuring its legitimacy, transparency, and adherence to legal standards. These functions include:

- **Verification of Voter Identities:** Cross-checking individuals against official electoral registers to ensure eligibility.
- **Ballot Distribution:** Issuing officially approved and stamped ballots to verified voters.
- **Electoral Secrecy and Privacy:** Ensuring the confidentiality of the voting process and protecting voter privacy.
- **Regulatory Compliance in Voting Procedures:** Overseeing voting activities to ensure adherence to established legal and procedural standards.
- **Preliminary Vote Counting:** Conducting an initial count of votes after polls close, following strict protocols.
- **Official Documentation:** Compiling and submitting detailed reports and results to the relevant electoral authority.

Collectively, these responsibilities form the operational and procedural backbone of polling station activities, thereby safeguarding the credibility of the electoral process and reinforcing public trust in democratic institutions[26].

1.5 Electoral Laws in Algeria

Elections in Algeria constitute a fundamental component of the country's political and constitutional system. They are governed by a comprehensive framework of legal and regulatory texts designed to ensure transparency, integrity, and broad citizen participation in political life.

1. **The Algerian Constitution (Particularly Articles 7 and beyond):**

   The Constitution serves as the supreme legal reference upon which all electoral laws are based. It outlines the foundational principles that govern the electoral process, including:

   - **Popular Sovereignty:** The people are the sole source of all political authority (Article 7).
   - **Right to Vote:** Every Algerian citizen aged 18 and above has the right to vote and participate in elections.
   - **Free and Secret Ballot:** Voting must be conducted freely and in complete secrecy to ensure the integrity of the process.
   - **Political Pluralism:** The Constitution guarantees a multi-party system and prohibits political monopoly.
   - **Election Monitoring:** The electoral process may be observed by both national and international monitors to enhance transparency[28].

2. **Organic Law No. 16-10: Fundamental Electoral Law of Algeria (2016):**

   - **Candidacy Requirements:**
     - **Presidential Elections:**
       * Must be of Algerian origin and not hold dual nationality.
       * Minimum age: 40 years.
       * Must have full civil and political rights.
       * Required to submit a nomination file that includes:
         · 600 endorsements from elected officials (e.g., mayors, deputies), **or**
         · 60,000 individual signatures from at least 25 different provinces (wilayas).

  - **National People's Assembly (Lower House):**
    * Minimum age: 25 years.
    * Must have no criminal record, especially for offenses involving moral turpitude.
    * May run under a political party or as an independent candidate.
  - **Council of the Nation (Upper House):**
    * Candidates are elected through indirect elections by local assemblies.
    * Minimum age: 40 years.

- **Voting System:**
  - Elections are conducted through universal, direct, and secret ballot.
  - Procedural Tools:
    * Use of voter cards and sealed envelopes.
    * Regularly updated electoral register.
    * Centralized electoral lists for consistency and transparency.
  - Oversight and Safeguards:
    * Candidate representatives may be present at polling stations.
    * Domestic and international observers are allowed.
    * Supervised by an independent electoral commission.

- **Results and Appeals:**
  - **Presidential Elections**: Final results are announced by the Constitutional Council, which also adjudicates electoral disputes.
  - **Legislative and Local Elections**: Results are announced by the National Independent Authority for Elections (ANIE).
  - Legal recourse: Candidates may submit appeals to the competent judicial bodies in the event of disputes[31].

3. **Organic Law No. 12-01: Law on Political Parties (Algeria):**

- **Foundational Conditions:**
  - Political parties may not be founded on religious, ethnic, linguistic, or regional bases.
  - Parties must strictly adhere to the Constitution and uphold national unity and sovereignty.

- **Party Financing:**
  - Parties may receive self-generated funds and public funding in line with legal provisions.
  - Foreign funding is strictly prohibited in any form to safeguard national sovereignty and electoral integrity[30].

4. **Organic Law No. 21-01: 2021 Reforms for Electoral Transparency and Integrity:**

- **Establishment of the National Independent Authority for Elections (ANIE):**
  - ANIE replaces the executive administration in managing elections.
  - It is institutionally and functionally independent from the executive branch.
  - Oversees all stages of the electoral process from voter registration to the final announcement of results to ensure impartiality and fairness.
- **Reform of Candidacy Requirements:**
  - Stricter signature collection requirements for presidential candidates.
  - Regulation of electoral campaign financing to ensure equity and prevent illicit funding.
  - Promotion of inclusivity with improved mechanisms for youth and women's political participation.
- **Voting Abroad:**
  - Simplified voting procedures for Algerians residing abroad.
  - Expansion of overseas polling stations to enhance accessibility.
  - Supervised by embassies and consulates in coordination with ANIE to ensure legal compliance.
- **Electoral Register Modernization:**
  - Digitization of the electoral register to reduce fraud and duplication.
  - Periodic revision of electoral lists to ensure accuracy and validity.
  - Integration of the National Identification Number (NIN) to ensure traceability and voter eligibility[29].

1.6 International Examples

In this section, we will discuss the successful implementation of electronic voting in some countries, as well as the challenges faced by other countries where the system has failed, particularly due to security and trust issues.

1.6.1 Pioneering Countries in Electronic Voting

1. **Estonia – Global Leader in Online Voting:**
    - Estonia has used internet voting since 2005.
    - Features include:
        - Digital ID card with RSA-2048 encryption.
        - KOVS system allowing vote verification without revealing voter identity.
        - 44% online participation rate in the 2023 elections.
        - Cost per voter: €2 (online) vs. €5 (paper)[20] [8].
2. **Switzerland – A Hybrid Model:**
    - In Geneva, a mixed electronic and paper voting system is used.
    - Key features:
        - Quantum-resistant encryption.
        - Exceptionally low error rate: 0.001% (e-voting) vs. 0.8% (traditional)[35][36].
3. **India – The Largest Technical Experiment:**
    - India uses Electronic Voting Machines (EVMs) on a massive scale.
    - Main features:
        - Offline operation to prevent hacking.
        - Dual-unit architecture: Control Unit (CU) + Ballot Unit (BU) for separating functions.
        - 900 million votes processed in 2019 without major security incidents[7].

1.6.2 Case Studies on Failures

1. **United States – The 2000 Florida Crisis:**
    - The failure of punch-card voting systems resulted in:
        - 180,000 invalidated votes due to improperly detached "chads".

- 36-day delay in presidential election results.
- Total recount cost: $15 million[38].

2. **Germany – Constitutional Ban in 2009:**

   - Electronic voting machines were banned due to:
     - Lack of a verifiable paper trail for public scrutiny.
     - Violation of absolute transparency principles.
     - Risks of undetectable software manipulation[13].

3. **Venezuela – Fraud Allegations in 2017:**

   - The Constituent Assembly elections faced serious credibility issues:
     - Server outages during vote counting.
     - Results inconsistent with independent polls.
     - Lack of transparency in audit processes[3].

1.7 Criticisms and Solutions

In this section, we will present the main criticisms of electronic voting systems, both technical and legal, and propose possible solutions to improve their effectiveness and ensure integrity.

1.7.1 Criticisms:

The electoral system in Algeria faces several structural criticisms related to its implementation mechanisms, transparency, and the credibility of its outcomes. Despite recent reforms, the system remains fraught with challenges that hinder its effectiveness in fostering genuine political representation and democratic change.

1. **Administrative and State Interference in the Electoral Process:**
   Although Algeria's elections are officially governed by democratic regulations, the historical involvement of state institutions in overseeing elections has raised persistent doubts about their fairness. The establishment of the National Independent Authority for Elections (ANIE) was intended to mitigate this interference, but its effectiveness remains contested.

2. **Declining Voter Turnout and Erosion of Public Trust:**
   Voter turnout has been steadily declining, with only 30.20% participation in the 2021 legislative elections, down from 37.09% in 2017 and 42.90% in 2012. This trend

reflects growing public skepticism about the value of elections as a mechanism for political change[6].

3. **Electoral Corruption and Political Disenchantment:**
   Despite reform efforts such as the open-list system, electoral corruption—including vote-buying and undue political financing—remains prevalent. The fragmented party landscape further erodes public confidence in political actors[6].

4. **Restrictive Candidacy Requirements and Political Exclusion:**
   Stringent legal requirements (e.g., 50,000 signatures or 600 endorsements) limit candidacy and have led to the exclusion of notable political figures. These constraints hinder political pluralism and equitable competition[24].

5. **Complex Vote Counting Procedures and Transparency Issues:**
   The new two-phase vote counting system (by list, then individual ballots) adds complexity, raising the risk of procedural errors and reducing transparency, thereby affecting public trust in the results.

6. **Limited Impact of Elections on Political Transformation:**
   Many citizens believe that elections in Algeria do not lead to substantive political change, but rather serve to reinforce existing power structures, weakening electoral legitimacy and public engagement[6].

Despite notable reforms such as the creation of the National Independent Authority for Elections and the implementation of an open-list system to combat political corruption, Algeria's electoral system continues to suffer from systemic deficiencies. These include undue state interference, low voter engagement, electoral corruption, restrictive candidacy rules, and procedural opacity. Collectively, these issues compromise the credibility of elections as tools for democratic renewal and contribute to the deepening gap between the state and civil society.

1.7.2 Solutions

In light of the persistent challenges associated with traditional voting systems—such as electoral fraud, procedural delays, and limited accessibility for certain segments of the population this electronic platform has been developed as a comprehensive digital solution aimed at streamlining the electoral process and enhancing its transparency.A series of practical, context-sensitive measures have been proposed to address these issues, taking into full consideration the prevailing social, technical, and institutional conditions:

- **Remote voting capability:** Voters can participate in the election process without being physically present.

- **Clear role separation:** Each user (administrator, assistant, voter, candidate) has defined permissions and access based on their role.
- **Digital voter registration:** The platform replaces manual methods with a more reliable and efficient digital process.
- **Instant results and statistics:** Election results and related statistics are generated immediately after the voting ends.
- **Reduction of manual counting errors:** Automated vote processing helps minimize human errors.
- **Transparency through dedicated user interfaces:** Each user accesses only the data relevant to their role, promoting clarity and trust.

1.8 Conclusion

In this chapter, we have aimed to provide a comprehensive conceptual overview of the project by identifying key stakeholders, core processes, and major challenges. We have also proposed targeted solutions for each issue. We will now transition to the design phase, which presents all relevant information and adopted solutions in a well-structured and easily understandable manner.

Chapter 2:Design

2.1 Introduction

In the previous chapter, we focused on studying the existing system, which allowed us to analyze it and gather as much information as possible. From this analysis, we extracted a set of knowledge that will guide the design of the future system, ensuring it meets user needs. At this stage, we will use UML (Unified Modeling Language) to explore the main components of the system design. The UMLStar tool will be used to model and represent the project to be developed.

2.2 Unified Modeling Language (UML)

The Unified Modeling Language (UML) is a standard language used to create the blueprints of software systems. UML can be used to visualize, specify, construct, and document the artifacts of a system with a strong software component[5].

2.2.1 The importance of using the Unified Modeling Language (UML)

- Enables professional software design.
- Allows for easy and low-cost modifications and maintenance.
- UML diagrams help developers quickly and easily understand the system.
- Acts as a communication language between developers and designers.
- Provides documentation of the design before programming begins.
- Is independent of any specific programming language or development process[5].

2.2.2 Types of UML Diagrams

In UML there are 14 types of diagrams divided into two main categories:

- Structural Diagrams
- Behavioural Diagrams

As shown in the following figure 2.1:

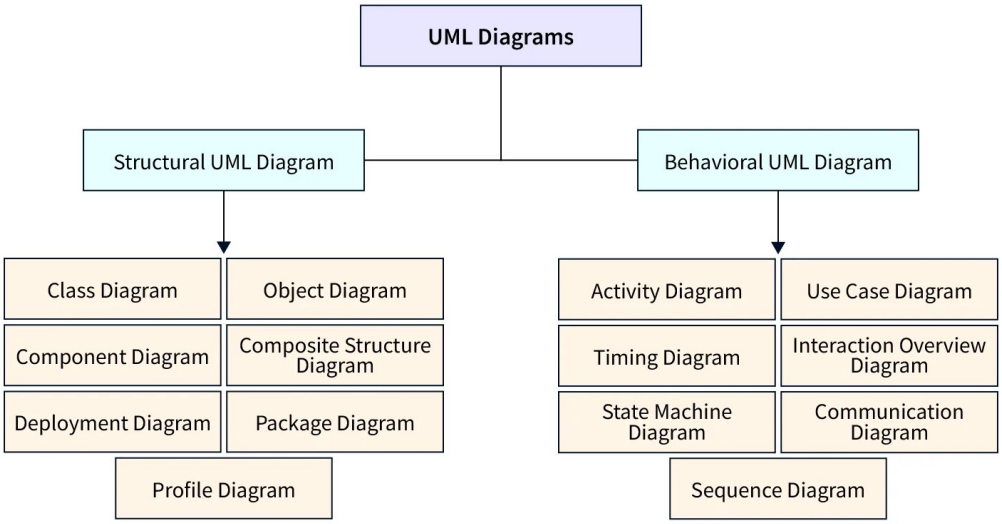


Figure 2.1: Types of UML Diagrams
[33]

2.3 Diagrams Used in the Design

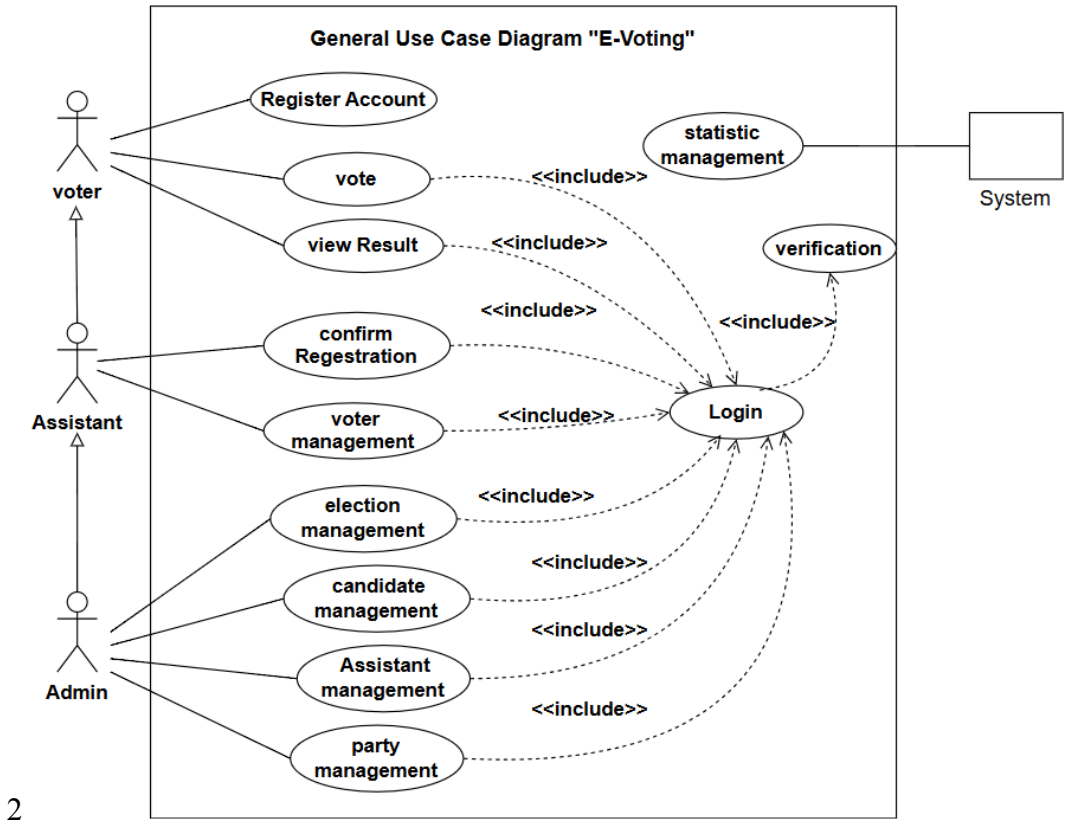
Various types of diagrams are used in software modeling. In our project, we have chosen to use four key diagrams, which are listed below:

2.3.1 Use Case Diagram

The Use Case Diagram is employed to collect and describe the requirements of the system's stakeholders.It illustrates the interaction between the actors and the system by identifying the specific use cases and the corresponding actors responsible for executing them.This diagram is foundational in capturing functional requirements and provides a high-level overview of how external entities interact with the system.Two fundamental concepts underpin the use case diagram:

- **Actor:** An external user or another system that interacts with the system under development.
- **Use Case:** A specific function or service that the system provides in response to an actor's interaction[18].

As illustrated in the figure:



2

Figure 2.2: General Use Case Diagram "E-Voting"

Description:

This is a Use Case Diagram for an E-Voting system, showing how different types of users (actors) interact with the system's various functionalities (use cases). Here's a breakdown of its components:

1)Actors:

- **Voter:**
  Can perform the following actions:
  - Register an account
  - Vote
  - View results
- **Assistant:**
  Inherits all permissions from the Voter and can additionally:
  - Confirm voter registration

  - Manage voter information

- **Admin:**
  Inherits all permissions from the Assistant and can additionally:
  - Manage elections
  - Manage candidates
  - Manage assistants
  - Manage political parties

2)Use Cases:

- **Register Account**: Enables a citizen to create a new account in the system.
- **Vote**: Allows users to cast their vote; requires login.
- **View Result**: Displays election results; requires login.
- **Confirm Registration**: Assistant verifies and approves voter registration.
- **Voter Management**: Assistant manages voter records and information.
- **Election Management**: Admin organizes and oversees elections.
- **Candidate Management**: Admin handles the addition, editing, and removal of candidates.
- **Assistant Management**: Admin manages assistant accounts and permissions.
- **Party Management**: Admin manages political party information.
- **Statistic Management**: Gathers and analyzes election-related statistics.
- **Login**: Required for system access to protected features; includes verification.
- **Verification**: Confirms user identity during the login process.

3)Relationships:

- The `<<include>>` relationship means that one use case always requires including another use case.
  For example:
  - Vote requires Login first.
  - View Result requires Login.

- Login requires Verification to ensure user identity.

- Actor Inheritance:
  - Admin inherits the privileges of Assistant.
  - Assistant inherits the privileges of Voter.

2.3.2 Detailed Use Case Diagram

1) Use Case “Request to Login to the Platform”:

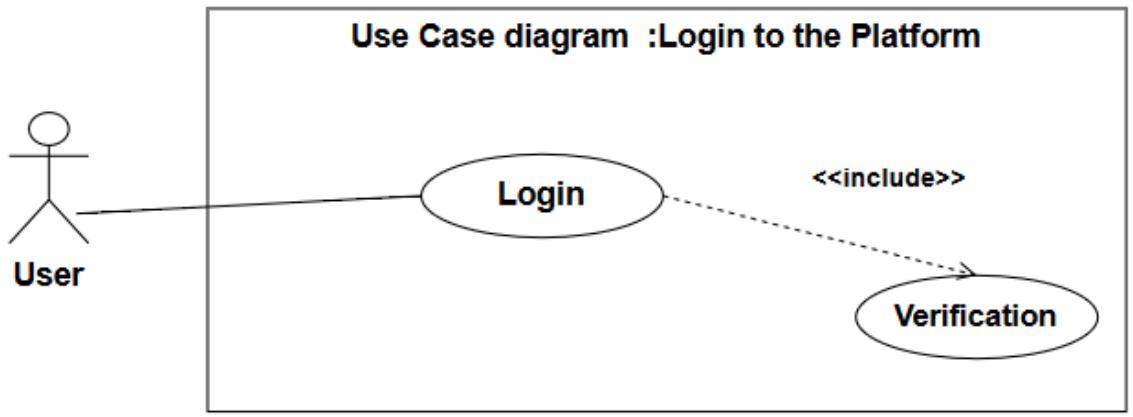


Figure 2.3: Use Case "Login to the Platform"

Description:

Use Case Name	Request to Login to the Platform
Actor(s)	Admin, Assistant, Voter (Citizen)
Precondition	The entered username and password must be valid.
Flow of Events	• The system displays the login interface. • The user enters their username and password. • The system verifies the entered credentials. • If the user is authenticated, access to the system is granted.

Table 2.1: Use Case Description "Login to the Platform"

2) Use Case “Voting for a Candidate”:

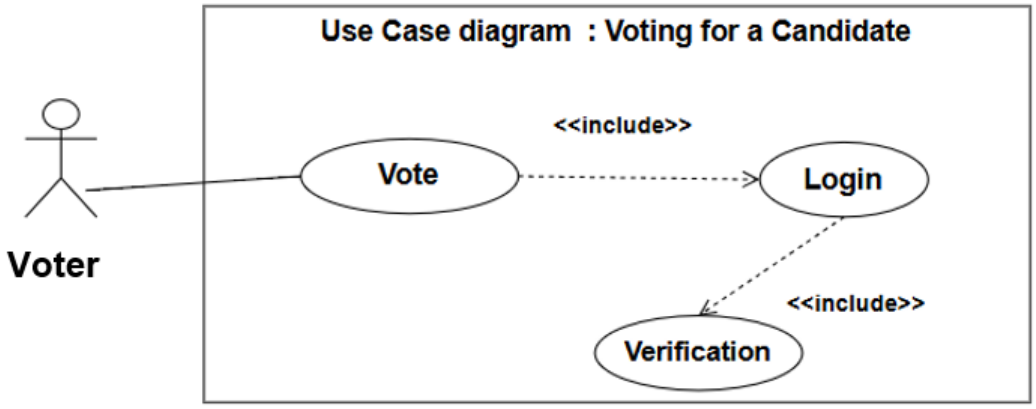


Figure 2.4: Use Case "Voting for a Candidate"

Description:

Use Case Name	Vote for a Candidate
Actor(s)	Voter (Citizen)
Precondition	The user must be authenticated and the voting period must be active.
Flow of Events	• The voter logs into the system during the election period. • The system displays a list of eligible parties and candidates. • The voter selects one party to vote for, along with a number of candidates from the available lists. • The system confirms the selections and records the vote. • The system prevents any additional voting attempts by the same voter.

Table 2.2: Use Case Description "Vote for a Candidate"

3) Use Case "Manage Voter Information":

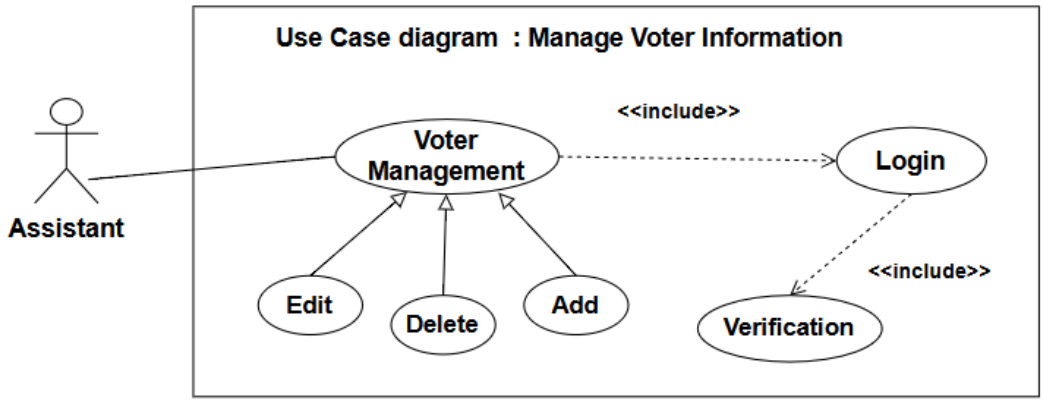


Figure 2.5: Use Case" Manage Voter Information"

Description:

Use Case Name	Manage Voter Information
Actor(s)	Assistant
Precondition	The assistant must be authenticated and authorized to manage voters.
Flow of Events	• The assistant logs into the platform. • The system displays the voter management interface. • The assistant selects an action: Add, Edit and Delete voter data. • The assistant performs the desired operation. • The system validates and confirms the changes.

Table 2.3: Use Case Description "Manage Voter Information"

4) Use Case "Manage Assistant Information":

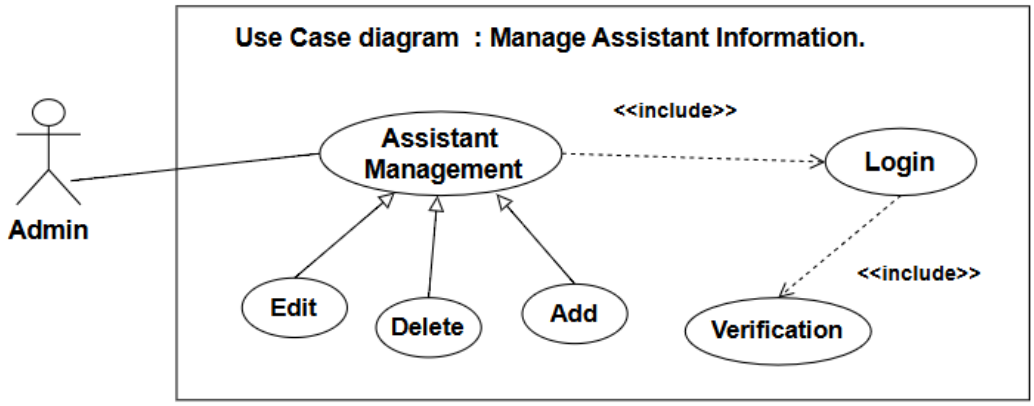


Figure 2.6: Use Case" Manage Assistant Information"

Description:

Use Case Name	Manage Assistant Information
Actor(s)	Administrator
Precondition	The administrator must be authenticated and have permission to manage assistants.
Flow of Events	• The administrator logs into the platform. • The system displays the assistant management interface. • The administrator chooses to add, edit, or delete assistant records. • The system verifies the input and updates the assistant data accordingly. • A confirmation message is shown upon successful operation.

Table 2.4: Use Case Description "Manage Assistant Information"

5) Use Case “View Results”:

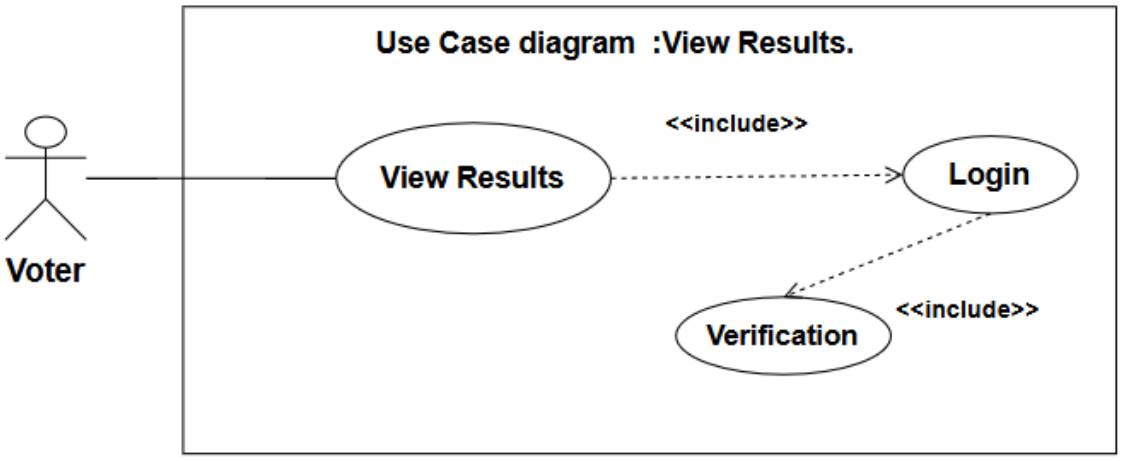


Figure 2.7: Use Case "View Results"

Description:

Use Case Name	View Results
Actor(s)	Voter (Citizen)
Precondition	The election must be completed and the results must be published by the administrator.
Flow of Events	• The user logs into the system. • The system checks if the election results are available. • The system retrieves and displays the final results to the user. • The user can view detailed results per candidate.

Table 2.5: Use Case Description "View Results"

6) Use Case "Candidate Management":

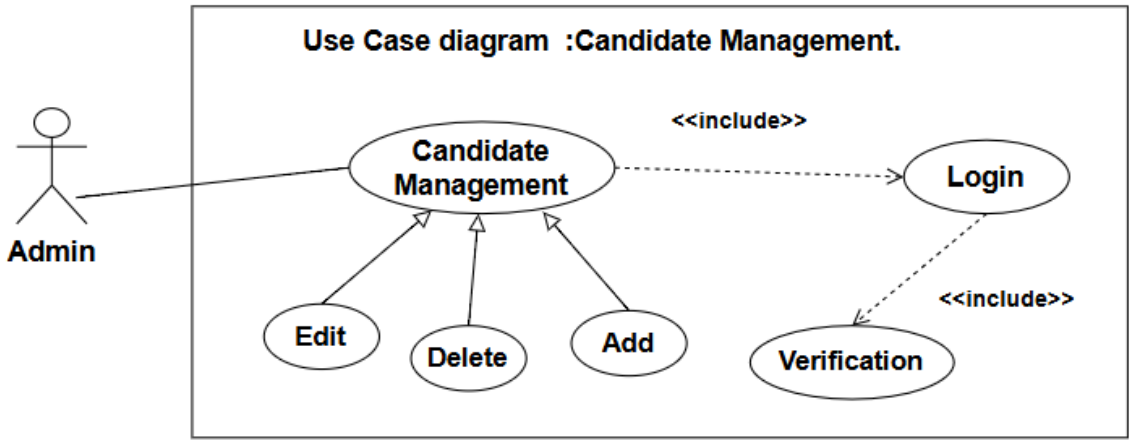


Figure 2.8: Use Case"Candidate Management"

Description:

Use Case Name	Candidate Management
Actor(s)	Administrator
Precondition	The user must be logged in and authenticated.
Flow of Events	• The admin logs into the system. • The system verifies the admin credentials. • The admin accesses the candidate management interface. • The admin can add a new candidate. • The admin can edit candidate details. • The admin can delete and archive candidate details.

Table 2.6: Use Case Description "Candidate Management"

7) Use Case "Party Management":

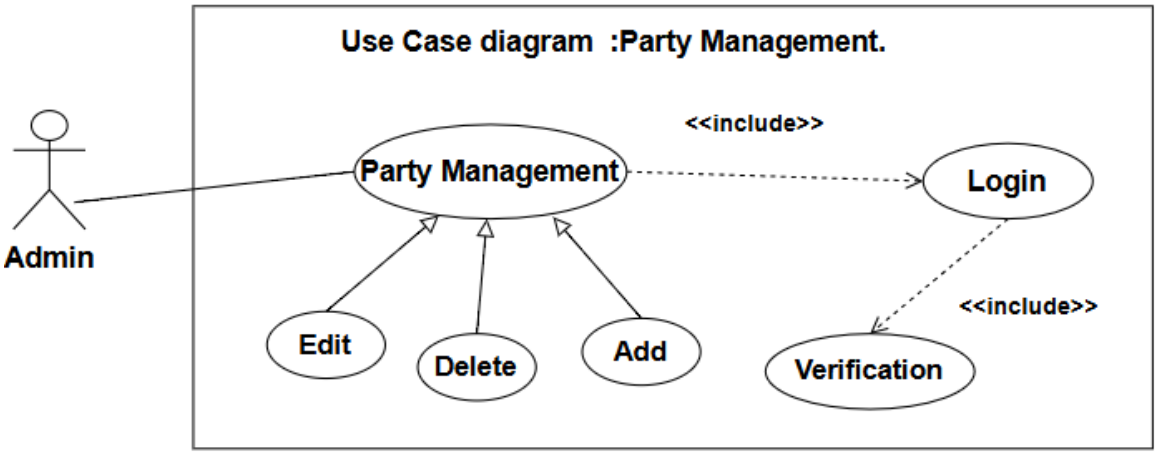


Figure 2.9: Use Case" Party Management"

Description:

Use Case Name	Party Management
Actor(s)	Administrator
Precondition	The user must be logged in and authenticated.
Flow of Events	• The administrator logs into the system. • The system verifies the administrator credentials. • The administrator navigates to the party management section. • The administrator can add a new political party. • The administrator can edit party details (name, logo, etc.). • The administrator can delete or archive existing parties. • The administrator can assign candidates to parties.

Table 2.7: Use Case Description " Party Management"

8) Use Case “Statistics Management”:

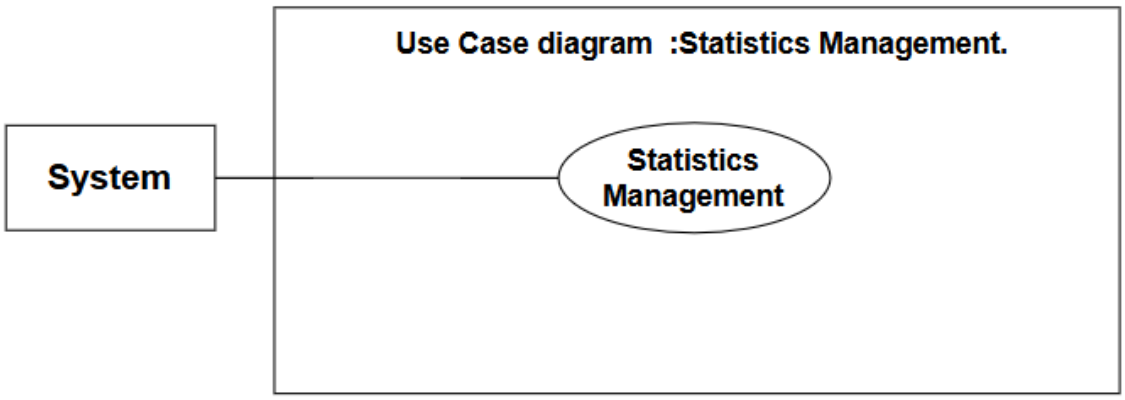


Figure 2.10: Use Case" statistics Management"

Description:

Use Case Name	statistics Management
Actor(s)	System
Precondition	Voting must be ongoing or completed.
Flow of Events	• Collect vote and user data. • Calculate turnout and abstention. • Analyze gender distribution. • Count votes per candidate and party. • Display pie charts: – Voter vs. Non-voter – Male vs. Female

Table 2.8: Use Case Description "Statistics Management"

2.3.3 Sequence Diagram

The sequence diagram is a type of interaction diagram within the Unified Modeling Language (UML) that captures the dynamic behaviour of a system by modelling the sequence of interactions between various structural elements over time. It visualizes the objects and classes involved in a particular scenario and the chronological order of message exchanges among them to realize specific system behaviour. Sequence diagrams are typically linked to use cases as they provide a detailed logical representation of system execution. This diagram is also referred to as an event diagram or an event scenario in some contexts[5].

1) Sequence Diagram “Signup”:

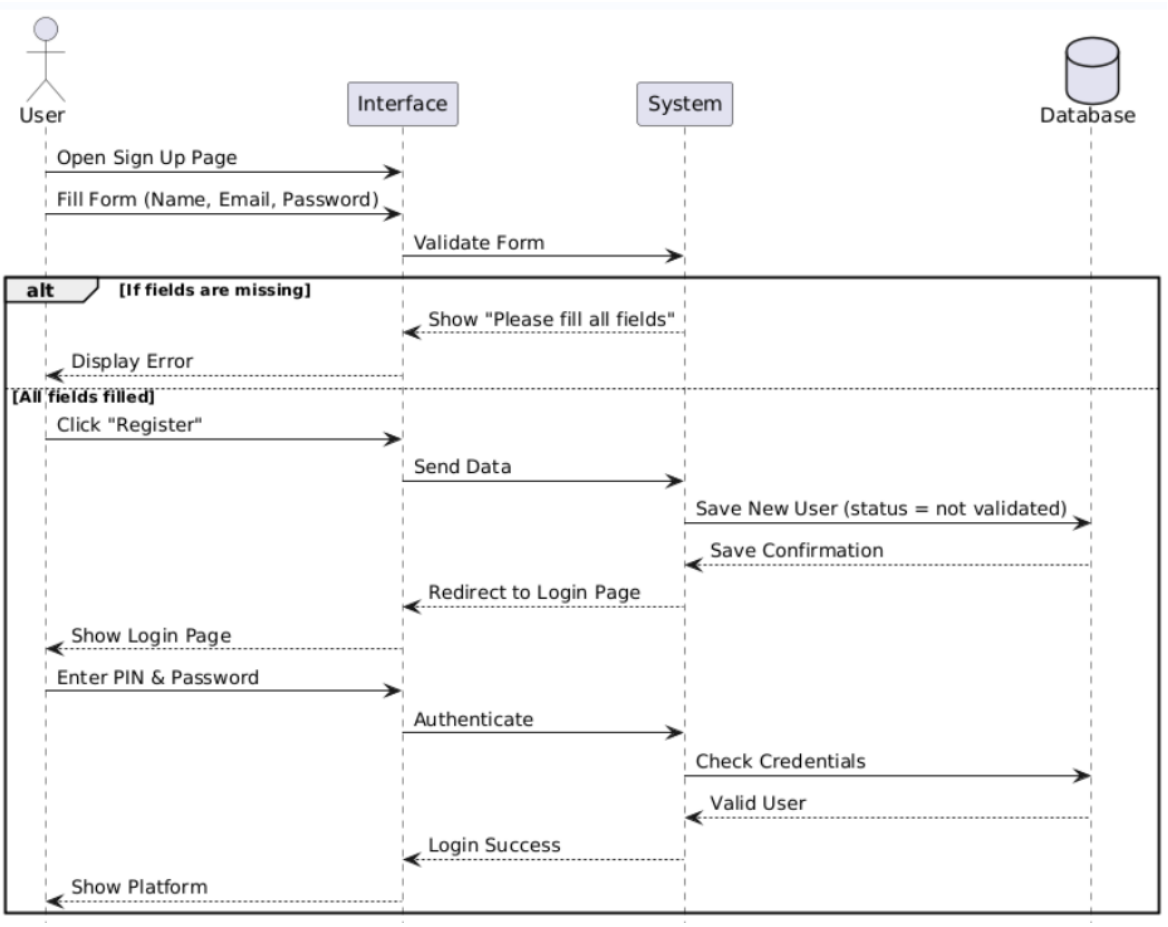


Figure 2.11: Sequence Diagram “Signup"

Description:

This UML sequence diagram shows the process of registering a new user. The user starts by opening the registration page and entering personal information. Then, the system validates the data. If there are any missing fields, an error message is displayed. If all fields are complete, the data is sent to the system, which saves the user in the database with a status of

"inactive." Then, the user is redirected to the login page. After that, the user enters their ID number and password, and the system verifies the data in the database. If the credentials are correct, the login is successful, and the user is granted access to the platform but cannot vote.

2) Sequence Diagram "login to the platform":

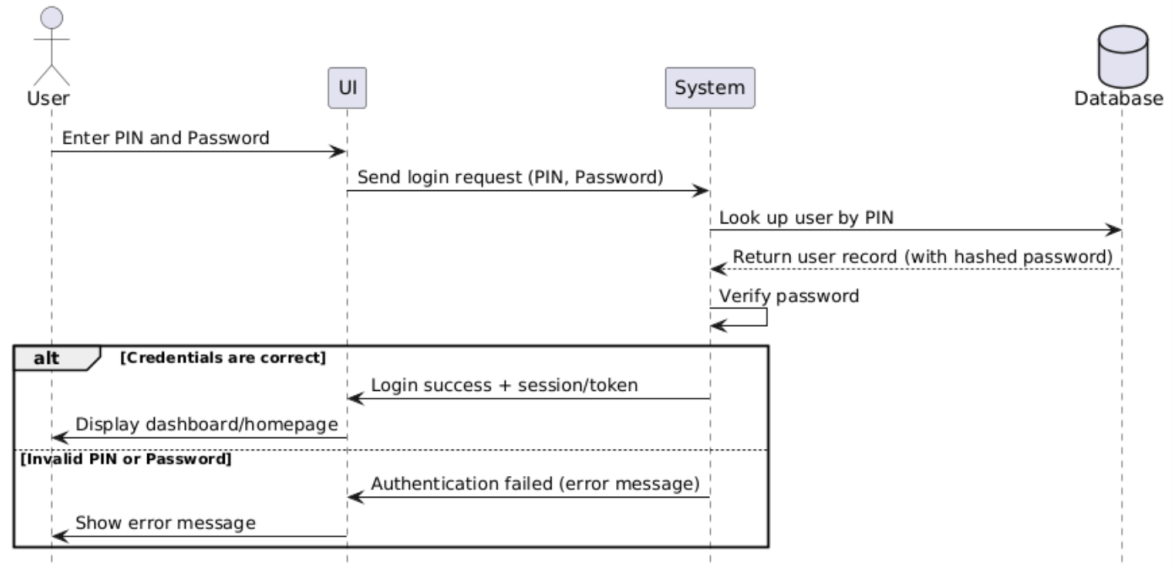


Figure 2.12: Sequence Diagram "login to the platform"

Description:

This sequence diagram illustrates the login process using a PIN and a password. First, the user enters their PIN and password into the user interface. The UI sends this login request to the system. The system then queries the database to find a user record that matches the provided PIN. If a matching record is found, the system verifies whether the entered password matches the stored (hashed) password. If the credentials are correct, the system returns a success response along with a session token or login confirmation to the UI, which then redirects the user to the dashboard or home screen. However, if the PIN or password is incorrect, the system sends back an error response, and the UI displays an error message to inform the user that the login attempt has failed.

3) Sequence Diagram "Voter Registration":

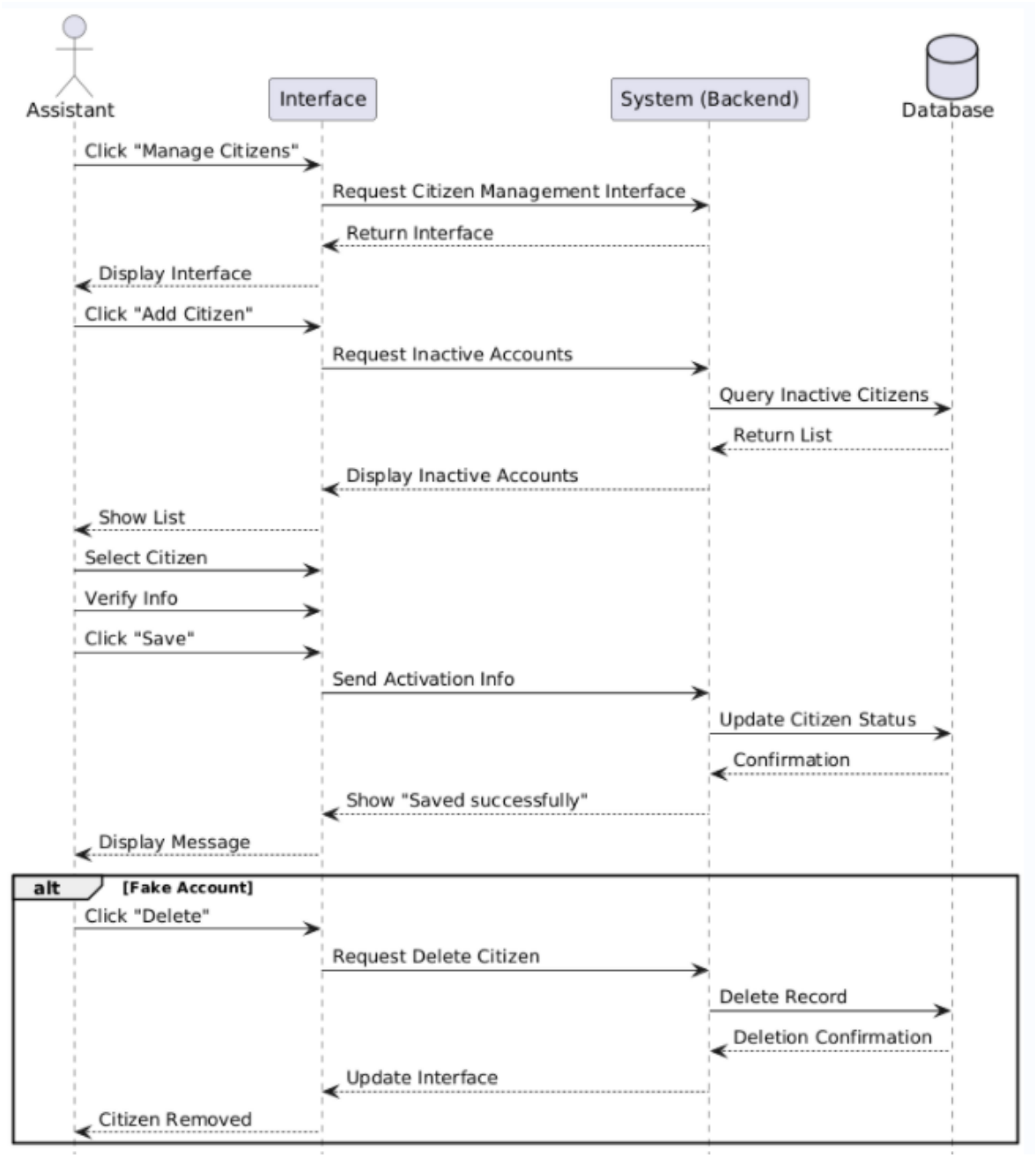


Figure 2.13: Sequence Diagram "Voter Registration"

Description:

The sequence diagram shows how an assistant manages citizen accounts. The assistant accesses the citizen management interface, views inactive accounts, selects a citizen, and either activates the account if the information is correct or deletes it if it's fake. The system handles data retrieval, validation, and database updates, while the interface displays confirmations.

4) Sequence Diagram “Add new political party ”:

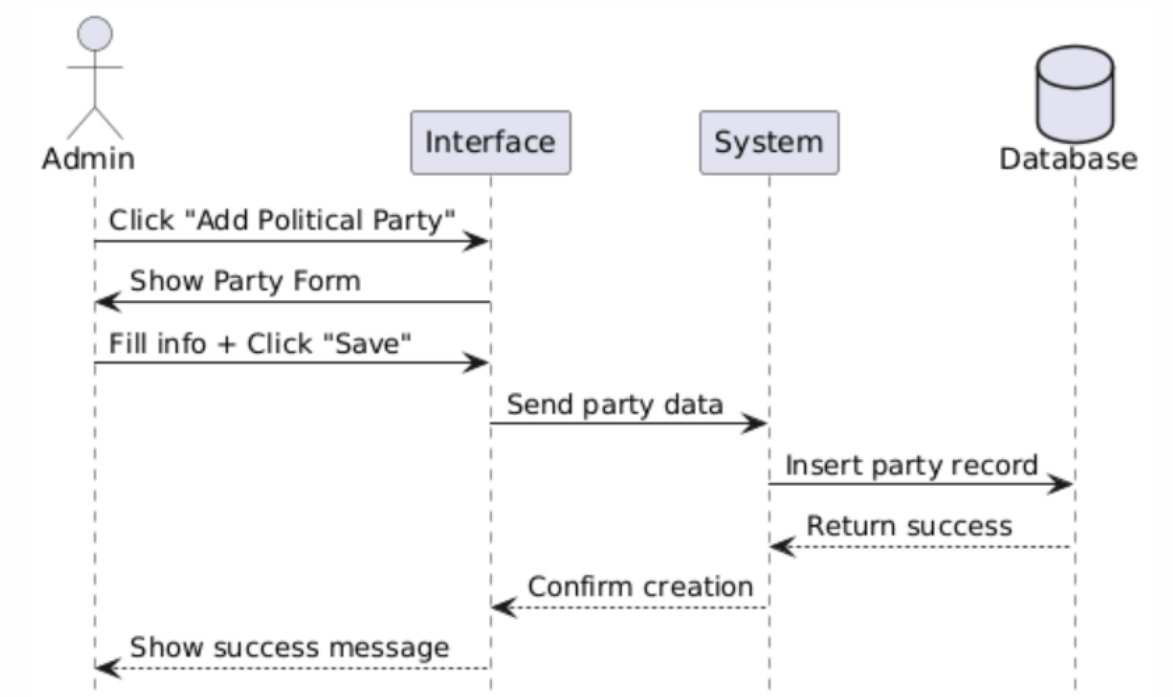


Figure 2.14: Sequence Diagram “ Add new political party”

Description:

This diagram shows the steps for adding a new political party. The process starts when the administrator clicks "Add Political Party," triggering a data entry form. After filling it out and clicking "Save," the information is sent to the system, which inserts it into the database. Upon successful insertion, the system confirms back to the interface, which then displays a success message to the administrator.

5) Sequence Diagram “Add new candidate”:

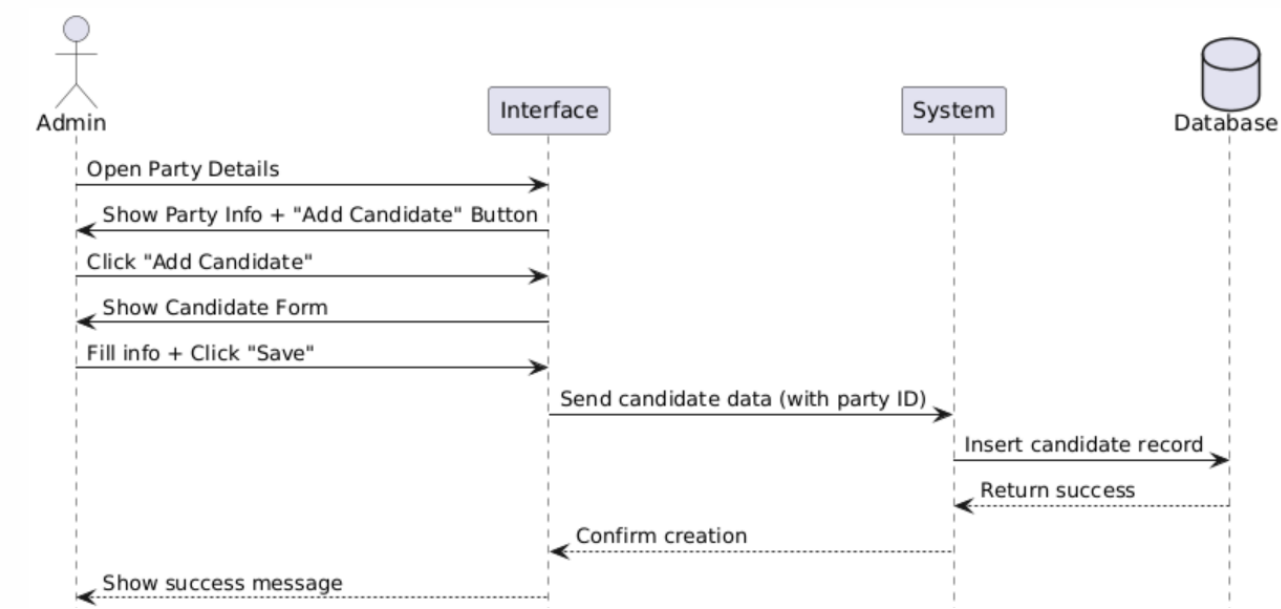


Figure 2.15: Sequence Diagram “ Add new candidate”

Description:

This diagram shows the process of adding a new candidate to a political party. The admin opens the party details and clicks "Add Candidate," prompting a form to appear. After submitting the form, the system saves the candidate with the party ID to the database. Once successful, a confirmation message is shown to the admin.

6) Sequence Diagram "vote":

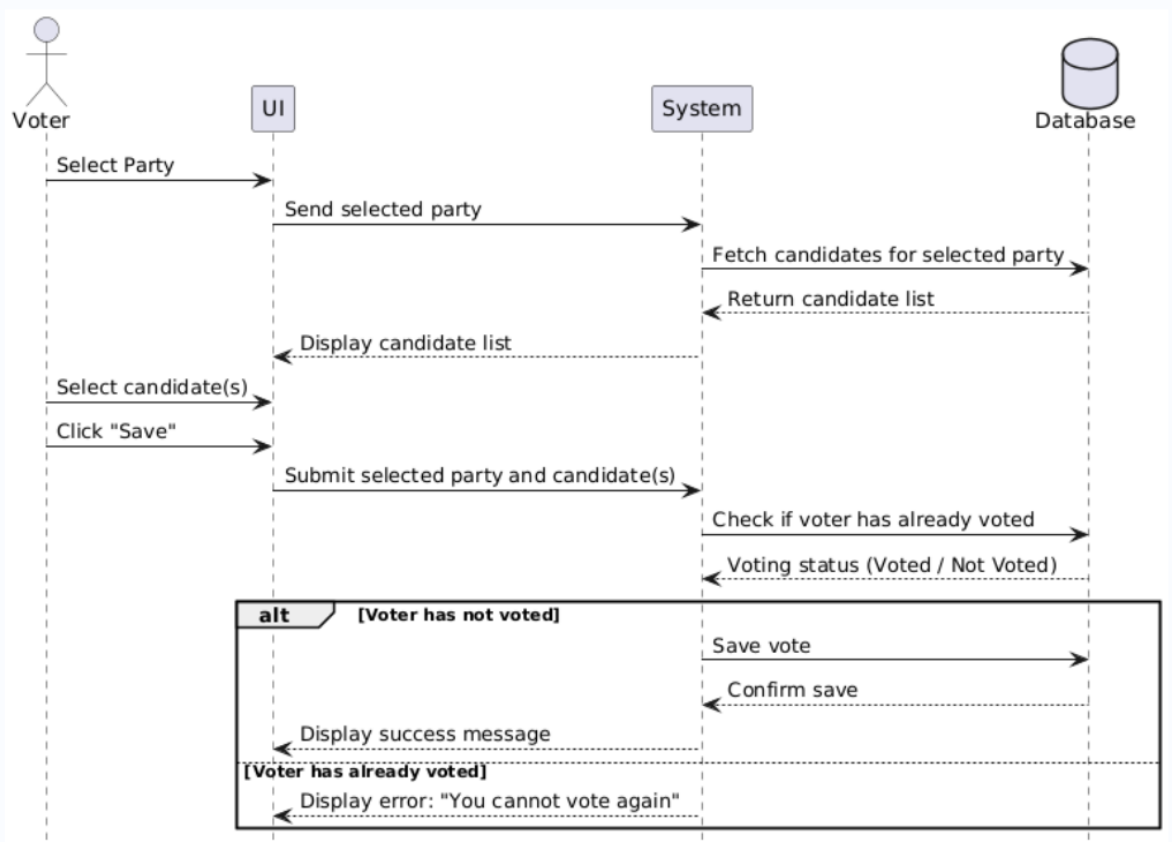


Figure 2.16: Sequence Diagram " vote"

Description:

The sequence diagram illustrates the electronic voting process, beginning with the voter selecting a party and viewing its candidates. After choosing one or more candidates, the voter submits their vote. Before recording it, the system checks whether the voter has already voted. If not, the vote is saved, and a confirmation message is displayed. If the voter has already voted, an error message is shown, preventing duplicate voting. This ensures the integrity and transparency of the electoral process.

7) Sequence Diagram "View statistics":

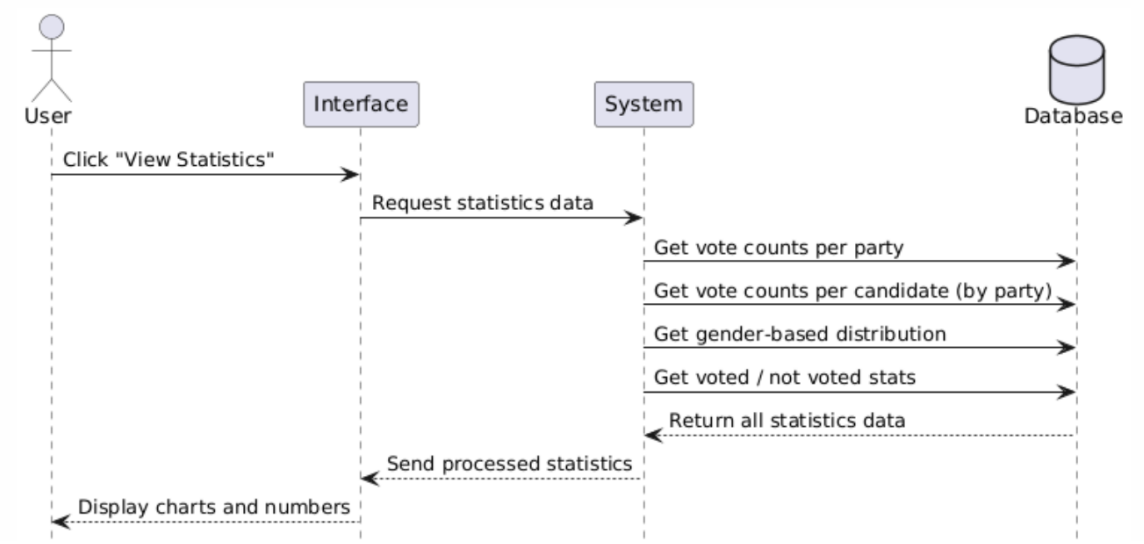


Figure 2.17: Sequence Diagram " View statistics":
"

Description:

This sequence diagram illustrates the process of viewing election statistics. It shows how an authorized user accesses the statistics module to retrieve data such as votes per party, votes per candidate, gender distribution, and voting participation. The system collects the data from the database and displays it through the interface using visual charts and summaries.

2.3.4 Activity diagram

The activity diagram serves as a fundamental behavioral diagram within UML, utilized to illustrate the dynamic features of the system. It can be regarded as a more sophisticated iteration of the flowchart, representing the progression from one activity to the next[27].
The figure below illustrates an activity diagram showing the steps of the electronic voting process :

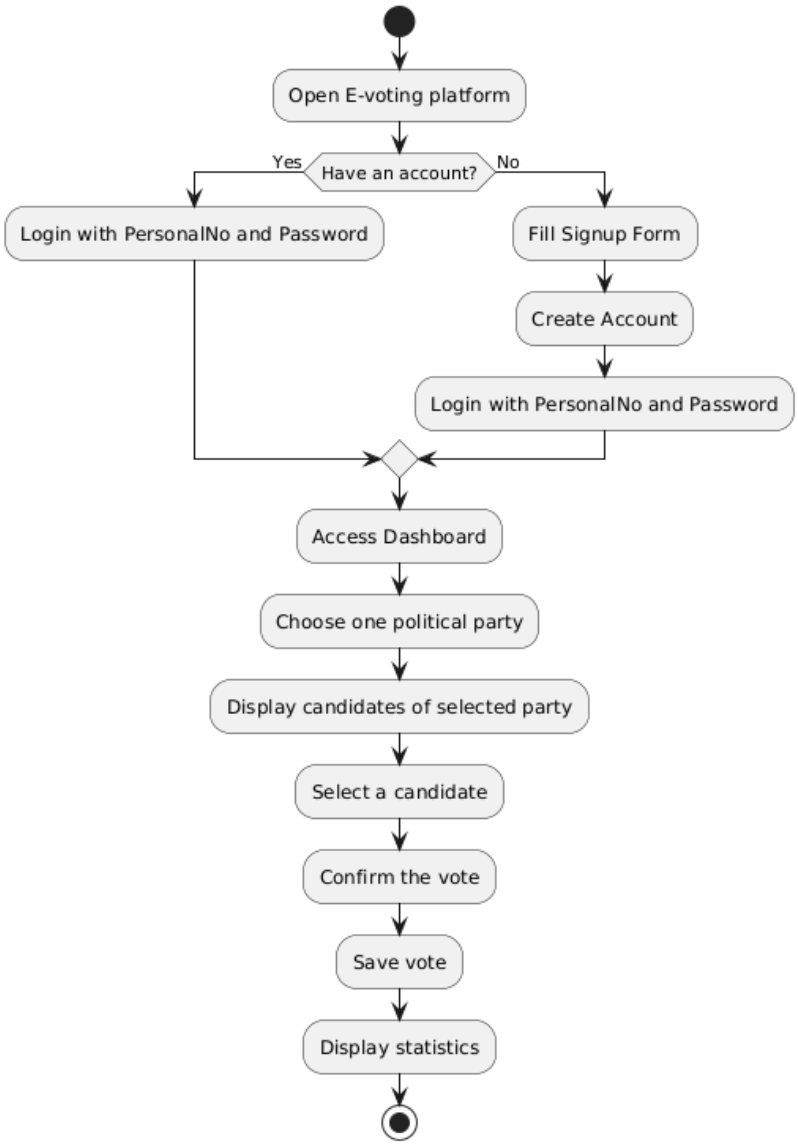


Figure 2.18: Activity diagram"E-Voting"

Description:

The user either logs in or signs up, accesses the dashboard, selects a political party, views its candidates, chooses one candidate, confirms the vote, and the vote is saved. Finally, voting statistics are displayed.

2.3.5 Class Diagram

The class diagram is among the most fundamental and widely used diagrams in UML. It offers a static structural view of a system by depicting its classes and the relationships among them, including associations such as composition, aggregation, and inheritance. Each class in the diagram is characterized by three key elements:

- The Class name
- The Attributes
- The Operations [5].

Figure below presents the class diagram of the electronic voting system developed for municipal election processes:

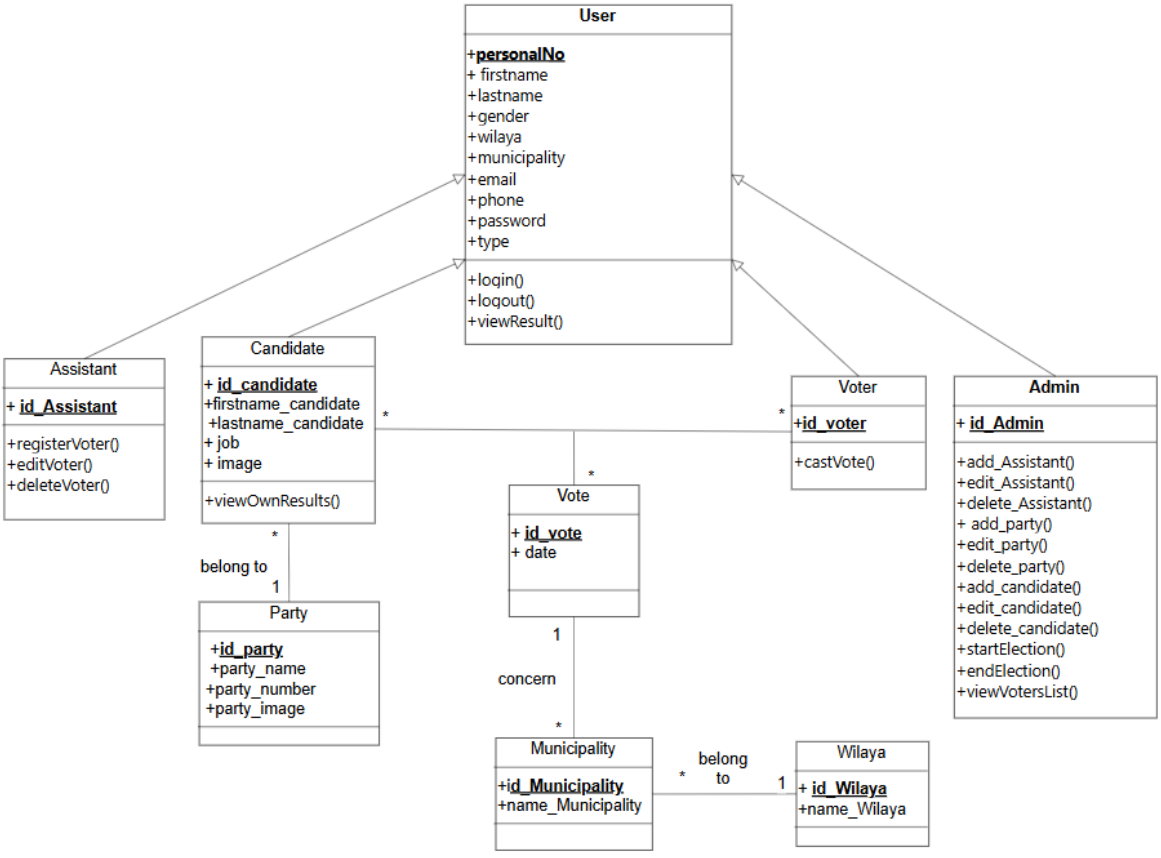


Figure 2.19: Class Diagram "E-Voting"

2.4 Relational Model

- **User** (**personalNo**, firstname, lastname, gender, wilaya, municipality, email, phone, password, type)
- **Admin** (**id_Admin**, personalNo#)
- **Assistant** (**id_Assistant**, personalNo#)
- **Voter** (**id_voter**, personalNo#)
- **Candidate** (**id_candidate**, personalNo#, job, image_Candidate, id_party#)
- **Party** (**id_party**, party_name, party_number, party_image)
- **Vote** (**id_vote**, date)
- **VoteCandidateVoter** (**id_vote#**, **id_candidate#**, **id_voter#**)
- **Wilaya** (**id_Wilaya**, name_Wilaya)
- **Municipality** (**id_Municipality**, name, id_Wilaya#)

2.5 Conclusion

At the end of this chapter, we have completed the design and development phase and arrived at a prototype of the e-voting platform through illustrative diagrams. We have also examined the criteria used to evaluate the integrity of the voting process, in addition to presenting the structure of the implemented database.In the following chapter, we will focus on the implementation phase, detailing how the proposed design is translated into a functional system.

Chapter 3: Implementation

3.1 Introduction

In this chapter, we will design a web platform for electronic voting. We will present the tools, programming languages, and operating system used in the development process, as well as some interface examples that represent the main functions of the implemented platform.

3.2 Development Environment

In this section, we present the software tools, programming languages, development platforms, and the operating system used in the implementation of our electronic voting platform.

3.2.1 Characteristics of a Computer

Device Name	Features
hp	RAM: 2GB
	CPU: AMD E-350 @ 1.60 GHz
	Hard Disk: 300GB HDD
	Operating System: Windows 7

Table 3.1: Used hardwares

3.2.2 Software Tools

1. **HTML:**

   HTML is the standard markup language used to create the structure of web pages. It defines the basic layout and elements such as headings, paragraphs, images, and input forms[21].

Figure 3.1: HTML

2. **CSS:**

   CSS is used to style HTML elements, making the interface more appealing and organized. It defines visual aspects such as layout, colors, fonts, and spacing[39].

Figure 3.2: CSS

3. **JavaScript:**

JavaScript is a client-side programming language used to add interactivity and dynamic behavior to web pages. It enhances user experience by responding to events and managing logic on the client side[22].

Figure 3.3: JavaScript

4. **PHP:**

PHP (Hypertext PreProcessor) is a programming language whose main application is the management of dynamic websites. It can create the content of HTML pages according to different parameters. The capabilities of PHP extend beyond web pages to include image manipulation, PDF creation, and database connectivity.[32]

Figure 3.4: PHP

5. **XAMPP:**

XAMPP (X (cross) Apache MariaDB Perl PHP) is a set of software to easily set up a web server and a File Transfer Protocol (FTP) server. This is a distribution of free software with good flexibility of use, known for its simple and fast installation[2].

Figure 3.5: XAMPP

6. **Visual Studio Code:**

Visual Studio Code (VS Code) is a source code editor created by Microsoft, compatible with Windows, Linux, macOS, and web browsers. It offers features such as debugging support, syntax highlighting, intelligent code completion, code snippets, code refactoring,and integrated version control using Git[23].

Figure 3.6: VS Code

3.3 Presentation of the Interfaces

3.3.1 Signup Interface of the E-Voting Platform:

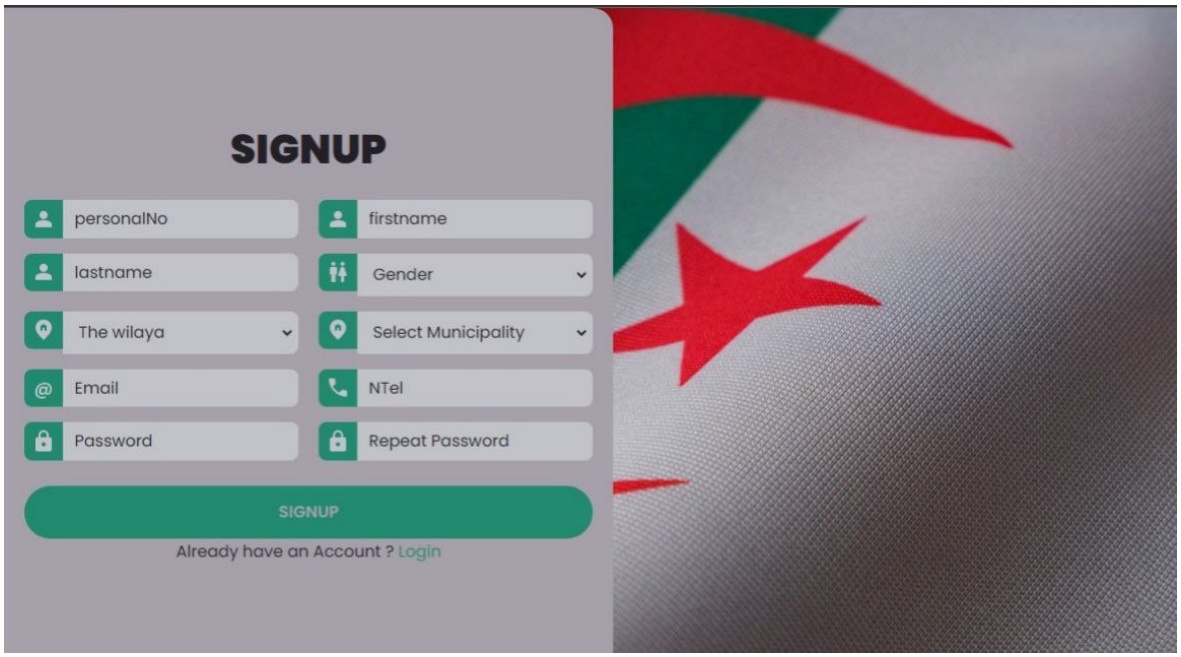


Figure 3.7: Signup Interface of the E-Voting Platform

Description:

This figure displays the signup interface intended for new users of the municipal e-voting platform. The form includes essential fields such as personal number, first name, last name, gender, wilaya, municipality, email, phone number, and password with confirmation. The interface is designed to be intuitive and user-friendly, with a clean layout and clearly labeled fields. The inclusion of the Algerian flag in the background reinforces the national identity and contextual relevance of the platform.

3.3.2 Login Interface of the E-Voting Platform:

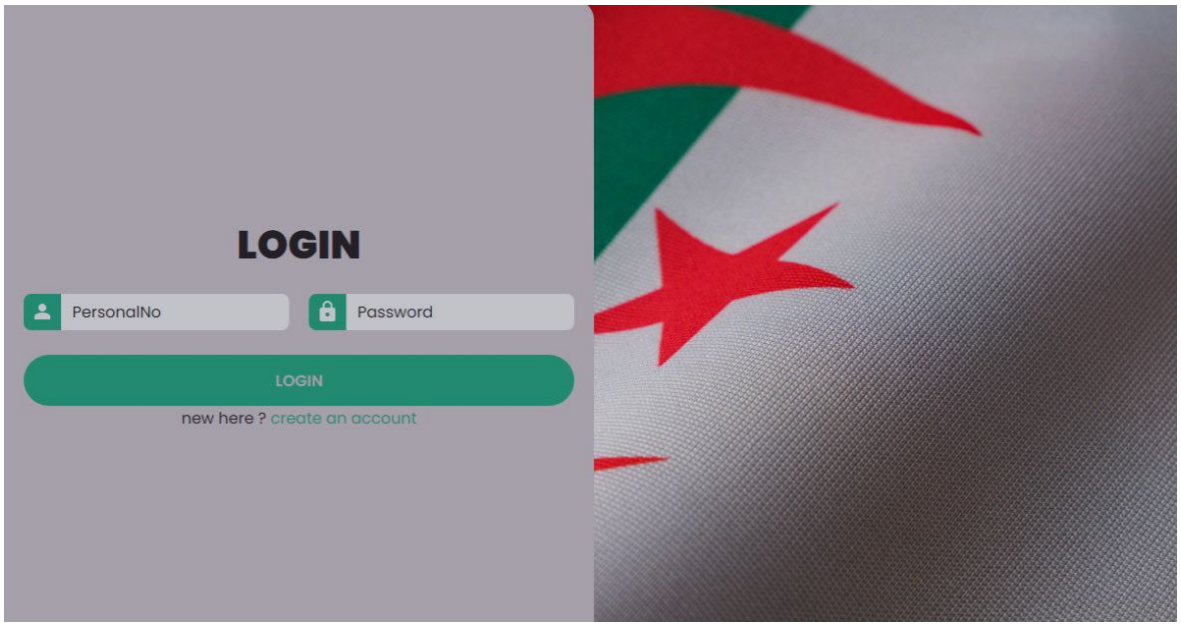


Figure 3.8: Login Interface of the E-Voting Platform

Description:

This figure shows the login interface of the municipal e-voting system. It features fields for entering a personal identification number and password, ensuring secure user authentication. The design includes national symbolism through the Algerian flag background, highlighting the platform's identity. A registration link is also provided for new users, enhancing accessibility and usability.

3.3.3 Admin Dashboard for E-Voting Platform:

Figure 3.9: Admin Dashboard for E-Voting Platform

Description:

The figure illustrates the main interface of a web-based electronic electoral platform, designed to facilitate the organization and management of municipal elections with ease. The interface features a list of participating political parties, accompanied by interactive tools, including an "Add Political Party" button for inserting new parties into the list, a "Start Vote" button to initiate the electoral process, and a "Clear All" function to reset or clear the displayed data.

3.3.4 Political Party Registration Interface in an E-Voting System

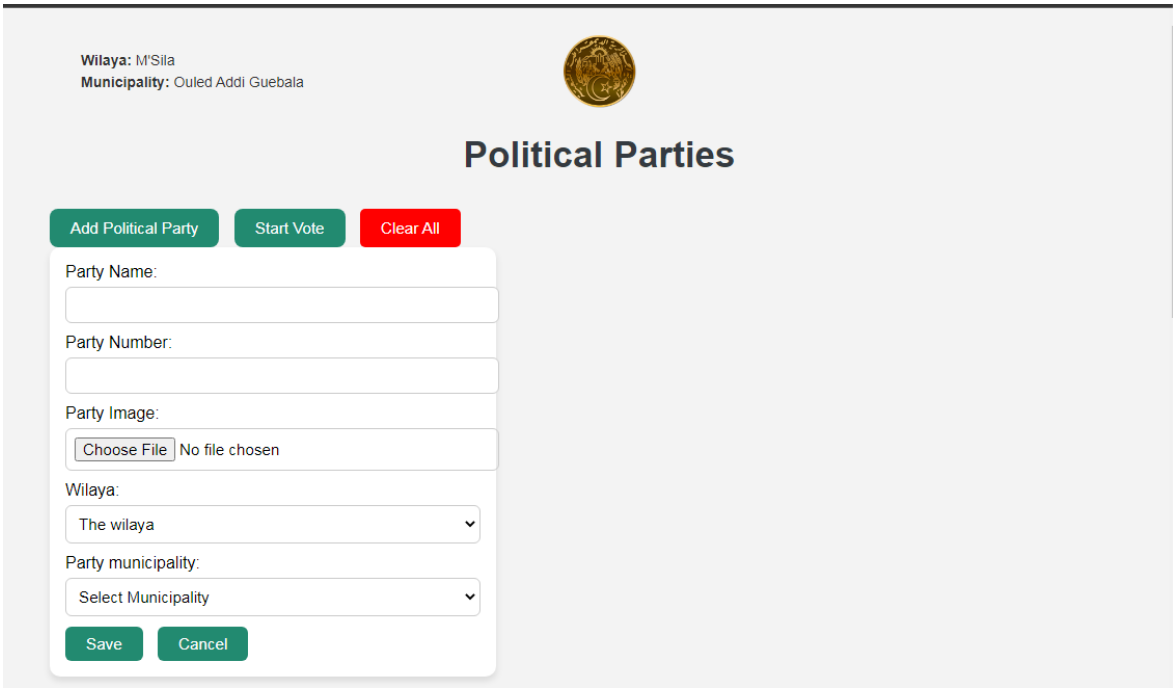


Figure 3.10: Political Party Registration Interface in an E-Voting System

Description:

The interface displays a form for entering political party information in an electronic voting system. It includes fields for the party's name, number, logo, as well as selecting the corresponding wilaya and municipality.

3.3.5 Candidate Registration Interface

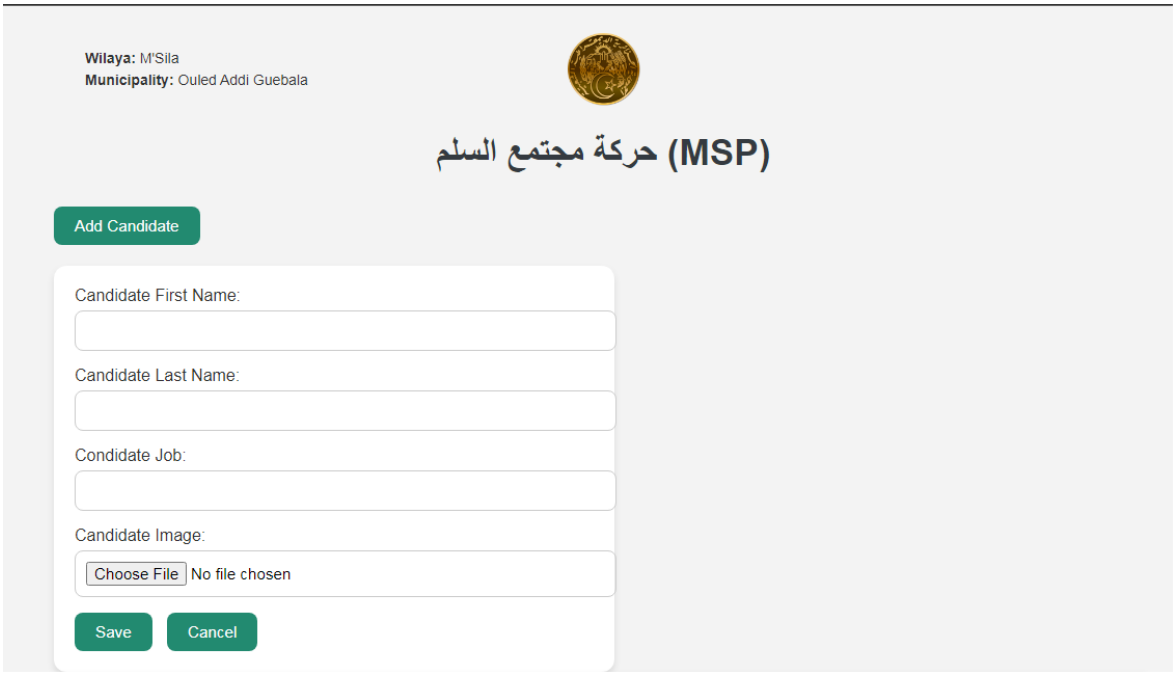


Figure 3.11: Candidate Registration Interface

Description: The interface provides a simple form to register candidates for a political party, including basic personal and professional information. It is designed for use within a specific municipality and wilaya.

3.3.6 Citizen Management interface:

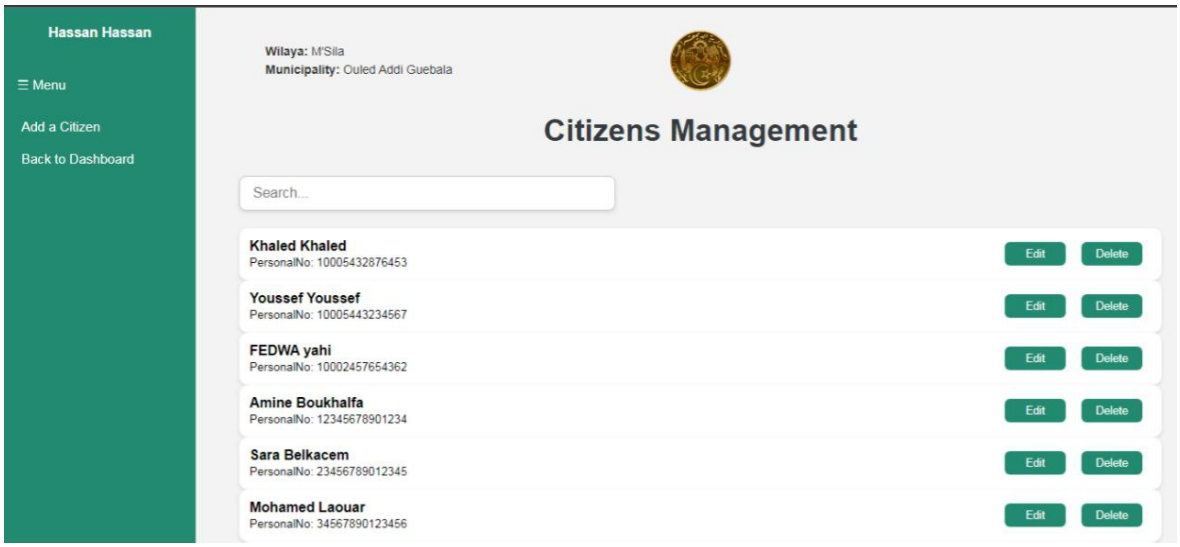


Figure 3.12: Citizen Management interface

Description:

The Citizen Management interface in the electronic voting platform allows for easy management of the data of citizens participating in the electoral process. Through this interface, users can add new citizens, edit the information of registered citizens, or delete them when necessary. It also provides a search bar to facilitate access to any citizen using their name . Additionally, the interface enables navigation between pages, such as returning to the control panel, making it an effective tool for organizing the citizen database during elections.

3.3.7 Voter interface

Figure 3.13: Voter interface

Description:

The voter interface is characterized by allowing the user to select only one party from the available options. Then, depending on the applicable electoral system, the user can either choose a single candidate or select multiple candidates within the chosen party. Once the selection process is complete, the user confirms their vote to ensure that the choices are accurately recorded.

3.3.8 Statistics Management interfaces:

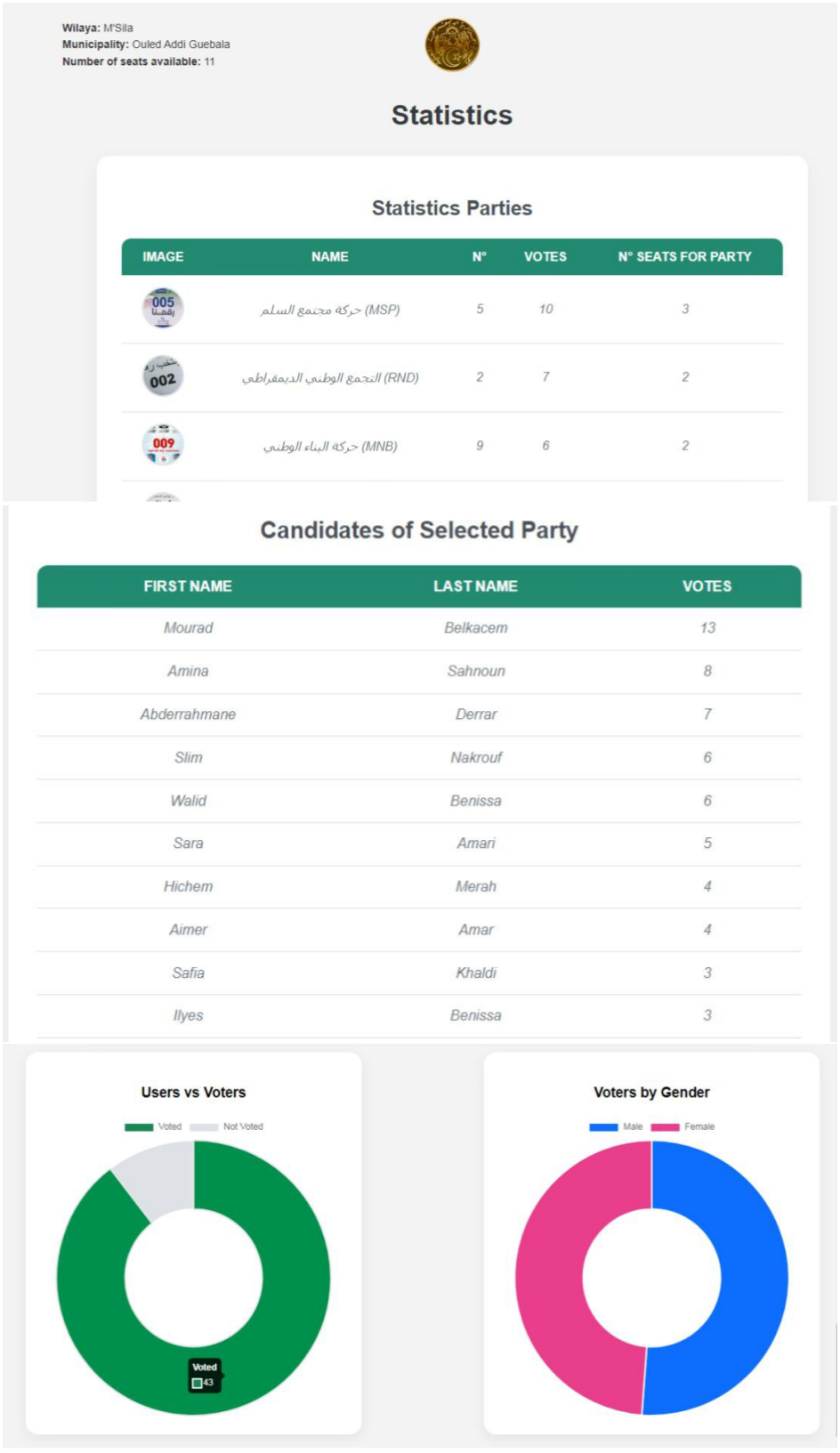


Figure 3.14: Statistics Management interfaces

Description:

The three figures present statistical charts related to the results of the municipal elections. The first figure illustrates the distribution of seats among political parties, while the second focuses on the performance of candidates within a specific party based on the number of votes each received. The third figure highlights voter turnout rates and demographic breakdowns by gender. Collectively, these figures provide a comprehensive overview of key aspects of the electoral process.

3.4 Conclusion

Through this chapter, we have completed our study of this platform by presenting the various tools and technologies used in its development. We also addressed the practical aspect by showcasing examples of the most important developed interfaces. This study enabled us to achieve the intended objective by providing a comprehensive analysis of the technical and functional aspects offered by the platform.

General Conclusion

In conclusion, this project has been a highly enriching experience that allowed us to consolidate theoretical knowledge through practical application. It served as a concrete example of how academic learning can be effectively translated into real-world contexts, deepening our appreciation for the interplay between theory and practice.

Throughout the course of the project, we navigated a range of technical, organizational, and time-related challenges. These obstacles strengthened our abilities in analytical thinking, problem-solving, and decision-making, while also enhancing our capacity to work efficiently under pressure. The project also provided us with hands-on experience using advanced tools and modern technologies, broadening our understanding of the field and exposing us to various professional practices.

Moreover, the project cultivated a strong sense of personal and academic responsibility. It encouraged us to engage in independent research and critical inquiry, both of which are vital components of academic excellence. We also gained a deeper appreciation for the importance of clear documentation, structured planning, and strict adherence to ethical and legal guidelines particularly when dealing with sensitive data or complex systems.

Overall, we take pride in what has been accomplished. The challenges encountered and the knowledge gained throughout this process have not only enhanced our technical competence but also contributed meaningfully to our intellectual and personal development. **Perspectives**

The future development of the electronic voting platform is guided by a strategic vision focused on enhancing **security**, **transparency**, and **user accessibility**. Key advancements are anticipated across both technological and operational dimensions:

- **Integration of Artificial Intelligence (AI):** AI will be employed to analyze voting patterns, detect irregularities in real time, and optimize the overall voting experience. It can also assist in forecasting turnout and improving system responsiveness.
- **Remote Voting Functionality:** One of the major goals is to enable secure remote voting, allowing eligible citizens to cast their votes from any location using a verified internet connection. This aims to boost participation, especially among overseas voters and individuals with limited mobility.

- **Implementation of Two Factor Authentication (2FA):** Strengthening user authentication mechanisms will be critical. The adoption of 2FA through biometric verification or dynamic codes will significantly reduce the risk of unauthorized access and identity fraud.
- **Multilingual Interface Support:** To ensure inclusivity, the platform will offer multilingual support initially in Arabic, French, and English catering to the linguistic diversity of the electorate.
- **Connection with Official Databases:** Real time integration with national identity and civil registry databases will help verify voter eligibility dynamically, preventing duplicate registrations and reducing administrative errors.
- **Adoption of Blockchain Technology:** To enhance trust and transparency, blockchain will be integrated to ensure immutable recording of votes, enabling public auditability and resistance to tampering or data manipulation.
- **Enhanced Cryptographic Protocols:** A core focus will be placed on developing and implementing advanced cryptographic techniques such as end-to-end encryption, homomorphic encryption, and zero-knowledge proofs. These methods will ensure that votes remain confidential, verifiable, and secure from the point of casting to the final count without compromising voter anonymity.
- **Security-First Architecture:** Cybersecurity will be embedded at every layer of the system design, from network security to application hardening. Regular penetration testing, continuous monitoring, and the adoption of post-quantum cryptographic algorithms will prepare the platform for evolving threats.

Through these enhancements, the platform aspires not only to digitize the voting process but to redefine digital democracy by making elections more **secure**, **inclusive**, and **trustworthy**.

References

[1] Michael R. Alvarez and E. Thad Hall. *Electronic Elections: The Perils and Promises of Digital Democracy*. Accessed: May 21, 2025. Princeton, NJ: Princeton University Press, 2008. ISBN: 9780691135668. URL: https://www.amazon.com/dp/0691146225.

[2] Apache Friends. *XAMPP - Apache, MySQL, PHP, Perl*. Accessed: 2025-06-08. 2025. URL: https://www.apachefriends.org/index.html.

[3] BBC News. *Venezuela crisis: Smartmatic says turnout figures were 'tampered with'*. Accessed: May 23, 2025. Aug. 2017. URL: https://www.bbc.com/news/world-latin-america-40812312.

[4] Mohamed Benyahia. ``The Role of Polling Center and Station Staff in Electoral Integrity." In: *Journal of Social and Human Sciences* 15.3 (2021), Article ID: 141076. URL: https://asjp.cerist.dz/en/downArticle/131/15/3/141076.

[5] Grady Booch, James Rumbaugh, and Ivar Jacobson. *The Unified Modeling Language User Guide*. 2nd. Boston: Addison-Wesley, 2005.

[6] Goui Bouhania. *An Analysis of the Algerian Legislative Election Results*. Arabic. Al Jazeera Centre for Studies, Published July 13, 2021. 2021. URL: https://studies.aljazeera.net/ar/article/5065.

[7] Chief Electoral Officer, Bihar. *EVM Brochure for Candidates and Political Parties 2024*. Accessed: May 23, 2025. 2024. URL: https://ceoelection.bihar.gov.in/pdf/EVM/EVM%20Brochure%20for%20Candidates%20and%20Political%20Parties%202024.pdf.

[8] e-Estonia. *How did Estonia carry out the world's first mostly online national elections?* Accessed: 2025-05-22. 2023. URL: https://e-estonia.com/how-did-estonia-carry-out-the-worlds-first-mostly-online-national-elections/.

[9] e-Estonia. *How did Estonia carry out the world's first mostly online national elections?* Accessed: May 21, 2025. 2024. URL: https://e-estonia.com/how-did-estonia-carry-out-the-worlds-first-mostly-online-national-elections/.

[10] Election Commission of Pakistan. *Final Report on the Use of Electronic Voting Machines (EVMs) and Voting by Overseas Pakistanis (OV)*. Technical Report ECP-REP-2021-EVM-OV. Accessed: 2025-05-21. Islamabad, Pakistan: Election Commission of Pakistan, Dec. 2021. URL: https://www.ecp.gov.pk/storage/files/2/reports/EVM%20%26%20OV%20Final%20Report.pdf.

[11] Encyclopædia Britannica. *Are Electronic Voting Machines the Best Method for Voting?* https://www.britannica.com/procon/voting-machines-debate. Accessed: 2025-05-21. 2024.

[12] Estonian National Electoral Committee. *Statistics about Internet Voting in Estonia*. Accessed: 2025-05-21. 20y7zzty 25. URL: https://www.valimised.ee/en/archive/statistics-about-internet-voting-estonia.

[13] Federal Constitutional Court of Germany. *Judgment of the Second Senate of 3 March 2009*. Accessed: May 23, 2025. Mar. 2009. URL: https://www.bundesverfassungsgericht.de/SharedDocs/Downloads/EN/2009/03/cs20090303_2bvc000307en.pdf.

[14] Ben Goldsmith and Holly Ruthrauff. *Implementing and Overseeing Electronic Voting and Counting Technologies*. Accessed: 2025-05-21. Washington, D.C.: International Foundation for Electoral Systems (IFES) and National Democratic Institute (NDI), 2013. ISBN: 978-0-9910142-0-0. URL: https://www.eods.eu/library/IFES.NDI.Implementing_and_Overseeing_Electronic_Voting_and_Counting_Technologies.pdf.

[15] Guardtime. *Blockchain in Estonia & Project PRIViLEDGE H2020*. Accessed: 2025-05-21. Dec. 2019. URL: https://northsearegion.eu/media/11757/20191217-guardtime.pdf.

[16] International IDEA. *Introducing Electronic Voting: Essential Considerations*. Retrieved from the official website. International Institute for Democracy and Electoral Assistance (IDEA), 2011. URL: https://www.idea.int/sites/default/files/publications/introducing-electronic-voting-AR.pdf.

[17] Douglas W. Jones. *Punched Card Ballots*. https://homepage.divms.uiowa.edu/~jones/cards/collection/i-ballot.html. Accessed: 2025-05-21. n.d.

[18] Craig Larman. *Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development*. 3rd. Prentice Hall, 2004. ISBN: 978-0131489066.

[19] Legislative and Legal Opinion Commission. *Electronic Voting: Concept and Challenges*. Retrieved from the official website. n.d. URL: https://lloc.gov.bh/QTopics/Q12T01.PDF.

[20] MapExpress. *Estonia: The Cradle of Electronic Voting*. Originally published in Arabic. Accessed May 22, 2025. 2023. URL: https://www.mapexpress.ma/ar/actualite/%D8%A7%D8%B3%D8%AA%D9%88%D9%86%D9%8A%D8%A7-%D9%85%D9%87%D8%AF-%D8%A7%D9%84%D8%AA%D8%B5%D9%88%D9%8A%D8%AA-%D8%A7%D9%84%D8%A5%D9%84%D9%83%D8%AA%D8%B1%D9%88%D9%86%D9%8A/%D8%A7%D9%84%D8%A2%D8%B1%D8%A7%D8%A1-%D9%88-%D8%AD%D9%88%D8%A7%D8%B1%D8%A7%D8%AA/.

[21] MDN Web Docs. *HTML: HyperText Markup Language*. Accessed: 2025-06-08. 2025. URL: https://developer.mozilla.org/en-US/docs/Web/HTML.

[22] MDN Web Docs. *JavaScript Guide*. Accessed: 2025-06-08. 2025. URL: https://developer.mozilla.org/en-US/docs/Web/JavaScript.

[23] Microsoft. *Visual Studio Code*. Accessed: 2025-06-08. 2025. URL: https://code.visualstudio.com/.

[24] Sally Nabil. *Algeria's 2024 Elections: Do Algerians Believe These Elections Will Bring Change?* BBC Arabic. Sept. 2024. URL: https://www.bbc.com/arabic/articles/cp81lxg1p5mo (visited on 06/02/2025).

[25] OECD. *Digital Government Review*. Accessed: 2025-05-21. OECD Publishing, 2021. URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/12/the-e-leaders-handbook-on-the-governance-of-digital-government_2523ea2c/ac7f2531-en.pdf?utm_source=chatgpt.com.

[26] OSCE Office for Democratic Institutions and Human Rights (ODIHR). *Election Observation Handbook*. Sixth Edition. Accessed: 2025-05-29. Organization for Security and Co-operation in Europe. Warsaw, 2012. URL: https://www.osce.org/files/f/documents/4/b/91106.pdf.

[27] Visual Paradigm. *What is Activity Diagram?* Accessed: 2025-04-28. 2025. URL: https://www.visual-paradigm.com/guide/uml-unified-modeling-language/what-isactivity-diagram/.

[28] People's Democratic Republic of Algeria. *Constitution of the People's Democratic Republic of Algeria*. https://www.joradp.dz/TRV/FConsti.pdf. Adopted by referendum on November 1, 2020. 2020.

[29] People's Democratic Republic of Algeria. *Journal Officiel de la République Algérienne Démocratique et Populaire, No. 65*. https://www.joradp.dz/FTP/jo-francais/2021/F2021065.pdf. Includes Ordinances No. 21-10, 21-11, 21-12; Presidential Decrees No. 21-322, 21-323. Aug. 2021.

[30] People's Democratic Republic of Algeria. *Organic Law No. 12-04 of January 12, 2012, on Political Parties*. Official Journal of the Algerian Republic, No. 02. Available at: https://www.joradp.dz/FTP/jo-francais/2012/F2012002.pdf. Jan. 2012.

[31] People's Democratic Republic of Algeria. *Organic Law No. 16-10 on the Electoral System*. Official Journal of the Algerian Republic, No. 50, August 28, 2016. Available at: https://www.joradp.dz/FTP/jo-francais/2016/F2016050.pdf. Aug. 2016.

[32] PHP Documentation Group. *PHP Manual*. Accessed: 2025-06-08. 2025. URL: https://www.php.net/.

[33] Scaler Topics. *UML Diagrams in Software Engineering*. Accessed: 2025-06-04. 2023. URL: https://www.scaler.com/topics/software-engineering/uml-diagrams/.

[34] Smartmatic. *Estonia: The world's longest standing, most advanced internet voting solution*. Accessed: May 21, 2025. 2023. URL: https://www.smartmatic.com/featured-case-studies/estonia-the-worlds-longest-standing-most-advanced-internet-voting-solution/.

[35] A. Smith and B. Johnson. ``E-Voting in Estonia: Technological and Legal Aspects.'' In: *Proceedings of the International Conference on Electronic Voting*. GI Digital Library, 2023, pp. 45–58. URL: https://dl.gi.de/server/api/core/bitstreams/35e76f86-9af5-4ed7-9540-24004a509616/content.

[36] Swiss Federal Chancellery. *E-Voting*. Accessed: 2025-05-22. 2025. URL: https://www.bk.admin.ch/bk/en/home/politische-rechte/e-voting.html.

[37] The Council of State Governments. *Election Technology Through the Years*. https://csg.org/2023/11/08/election-technology-through-the-years/. Accessed: 2025-05-21. 2023.

[38] The Pew Charitable Trusts. *Back to Paper: A Case Study*. Electionline Briefing 21. The Pew Charitable Trusts, Feb. 2008. URL: https://www.pewtrusts.org/~/media/legacy/uploadedfiles/pcs_assets/2008/eb21briefpdf.pdf.

[39] W3Schools. *CSS Tutorial*. Accessed: 2025-06-08. 2025. URL: https://www.w3schools.com/css/.

[40] X. Zhang. *Counting Votes*. Accessed: 2025-05-21. 2009. URL: https://www.gilderlehrman.org/sites/default/files/file_media/09_Zhang.pdf.