International Journal of Multidisciplinary Engineering in Current Research - IJMEC
Volume 9, Issue 02, February-2024, http://ijmec.com/, ISSN: 2456-4265

THE DEVELOPMENT OF AN ELECTRONIC VOTING SYSTEM USING BLOCKCHAIN TECHNOLOGY

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ABSTRACT: Voting is an important element of a democratic system because it gives individuals the opportunity to express their opinions about the people that represent them and matters that affect them. The traditional electoral system that has existed for centuries has many shortcomings. Many cases of fraud, tampering, and errors have brought the integrity of the system into question. The use of electronic voting systems can improve the efficiency, convenience and security of voting. However, these systems face many challenges, including hacking, fraud, and lack of voter trust. Blockchain technology, a distributed ledger that maintains records in a secure and transparent manner, presents a possible solution to these problems. Blockchain-based electronic voting systems as developed in this work can make online voting more secure, private and scalable, while providing end-to-end verification. We can guarantee it. This study also provides an overview of designed blockchain-based electronic voting systems and highlights various applications and methods used in their design. It also reveals the process it takes to design, how different applications work, and how they interact.

Keywords: Blockchain, Decentralization, Distributed Ledger, Electronic Voting System, Smart Contracts

I. INTRODUCTION

In a democratic government, voting is a right of the people. It can be defined as the process by which citizens choose, through voting, the government to lead them [1]. Paper-based voting systems are the oldest and most commonly used voting systems that use paper ballots and ballot boxes to vote. It was reliable until various election-related issues arose. Problems such as corruption, violence, affordability, inaccessibility and transparency were rampant. These problems necessitated the development of a new voting technology - an electronic voting system. Electronic voting is a voting system that uses electronic devices to vote and count. Electronic voting allows voters to vote from anywhere with an internet connection. The electronic voting system was designed to eliminate tampering and improve the reliability and reliability of the voting system [1].

Blockchain is a distributed ledger technology that allows participants to record transactions in a secure and transparent manner without the need for a central authority. Each block in the chain contains a cryptographic hash of the previous block, ensuring data integrity and immutability [2].Blockchain based electronic voting blends blockchain technology's security and transparency with the convenience and efficiency of e-voting to establish a

DOI: https://doi-ds.org/doilink/02.2024-99539341

system that is tamperproof and reliable and ensures the accuracy of the voting process. E-voting systems are vulnerable to cyber-attacks and hacking, which can compromise the integrity of the voting system. Hackers can potentially alter or delete votes, manipulate votes, or disrupt the voting process.

.Voting systems are the mechanisms and processes used to conduct elections, enabling individuals to express their preferences and elect representatives or make decisions collectively. [3] They play a crucial role in democratic societies by ensuring fair and transparent elections. Traditional voting systems have evolved overtime, primarily consisting of two main categories: paper-based voting and electronic voting: Paper-based voting is the most traditional and widely recognized method of voting. It involves the use of physical ballots, usually in the form of paper sheets, on which voters mark their choices. These ballots are collected, counted, and verified manually. Electronic voting, also known as e-voting or digital voting, employs electronic systems to facilitate the voting process. Blockchain-based voting systems have gained significant attention as a potential solution to address the challenges and limitations of traditional voting systems. Several research projects, pilot programs, and real-world implementations have explored the use of blockchain technology in elections [4].

To address these problems, a blockchain based electronic voting system is necessary. The system would need to be carefully designed, tested, and implemented to ensure its effectiveness in eliminating voter fraud while protecting voter privacy, ensuring the system is not vulnerable to attacks and also maintaining the integrity of the voting process.

II. REVIEW OF RELATED WORK

A review of the state of the art in blockchain-based voting systems are carried out:

A. VOATZ

Voatz is one of the prominent blockchain based voting platforms that has conducted multiple pilot programs and real-world elections. Voatz utilizes a combination of blockchain technology, biometrics, and encryption to provide secure and transparent voting. [4][5] The platform has been used for elections in various settings, including universities, municipalities, and overseas military personnel.

B. HORIZON STATE

Horizon State is a blockchain-based voting system that aims to increase transparency and engagement in the electoral process. The platform provides secure and verifiable voting using blockchain technology. Horizon State has conducted several pilot programs and projects, including partnerships with organizations like the United Nations Development Programme.[6][7]

C. FOLLOW MY VOTE

Follow My Vote is a blockchain-based voting platform that emphasizes privacy, security, and transparency. The system utilizes end-to-end encryption and cryptographic techniques to ensure the integrity of votes. Follow My Vote has conducted pilot projects and demonstrated the feasibility of secure and auditable voting on the blockchain. [8]

D. AGORA

DOI: https://doi-ds.org/doilink/02.2024-99539341

Agora is a blockchain-based voting system that has been involved in conducting pilot programs and providing voting solutions for various organizations and governments. Agora focuses on secure and transparent voting, leveraging the immutability and decentralized nature of blockchain technology. [9]

E. POLYS

Polys is a blockchain-based voting system developed by Kaspersky Labs. It provides a secure and transparent platform for conducting elections and voting processes. Polys offers features such as voter identification, anonymous voting, and verifiability of results. [10]

F. *SMARTMATIC*

Smartmatic, a technology company specializing in election solutions, has explored the use of blockchain technology in voting systems. They have conducted pilot projects and research to leverage blockchain for secure and transparent elections. Smartmatic emphasizes the potential of blockchain to enhance trust, auditability, and accessibility in voting processes.[11]

III. METHODOLOGY

3.1 System Design and Specification

This work adopted system requirements [12 – 14] for a blockchain-based voting system involve various functional aspects that ensure the smooth operation of the system as shown in Fig.1.

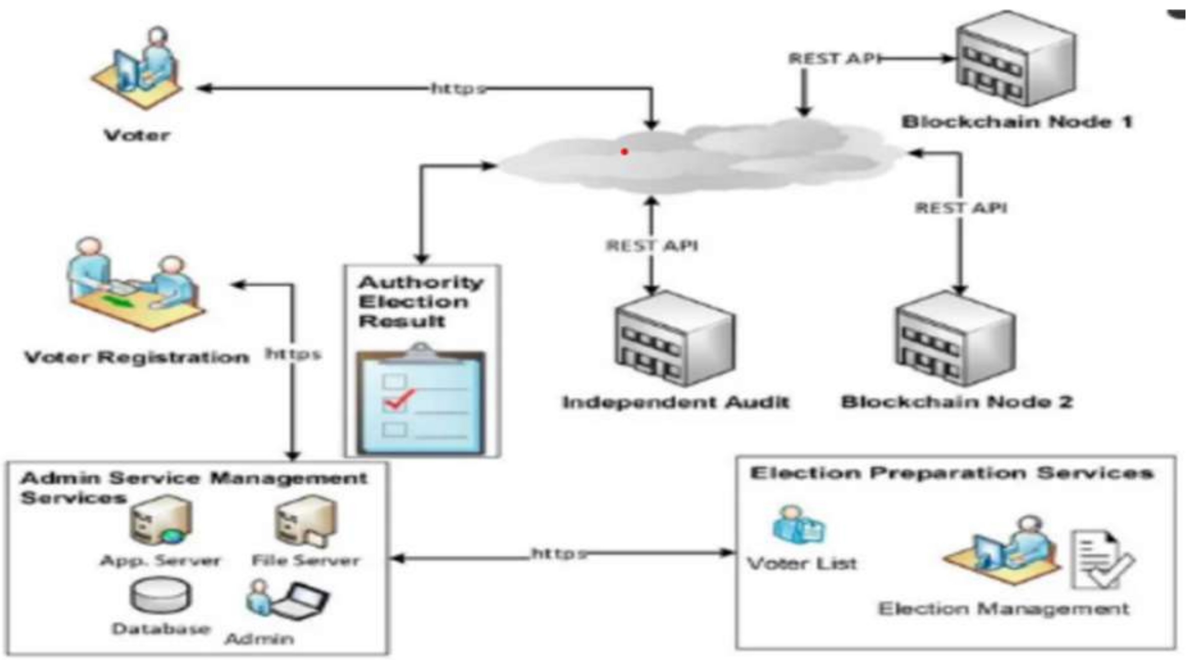

Figure 1. An overview of architecture of a blockchain voting system [12-14]

These system requirements include:

A. User Registration and Authentication**:** The system should allow eligible voters to register and authenticate their identity securely. This may involve integration with existing voter registration databases or implementing a new registration process within the system.

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B. Ballot Creation and Management: The system should provide the functionality to create and manage different types of ballots, including options for candidates, referendums, and other voting scenarios. Ballot customization, validation, and verification mechanisms should be implemented to ensure accuracy and integrity.

C. Secure Voting Process: The system should enable voters to cast their votes securely and anonymously. It should provide a user-friendly interface for selecting candidates or voting options and prevent duplicate or fraudulent voting.

D. Vote Recording and Validation: The system should securely record each vote on the blockchain, ensuring its integrity and immutability. The votes should be validated according to the specified rules and regulations of the election.

E. Vote Counting and Tallying: The system should have mechanisms to accurately count and tally the votes recorded on the blockchain. Automated counting algorithms or smart contracts can be used to streamline the process and ensure accuracy.

The system architecture provides an overview of the components and their interactions within the blockchain-based voting system. It typically consists of the following key components:

A. User Interface: The user interface component allows voters to interact with the system. It can be a web-based interface, a mobile application, or dedicated voting machines at physical polling stations. The user interface provides a secure and user-friendly platform for voters to cast their votes, verify their selections, and receive confirmation.

B. Blockchain Network: The blockchain network serves as the decentralized ledger that records and stores all voting transactions. It consists of multiple nodes that maintain a copy of the blockchain and participate in the consensus mechanism to validate and add new blocks to the chain. Popular blockchain platforms such as Ethereum or Hyperledger Fabric can be utilized for this purpose.

C. Smart Contracts:Smart contracts are self-executing contracts that automatically enforce the terms and conditions defined within them. In the context of blockchain-based voting systems, smart contracts can be utilized to automate various processes, such as voter authentication, ballot validation, vote counting, and result declaration. They help ensure the accuracy and transparency of the voting process while reducing the reliance on manual intervention.

D. Backend Infrastructure**:** The backend infrastructure comprises the servers, databases, and network infrastructure that support the functioning of the system. It handles tasks such as data storage, processing, and communication between different components. Security measures, such as encryption, firewalls, and intrusion detection systems, should be implemented to protect the system from unauthorized access and data breaches.

E. Integration Modules**:** Integration modules facilitate the interaction between the voting system and external systems, such as voter registration databases, identity verification systems, or other election-related systems. These modules ensure the seamless exchange of data and information, maintaining the integrity and accuracy of the overall electoral process.

The Admin Module Components are discussed in this section and shown in Fig 2:

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***A. Dashboard*:** This component will display various charts and statistics to provide the admin with an overview of the election. It can include the number of registered voters, the total number of votes cast, and the progress of the election.

***B. Add Candidate*:** This feature allows the admin to add candidates who are participating in the election. Once a candidate is added, their details such as name, will be displayed to the users during the voting process.

C. Create Election: The admin has the authority to create an election by setting the start and end dates. Only during this period can users cast their votes. The admin can define the duration of the election and any specific rules or requirements.

D. Election Details: The admin can update the election details if needed. This includes modifying the start and end dates, changing the eligibility criteria, or making any necessary adjustments to ensure the smooth conduct of the election.

E. Candidate Details: This component allows the admin to view and manage the details of the candidates. The admin can update candidate information, such as correcting any errors.

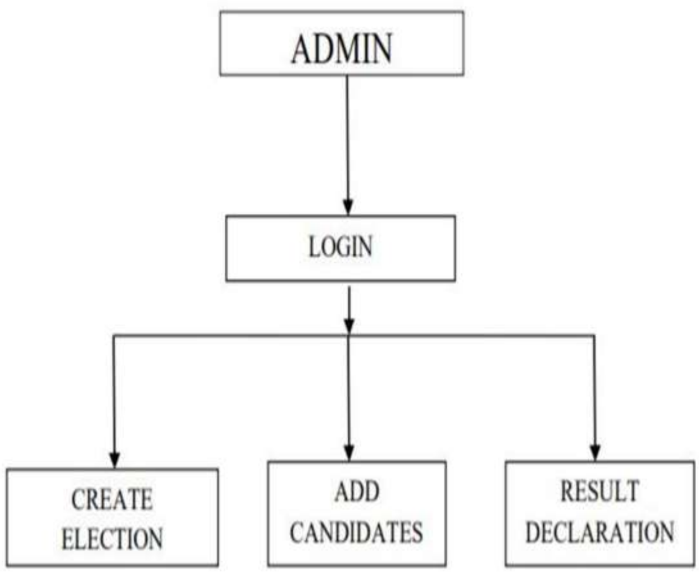

Figure 1: The admin flow diagram

The User Module Components are discussed in this section and shown in Fig 3:

A. Dashboard: The user dashboard provides information about the candidates participating in the election. Users can view candidate profiles, and any relevant information that aids in making an informed voting decision.

B. Voter Registration: Before casting their votes, users need to register as voters. This component captures user details such as name, and identification information to verify eligibility. Once registered, users can proceed to the voting area.

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C. Voting Area: After successful registration, users can access the voting area to cast their votes. The interface should present the candidates associated with their respective candidates, enabling users to select their preferred candidate.

D. Results: Once the voting period ends, the results component allows users to view the outcome of the election. It displays the vote counts for each candidate and provides an overall summary of the election results.

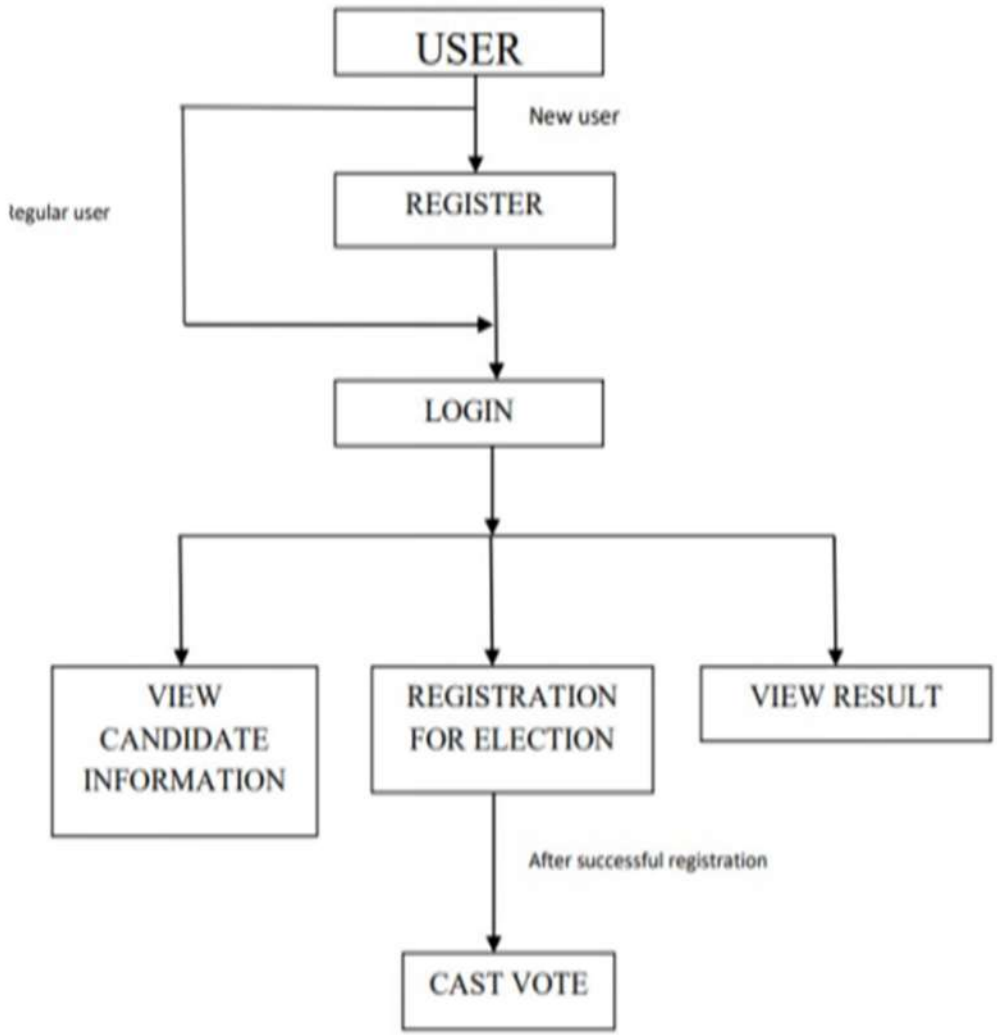

Figure 3: The user flow diagram

3.2 System Implementation

For our proposed plan of work, the above modules were completed in three phases as follows:

Phase 1: Front-end Development

In this phase, the front-end module is developed with the under-listed tasks.

i. Design and develop an interactive user interface for both the admin and user sides of the application.

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ii. Create a dashboard for the admin, displaying various charts and information such as the number of parties and voters.

iii. Implement the functionality for the admin to add candidates who are standing in the election.

iv. Develop a feature for the admin to create an election, specifying the start and end dates for voting.

v. Implement a section for the admin to manage election details, allowing updates to start dates, end dates, etc.

vi. Create a section for the admin to manage candidate details, enabling updates if necessary.

vii. Design and develop a user dashboard displaying information about parties and candidates.

viii. Implement user registration functionality, allowing users to register before casting their votes.

ix. Develop the voting area where registered users can cast their votes.

x. Create a results section for users to view the outcome of the election.

Phase 2: Back-end Development with Solidity

In this phase, the focus is on implementing the back-end module using Solidity, a programming language for smart contract development on the Ethereum blockchain.

i. Research and study the Ethereum framework and Solidity language for smart contract development.

ii. Smart contracts for managing the election process, including candidate registration, vote casting, and result tallying was carried out.

iii. Implement the necessary functions and logic within the smart contracts to ensure the integrity and security of the voting system.

iv. Integrate the smart contracts with the front-end application to enable communication between the user interface and the blockchain.

Phase 3: Integration and Testing

In this phase, the front-end and back-end modules are integrated as seen in Fig 4 and thorough testing of the system to ensure the proper functioning of the platform was performed

i. Connect the front-end application with the back-end blockchain by utilizing appropriate APIs or libraries.

ii. Perform integration testing to ensure smooth communication between the user interface and the blockchain.

iii. Conduct system testing to verify the overall functionality, performance, and security of the voting system.

iv. Test the user registration, vote casting, and result display functionalities to ensure they work as intended.

v. Address any issues or bugs identified during testing and perform necessary fixes or enhancements.

The completion of these phases brought us closer to achieving a secure, transparent, and efficient voting platform. To enable us implement the above, the following tools were used, Ganache, MySQL, Vs Code and Nodejs.

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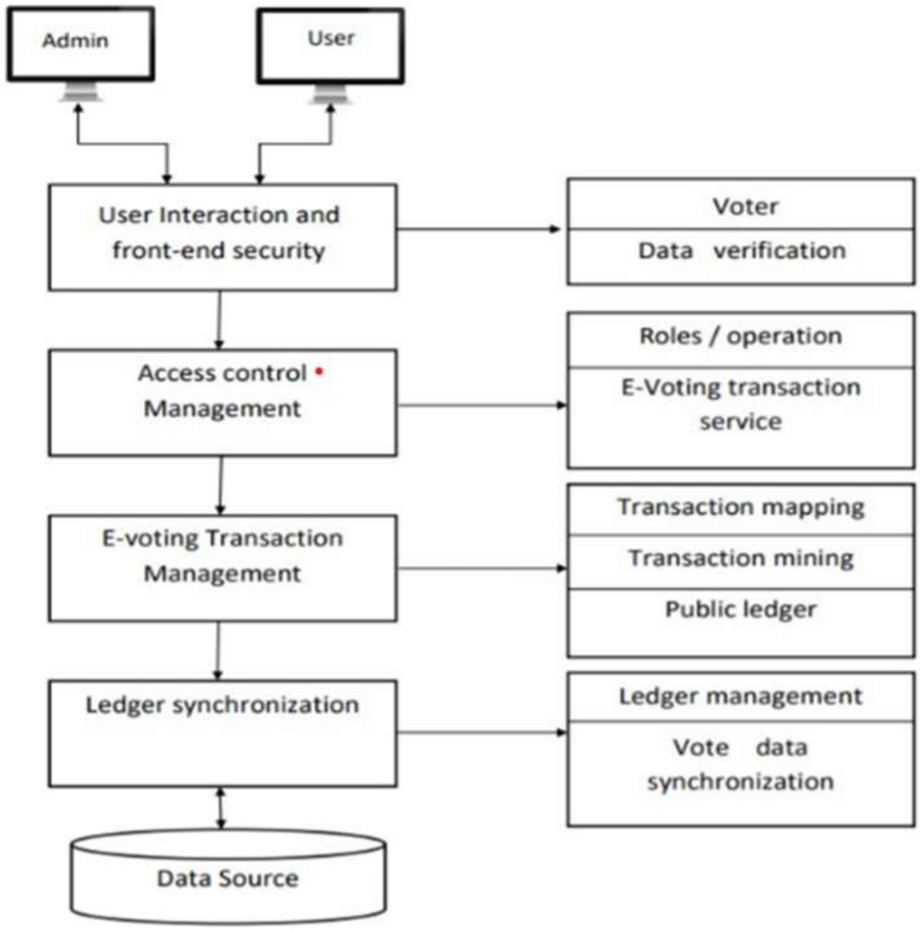

Figure 4: Voting system flow diagram

3.3 *Data Models and Data Flow*

The system relies on specific data models to manage and process the voting data. These models include:

***Voter Data Model*:** This model captures and stores the information related to registered voters, including their personal details, eligibility status, and unique identifiers. It ensures the integrity and confidentiality of voter information while facilitating secure voter authentication during the voting process.

***Ballot Data Model**:* The ballot data model defines the structure and content of each ballot. It includes information about the candidates, referendums, or voting options available for voters to select from. This model ensures consistency and accuracy in ballot design and facilitates proper validation and verification during the voting process.

Vote Data Model: The vote data model captures the individual votes cast by voters. It associates each vote with the corresponding voter identifier, ballot information, and a timestamp. This model maintains the integrity and immutability of the voting data on the blockchain.

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The data flow within the system involves various stages, including:

Registration: Voter registration data is captured and stored in the voter data model. This data is verified and authenticated to ensure the eligibility of voters.

Ballot Creation: Election officials utilize the ballot creation module to design and customize the ballots for the election. The ballot data model is updated to reflect the specific candidates, options, and referendums for each ballot.

Voting Process:Voters access the system through the user interface and authenticate their identity. They select their preferred candidates or voting options, and the vote data model is updated with their choices. The voting module records the votes securely on the blockchain.

Vote Counting: The vote counting and tallying module retrieves the votes recorded on the blockchain. It applies the necessary algorithms or smart contracts to aggregate the votes, calculate the results, and determine the winners. The final results are stored in a secure and tamper-proof manner.

Result Declaration: The system generates and publishes the final results based on the vote counting process. The results can be made available in real-time to the relevant stakeholders, including election officials, candidates, and the public.

IV. RESULT ANALYSIS

The Blockchain based Electronic voting system homepage website in Fig 5 offers an intuitive and user-friendly interface designed to enhance the user experience. The Login Page serves as the secure gateway for authorized verified voting members to access the Blockchain electronic voting system. After entering their credentials, the voting members gain access to their personalized dashboard, enabling them to vote and view election results as seen in Fig 6.

To validate the functionality and performance of the voting system, a comprehensive test plan and test cases was developed. These includes unit testing, integration testing, system testing, and user acceptance testing. Test cases covered both normal and exceptional scenarios to ensure the system’s robustness.

This subsection defines the criteria and metrics used to evaluate the performance, security, usability, and compliance of the voting system. It outlines the benchmarks and standards against which the system’s effectiveness and efficiency are measured. Considerations was given to factors such as response time, scalability, system uptime, and user satisfaction. These metrics showed a satisfactory performance. The integration points with external systems are identified. This may include integration with voter registration databases, identity verification systems, or election management systems. The data exchange protocols, APIs, and security measures for seamless integration should be defined.

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A user-friendly and intuitive interface is crucial to ensure smooth user interactions with the voting system. This has to do with the design principles, usability testing, and accessibility considerations for the user interface. It covers aspects such as clear instructions, visual design, support for multiple languages, and compatibility with assertive technologies. The voting system includes web applications, this outlines the design considerations specific to these platforms. It addresses responsiveness, platform compatibility, data encryption during transmission, and security measures for protecting user credentials and data stored on mobile devices.

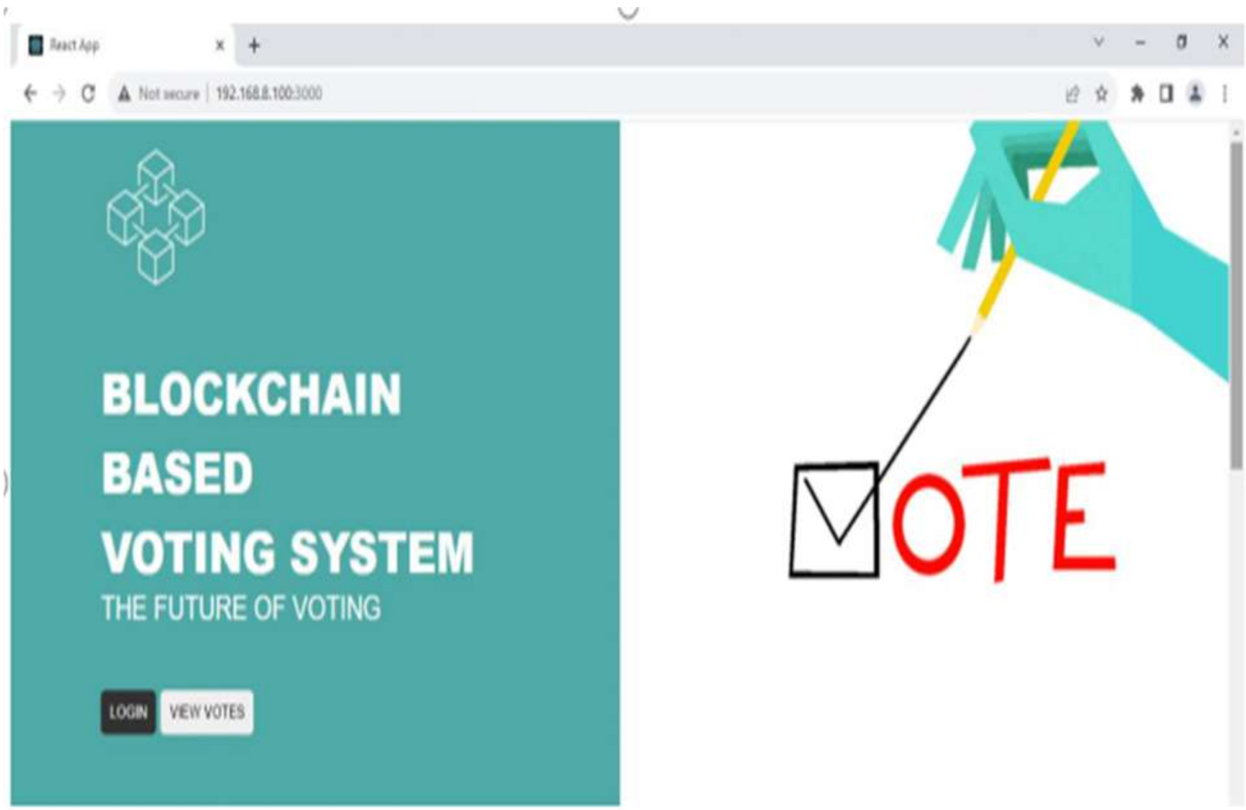

Figure 5: The Homepage

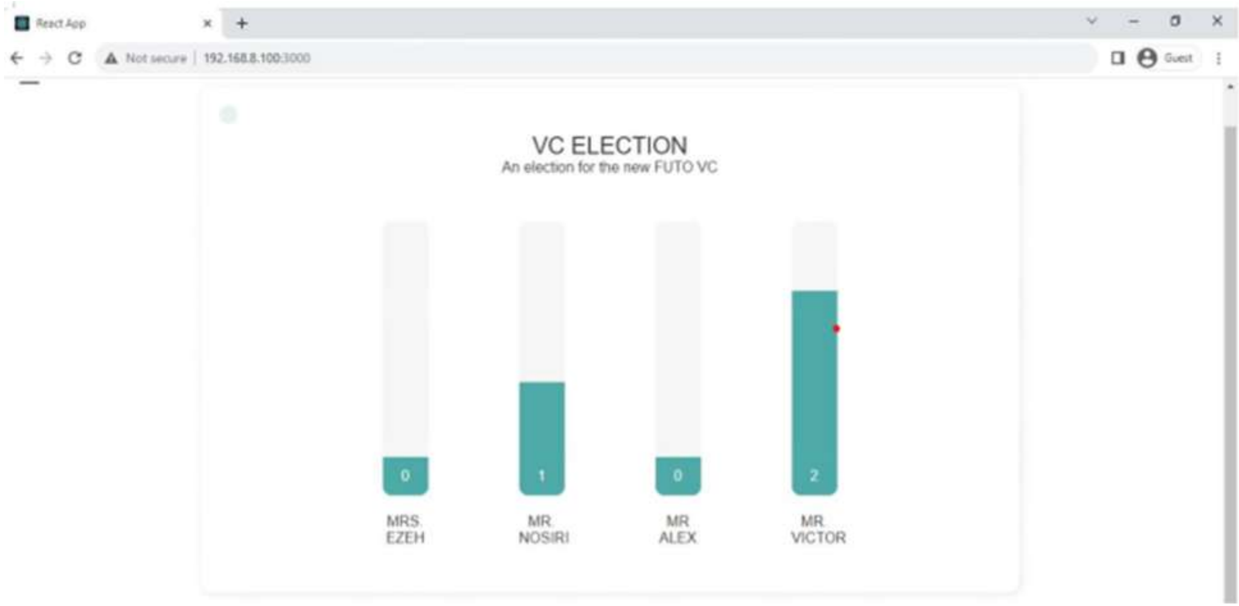

Figure 1: The Vote Viewing Page

The implementation of blockchain-based voting systems has the potential to revolutionize the way elections are conducted, enhancing transparency, security, and trust in the electoral process. However, further research, real-world testing, and collaboration are necessary to address the challenges and ensure the successful adoption of this technology. By continuing to explore and improve blockchain-based voting systems, we can strive for more inclusive, secure, and efficient democratic processes.

V. CONCLUSION

This research work has explored the implementation of electronic voting systems using Blockchain technology. Through the systematic analysis and evaluation of the system, we have highlighted the potential of Blockchain to enhance transparency, security, and trust in the voting process.The findings indicate that Blockchain-based voting systems offer advantages such as immutability, tamper resistance, and increased auditability. The evaluation results demonstrate promising outcomes in terms of system performance, security, and user satisfaction. However, challenges such as scalability, legal and regulatory frameworks, and user acceptance need to be addressed for widespread adoption.The research project contributes to the existing body of knowledge on electronic voting systems and Blockchain technology. It provides insights into the system design, implementation, and evaluation aspects, serving as a valuable resource for researchers, practitioners, and policy-makers interested in the field of electronic voting.

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