Decentralized Voting System Using Stellar Technology

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Abstract
The Stellar-based Blockchain Voting System lever ages blockchain technology and AI driven authentication to revolutionize electoral processes by providing secure, transparent, and efficient voting solutions. This project explores the integration of Stellar's low-cost transaction capabilities and Rust-based smart contracts, ensuring scalability and robust security. Advanced features such as AI-based face recognition and OCR models enhance voter authentication, while blockchain's immutability safeguards against tampering and fraud. The analysis highlights the system's adaptability across diverse electoral processes, from national elections to private organizational voting. By combining innovative technologies and user-centric design, the system sets a benchmark for tamper-proof, accessible, and scalable voting solutions, paving the way for a more inclusive and secures democratic process.

Keywords: Block chain Voting, Stellar, Rust Smart Contracts, AI Authentication, Electoral Security, Scalable Voting Systems.

I. INTRODUCTION

Elections form the cornerstone of democratic societies, ensuring that the voice of every eligible citizen is heard and respected. However, traditional voting systems often face challenges such as tampering, voter fraud, inefficiencies, and accessibility issues. To address these limitations, this project presents a secure and transparent voting system that integrates blockchain technology with artificial intelligence, offering an innovative approach to modernizing electoral processes.

This system is built on the Stellar Blockchain platform, known for its low-cost, fast, and efficient transactions. Stellar's inherent features of transparency and immutability ensure that every vote is securely recorded and cannot be altered, providing an incorruptible digital ledger for election data. Complementing the blockchain framework are Rust-based smart contracts, which enforce predefined rules and automate processes with precision and reliability.

To enhance voter authentication and prevent impersonation, the system employs AI-driven technologies for real-time face recognition and Aadhaar-based verification. By integrating an Optical Character

Recognition (OCR) model, the system verifies Aadhaar card details and extracts essential data, such as phone numbers, to ensure the authenticity of voters and candidates alike. This dual-layered verification process strengthens identity security, making it nearly impossible for unauthorized individuals to participate in the election.

The project uniquely combines the strengths of blockchain and artificial intelligence to create a tamper-proof, scalable, and user-friendly voting system. Blockchain's immutability ensures that once votes are recorded, they cannot be modified or deleted, safeguarding the integrity of election results. Mean while, AI-driven verification mechanisms mitigate the risks of voter fraud and human errors, fostering trust and reliability in the electoral process.

This solution is designed to cater to the needs of modern elections, addressing the growing demand for secure, efficient, and transparent voting systems. It not only streamlines the voting process but also ensures that democratic principles are upheld in a technologically evolving world.

II. LITERATURE REVIEW

A. Said El Kafhali, "Blockchain-Based Electronic Voting System: Significance and Requirements",2024.

This paper examines the potential of blockchain technology in electronic voting systems, highlighting its significance in ensuring transparency, security, and immutability. The author discusses the key requirements for a blockchain-based voting system, including scalability, voter anonymity, and data integrity. By analyzing existing challenges in traditional and electronic voting systems, the study provides insights into how blockchain can overcome these limitations. The paper emphasizes the role of smart contracts in automating processes and ensuring tamperproof transactions, presenting blockchain as a transformative tool for modern elections.

B. Beulah Jayakumari, S. Lilly Sheeba, Maya Eapen, Jani Anbarasi, Vinayakumar Ravi, A. Suganya, Malathy Jawahar, "E-voting system using cloud-based hybrid blockchain tech nology,"2024.

This paper presents a novel e-voting system that integrates cloud-based platforms with hybrid blockchain technology to enhance security, scalability, and efficiency. The authors ex plore the potential of combining public and private blockchain, leveraging the strengths of each to address the challenges in electronic voting systems. The study highlights the role of cloud technology in enabling scalability and accessibility while ensuring robust data protection and voter anonymity. It proposes a hybrid architecture that balances transparency for stakeholders with privacy for voters, offering a reliable framework for secure elections.

C. Kranthi Kiran Reddy, Gutha Vijay Kumar, Sai Siddu Sir imulla, Chanan Singh, Chaithanya Kumar Reddy, Ponnapati Pranay Santosh Reddy, "Decentralized Voting System".

This paper explores the design and implementation of a decentralized voting system leveraging blockchain technology. The authors propose a framework aimed at enhancing the transparency, security, and reliability of election processes. By eliminating the need for intermediaries, the system ensures tamper-proof data integrity and provides voters with a secure and anonymous platform. The study also emphasizes the use of smart contracts to automate various processes, enabling efficient and verifiable voting outcomes. The paper highlights the scalability and usability challenges in current implementations and suggests improvements through advanced consensus mechanisms.

III. SYSTEM DESIGN AND METHODOLOGY

A. System Architecture Overview

Figure 1 shows the system architecture of the Proposed System. It is design is built to ensure efficient, secure, and scalable interactions across various components. The frontend is powered by Next.js, providing a responsive and dynamic user interface for seamless user interaction. AioHTTP serves as the asynchronous HTTP client, enabling efficient communication between the frontend and the Stellar Blockchain through the FastAPI proxy server. FastAPI handles user registration, OTP verification, and blockchain integration, ensuring high performance and smooth backend operations. Redis is employed to securely store hashed OTPs for short durations, allowing quick and secure authentication processes. Twilio is integrated to send OTPs to clients' phone numbers, facilitating multi factor authentication. For identity verification, Pinata is used to store voter face images securely on the decentralized IPFS, enabling reliable and tamper-proof facial recognition. The Stellar Blockchain powers the transaction system, ensuring fast and secure processing of transactions, while the entire architecture is designed to handle edge cases and abnormal scenarios, ensuring system stability and robustness.

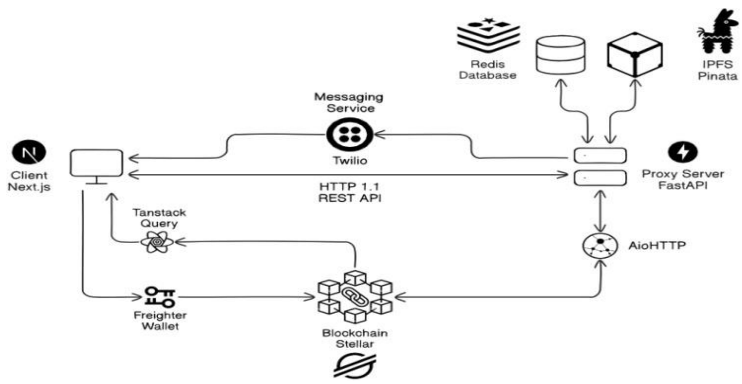

Fig.1.System Architecture of Decentralized Voting System

B. Process Flow Diagrams

a) Flow chart of Candidate Registration: Figure 2 shows the flow chart diagram of Candidate Registration. It begins with the user connecting their wallet (freighter). Once the wallet is connected successfully, the user proceeds to register as a candidate by entering valid personal information and uploading an Aadhaar card photo. The system extracts the phone number from the provided information and sends a One Time Password (OTP) to the registered number. The user must verify the OTP to continue; a successful OTP verification leads to the next phase of the process.

If the user's details are verified, the process checks whether the approval status is pending. If the owner is verified, the registration is deemed successful, and the process ends. However, if the approval conditions are not met, the flow reverts to entering valid information and uploading the Aadhaar card photo again, ensuring no step is skipped in the verification cycle. This systematic approach ensures secure and reliable candidate onboarding.

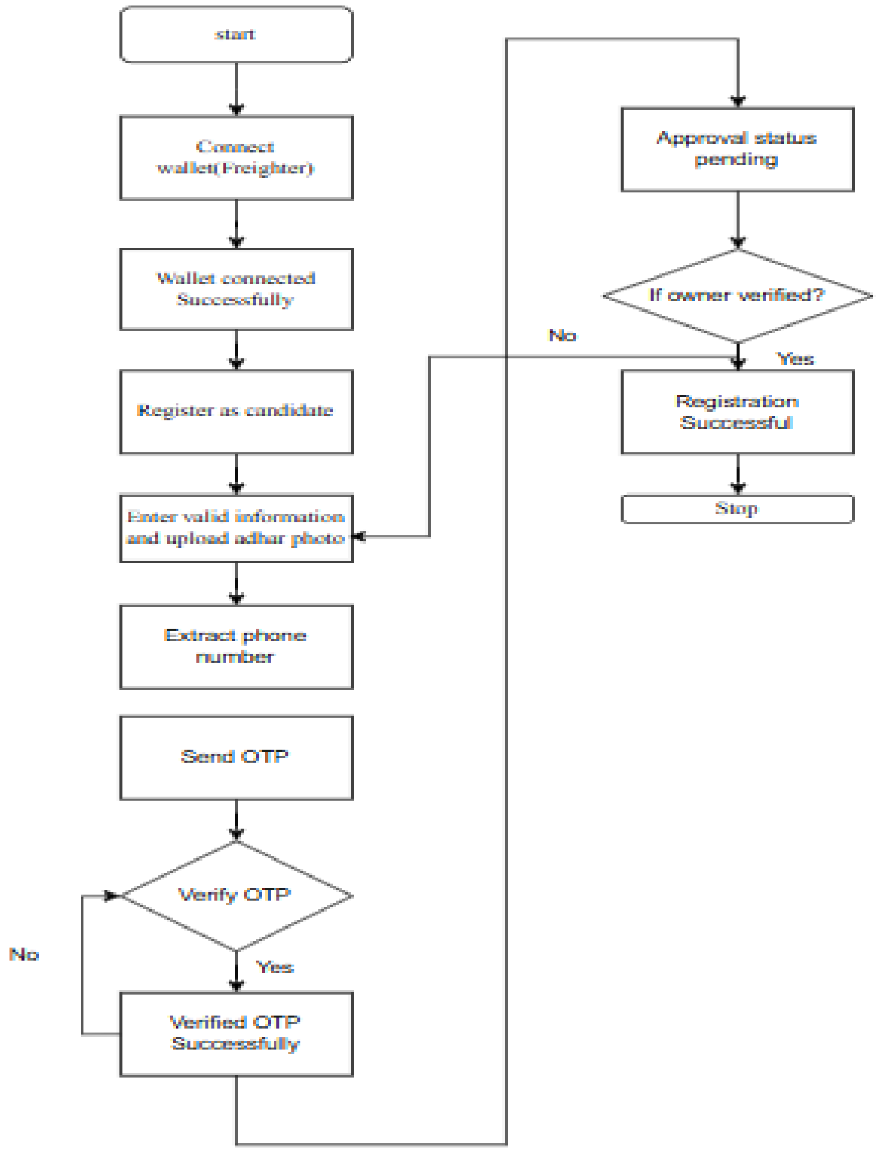

Fig.2.Flowchart of Candidate Registration.

b) Flow chart of Voter Registration: Figure 3 shows the f low chart diagram of Voter Registration. The process starts with the user connecting their wallet (freighter). Once the wallet connection is successful, the user proceeds to register as a voter by providing valid information and uploading an Aadhaar card photo. The system extracts the phone number from the uploaded information and sends a One Time Pass word (OTP) to the user. Upon receiving the OTP, the user must verify it. A successful OTP verification allows the process to continue, ensuring that only verified users move forward. In parallel, the flow includes an additional verification step involving a selfie capture.

The user is prompted to open their webcam and take a selfie. The system checks if the face in the selfie is visible and recognizable. If the criteria are met, the selfie is securely stored in Pinata for future reference. With both the document and facial verification complete, the registration is marked successful, and the process concludes. This integrated approach ensures a robust and secure voter registration system by combining document validation and biometric verification.

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c) Flow chart of Voting Process:

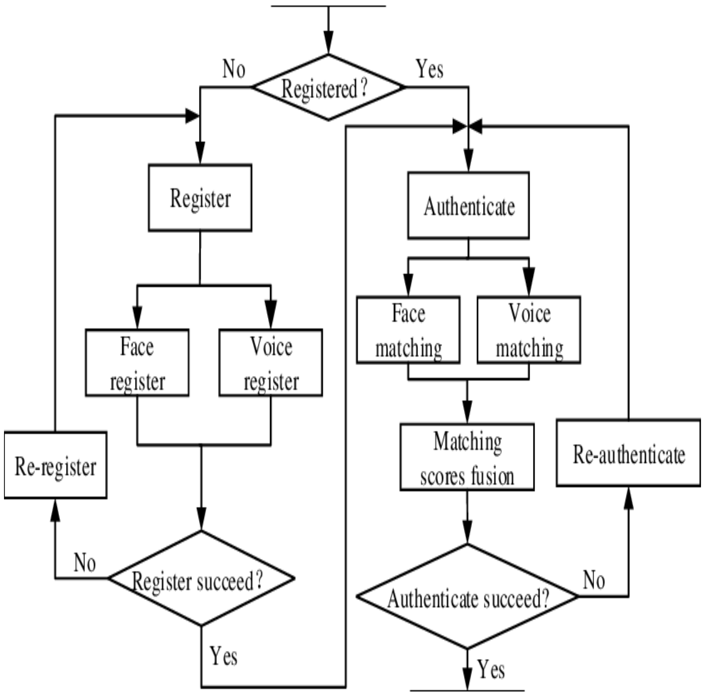

Fig.3.Flowchart of Voter Registration.

Figure 4 shows the flow chart diagram of Voting Process. The process begins with the user connecting their wallet (freighter), ensuring their identity is linked to the system. Once the wallet is successfully connected, the user selects the candidate profile they wish to vote for and initiates the voting process by clicking on the ”Vote to Candidate” option. The system then activates the user’s webcam, prompting them to capture a selfie as an additional layer of biometric verification. The system evaluates the selfie to determine if the face is visible and matches the registered details. If the verification is successful, the vote is cast successfully, and the process concludes. If the face is not visible or does not match, the system loops back, requiring the user to retake the selfie until the verification is complete.

IV. RESULTS AND DISCUSSION

A. Experimental Setup

To evaluate our decentralized voting system, we performed a series of controlled experiments using simulated voter and candidate data. These tests focused on assessing the performance of blockchain transactions, the AI-driven authentication components (face recognition and OCR), and the overall system responsiveness. Key performance indicators included transaction latency, authentication accuracy, and the efficiency of user interactions.

B. System Performance

Our face recognition module, which employs both 68 point and 5-point predictor techniques, achieved an average matching accuracy of about 96% across diverse lighting con ditions and facial orientations. Similarly, the OCR component demonstrated robust performance by accurately extracting phone numbers from Aadhaar images with an average accu racy near 92%. Furthermore, our system leverages the Stellar blockchain, where transactions are processed within a 3–5 second window per vote and fees are consistently maintained below $0.01. These results, as detailed in Table I, confirm that the system meets its targeted standards for speed, precision, and cost-effectiveness. Specifically, the table shows that Stellar supports approximately 10 transactions per second (with up to 1,000 operations per second when each transaction carries 100 operations), ensures ledger finalization in about 5 seconds, maintains negligible transaction costs, and achieves low energy consumption while guaranteeing data integrity through its immutable consensus protocol.

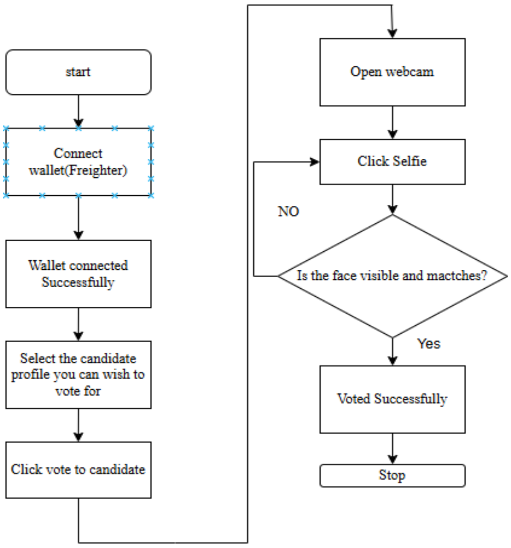

Fig.4.Flowchart of Voting Process.

TABLE I
STELLAR BLOCKCHAIN PERFORMANCE AND BENEFIT

Metric	Stellar/SystemValue	ProjectBenefit
TransactionThroughput	10TPS,upto1,000oper-ations/sec	Enablesrapidvoterecord-ing
LedgerFinalizationTime	5secperledgerclosure	Ensuresfastvoteconfirma-tion
TransactionCost	0.00005XLMpertransac-tion	Reducesoperationalcosts pervote
EnergyEfficiency	Lowenergyuse(SCP-based)	Lowenvironmentalimpact
DataIntegrity	ImmutableledgerviaSCP	Ensurestamper-proofvote records
FaceRecognitionAccuracy	96–97%(CNN-basedmod-els)	Enhancesvoterauthentica-tionsecurity

C. User Experience and Feedback

Initial user trials revealed that the multi-factor authentication process is both secure and user-friendly, instilling high con f idence in the system’s integrity. Nonetheless, feedback high lighted that the registration process, which incorporates several verification steps, might benefit from further streamlining to reduce processing delays without sacrificing security.

D .Discussion

The experimental data confirms that our approach delivers a secure, transparent, and scalable voting solution. The use of blockchain technology guarantees an immutable record of votes, while the AI-driven modules significantly enhance voter authentication. Despite these promising outcomes, challenges remain, particularly in optimizing the registration workflow and fine-tuning the face recognition algorithms to handle edge cases more effectively. Future work will focus on integrating advanced cryptographic techniques to further enhance security and scalability, as well as conducting broader field trials to evaluate the system's performance in real-world settings.

V. CONCLUSION AND FUTURE WORK

A. Conclusion

The Stellar-based Blockchain Voting System exemplifies a transformative leap in electoral technology by merging blockchain's immutability with AI-driven authentication for unparalleled security and transparency. With its low-cost trans actions, robust Rust-based smart contracts, and user-centric design, the system ensures efficient, scalable, and tamper-proof elections adaptable to diverse electoral needs, empowering voters and candidates alike.

This innovative approach redefines trust and accessibility in voting systems, addressing key challenges of traditional methods. By seamlessly integrating advanced technology, it paves the way for a more secure and inclusive democratic process.

B. Future work

Future enhancements for the Stellar-based Blockchain Voting System include:

- Optimizing scalability to support global elections efficiently.
- Integrating advanced AI for real-time anomaly detection to identify fraudulent activities.
- Extending device compatibility, including support for offline voting systems.
- Strengthening security with multi-factor authentication for enhanced voter verification.
- Enabling real-time analytics for comprehensive election monitoring and insights.
- Addressing regulatory challenges to facilitate global adoption of the system.
- Setting a new standard for secure and transparent electoral processes worldwide.

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