

Secure Blockchain-Based E-Voting System Using Smart Contracts

Kushal Berad, Abhishek Gavand, Ranjeet Waghmode, Tejas Vaidya, Prof. Suvarna A. Bahir

Department of Computer Engineering, Savitribai Phule Pune University, India

Abstract - Electronic voting systems have gained significant attention due to their ability to improve the efficiency and accessibility of elections. However, traditional voting methods and centralized electronic voting systems face challenges such as vote tampering, lack of transparency, unauthorized access, and delayed result generation. Blockchain technology offers a decentralized and secure solution to address these limitations.

This paper presents a Secure Blockchain-Based E-Voting System Using Smart Contracts that leverages Ethereum blockchain technology to provide transparent, secure, and tamper-resistant elections. The proposed system integrates voter authentication, election management, candidate registration, vote recording, and real-time result monitoring within a single platform. Smart contracts developed using Solidity are used to automate election operations and ensure the integrity of voting transactions.

The system is implemented using HTML, CSS, JavaScript, FastAPI, MySQL, Ethereum, Ganache, and MetaMask. Votes are securely recorded on the blockchain, preventing unauthorized modifications and improving election transparency. The proposed framework enhances voter trust, reduces dependency on centralized authorities, and simplifies election management. This solution can be effectively used for academic institutions, organizations, and small-scale election environments requiring secure and reliable voting processes.

Keywords: Blockchain, Electronic Voting, Ethereum, Smart Contracts, Solidity, Decentralized Voting.

I. INTRODUCTION

Voting is one of the most important processes in democratic and organizational decision-making. Traditional paper-based voting systems have been used for many years; however, they often involve significant operational costs, manual effort, and delays in result generation. Although electronic voting systems improve efficiency, many existing solutions rely on centralized infrastructures that are vulnerable to unauthorized modifications, insider threats, and single points of failure.

Recent advancements in blockchain technology have created new opportunities for developing secure and transparent voting systems. Blockchain provides a distributed ledger where transactions are recorded in an

immutable manner, making it difficult to alter previously stored information. Smart contracts further enhance blockchain applications by enabling automatic execution of predefined rules without requiring continuous human intervention.

Several researchers have investigated blockchain-based voting systems to improve election security, transparency, and voter trust. Existing studies demonstrate that blockchain can provide tamper-resistant vote storage and decentralized verification mechanisms. However, practical challenges related to election management, usability, voter authentication, and administrative control remain important considerations for real-world deployment.

This research proposes a Secure Blockchain-Based E-Voting System Using Smart Contracts that combines blockchain technology with a modern web-based architecture. The system integrates voter authentication, election management, blockchain vote recording, and real-time result generation within a single platform. Ethereum smart contracts are used to enforce election rules and maintain vote integrity throughout the voting process.

The primary objective of this work is to develop a secure and transparent voting framework that minimizes the limitations of traditional voting systems while providing a practical and user-friendly solution for modern election environments.

II. LITERATURE REVIEW

1. E-Voting System Using Blockchain Technology

Authors: Nagesh H. R., Guru Prasad M. S., Shivaraj B. G., Dhawal Jain, Puneeth B. R., and M. Anandkumar

The authors proposed a blockchain-based voting framework that utilizes Ethereum smart contracts to record votes securely and transparently. The system focuses on preventing vote tampering, improving election integrity, and enabling decentralized vote storage. The study demonstrates how blockchain technology can eliminate several limitations associated with traditional voting systems.

2. Blockchain for Electronic Voting System—Review and Open Research Challenges

Authors: Uzma Jafar, Mohd Juzaidin Ab Aziz, Zarina Shukur, and Hafiz Adnan Hussain

This paper reviews existing blockchain-based electronic voting systems and discusses their advantages, challenges, and limitations. The authors highlight important factors such as voter privacy, transparency, security, scalability, and vote verification. The study identifies several research opportunities for developing more secure and practical voting systems.

3. E-Voting Meets Blockchain: A Survey

Authors: Maria-Victoria Vladucu, Zhuang Dong, Jose Medina, and Roberto Rojas-Cessa

This survey analyzes different blockchain-based voting architectures and compares their security, privacy, and transparency features. The authors explain how blockchain technology improves trust in election systems while discussing challenges related to performance and adoption.

4. Blockchain-Based E-Voting Systems: A Technology Review

Authors: Mohammad Hajian Berenjestanaki, Hamid R. Barzegar, Nabil El Ioini, and Claus Pahl

The paper presents a comprehensive review of blockchain voting systems and their implementation approaches. The study discusses smart contracts, consensus mechanisms, security benefits, and practical deployment considerations. The authors conclude that blockchain can significantly improve election transparency and integrity.

5. A Survey on Blockchain Technology: Evolution, Architecture and Security

Authors: Muhammad N. M. Bhutta, A. A. Khwaja, A. Nadeem, H. F. Ahmad, M. K. Khan, M. A. Hanif, H. Song, M. Alshamari, and Y. Cao

This paper presents a comprehensive survey of blockchain technology, covering its evolution, architecture, consensus mechanisms, and security features. The authors discuss the advantages of blockchain in providing decentralization, transparency, and data integrity. The study provides a strong theoretical foundation for designing secure blockchain-based applications, including electronic voting systems.

6. Blockchain for Securing Electronic Voting Systems: A Survey of Architectures, Trends, Solutions and Challenges

Authors: Henry O. Ohize, A. K. Bashir, S. A. M. Ghaleb, A. Barnawi, M. Alshammari, and G. Srivastava

This paper reviews modern blockchain-based electronic voting systems and analyzes various architectures, security models, and implementation approaches. The authors examine challenges related to privacy, scalability, voter authentication, and election transparency. The study

highlights recent developments in blockchain voting technologies and provides recommendations for building secure and reliable electronic voting frameworks.

RESEARCH GAP

Most existing blockchain-based voting systems focus on security and transparency; however, many studies provide limited emphasis on user experience, election administration, and practical deployment. Several solutions also require complex configurations that reduce usability. Therefore, there is a need for a secure, user-friendly, and manageable blockchain-based voting platform that combines election management, voter authentication, and transparent vote recording within a single framework.

NOVELTY OF WORK

The proposed Secure Blockchain-Based E-Voting System Using Smart Contracts focuses on providing a secure, transparent, and decentralized voting environment using Ethereum blockchain technology.

Unlike traditional voting systems that rely on centralized databases and manual vote management, the proposed system records votes through blockchain transactions secured by smart contracts. This approach improves transparency and reduces the possibility of unauthorized modifications.

The system integrates voter authentication, role-based access control, election management, candidate management, vote recording, and result monitoring within a single platform. Administrators can manage election activities efficiently through a dedicated dashboard, while voters can securely participate using blockchain-supported transactions.

The integration of FastAPI, MySQL, Solidity smart contracts, Ethereum blockchain, Ganache, and MetaMask creates a practical and user-friendly voting framework suitable for educational institutions, organizational elections, and small-scale democratic processes.

The primary contribution of this work is the combination of blockchain-based vote security with simplified election management and improved user experience, resulting in a reliable and transparent electronic voting solution.

III. PROBLEM STATEMENT

- Traditional voting systems often suffer from challenges such as ballot tampering, manual errors, delayed result generation, and high operational costs.

- Centralized electronic voting systems rely heavily on trusted authorities and centralized databases, making them vulnerable to cyberattacks, unauthorized modifications, and single points of failure.
- Existing voting systems provide limited transparency, making it difficult for voters and election authorities to independently verify election results.
- Maintaining vote integrity, voter confidentiality, and election fairness remains a significant challenge in many electronic voting solutions.
- The absence of a secure and tamper-resistant mechanism for recording votes reduces public trust in electronic election systems.
- There is a growing need for a secure, transparent, and decentralized voting framework capable of ensuring accurate vote recording and trustworthy election management.

IV. OBJECTIVES

- Design and develop a secure blockchain-based electronic voting system using Ethereum smart contracts.
- Implement a decentralized voting mechanism that prevents vote tampering and unauthorized modifications.
- Develop a role-based authentication system for voters and administrators.
- Enable secure vote recording through blockchain transactions.
- Automate election management processes using smart contracts.
- Provide real-time vote counting and result visualization.
- Improve election transparency and voter trust through immutable blockchain records.
- Develop a user-friendly web interface that simplifies election participation and administration.

V. RESEARCH METHODOLOGY

The methodology adopted for the proposed system consists of literature analysis, system design, smart contract development, implementation, and system integration.

Literature Analysis

A detailed study of blockchain-based electronic voting systems was conducted to understand the security, transparency, and decentralization features offered by blockchain technology. Several research papers related to electronic voting, smart contracts, and blockchain applications were reviewed to identify existing challenges and possible solutions.

System Design

The overall architecture of the system was designed by defining separate modules for authentication, election management, vote recording, blockchain communication, and result generation. The workflow was planned to ensure secure interaction between users and blockchain components.

Smart Contract Development

Ethereum smart contracts were developed using Solidity. These smart contracts manage candidate registration, vote recording, election scheduling, and vote counting. The contracts automatically enforce election rules and prevent duplicate voting.

Backend Development

FastAPI was used to develop backend services responsible for user authentication, election management, and communication between the frontend, database, and blockchain network.

Database Integration

MySQL database was integrated to store voter information, election records, candidate details, and administrative data. Database validation mechanisms were implemented to ensure data consistency and integrity.

Frontend Development

The user interface was developed using HTML, CSS, and JavaScript. Separate interfaces were created for administrators and voters to simplify election management and voting activities.

Blockchain Environment

The Ethereum blockchain environment was simulated using Ganache. MetaMask was used for wallet management and transaction authorization. Smart contracts were deployed locally and interacted with through blockchain transactions.

System Integration

The developed modules were integrated to ensure proper communication between authentication, election management, database, and blockchain components.

VI. SYSTEM ARCHITECTURE

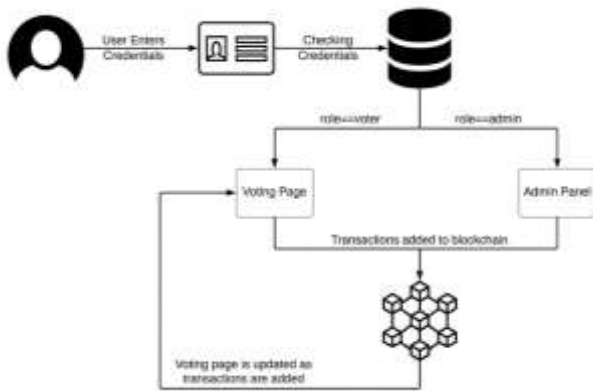


Figure 1: Proposed System Architecture

SECURE BLOCKCHAIN-BASED E-VOTING SYSTEM USING SMART CONTRACTS

The architecture of the proposed Secure Blockchain-Based E-Voting System is designed as a multi-layered framework that ensures security, transparency, and efficient election management.

1. User Interface Layer

The user interface serves as the primary interaction point between users and the system.

- Developed using HTML, CSS, and JavaScript.
- Provides separate interfaces for voters and administrators.
- Allows secure login, vote casting, election monitoring, and result viewing.
- Improves accessibility and user experience.

2. Authentication Layer

- This layer manages user verification and access control.
- Validates voter and administrator credentials.
- Implements role-based authentication.
- Prevents unauthorized access to election functions.
- Ensures secure participation in the voting process.

3. Backend Services Layer

The backend layer acts as the central processing unit of the system.

- Developed using FastAPI.
- Handles user requests and election operations.
- Manages communication between frontend, database, and blockchain layers.

- Performs validation and transaction processing.

4. Database Layer

- The database layer stores application-related information.
- Maintains voter records and authentication data.
- Stores election schedules and candidate information.
- Records administrative activities.
- Implemented using MySQL.

5. Blockchain Layer

- The blockchain layer forms the security foundation of the system.
- Built on the Ethereum blockchain network.
- Smart contracts are developed using Solidity.
- Stores voting transactions in an immutable ledger.
- Prevents vote manipulation and unauthorized modifications.

6. Wallet Integration Layer

- This layer facilitates secure blockchain interaction.
- MetaMask is used for wallet authentication.
- Enables transaction signing and verification.
- Provides secure communication with blockchain services.

7. Election Management Layer

This layer supports election administration activities.

- Candidate registration.
- Election scheduling.
- Vote monitoring.
- Result generation.
- Administrative dashboard controls.

Working Process

1. The administrator creates an election and registers candidates.
2. Voters authenticate themselves through the system.
3. Eligible voters connect their wallet and cast votes.
4. Smart contracts validate and record voting transactions.
5. Voting transactions are recorded on the Ethereum blockchain through deployed smart contracts, ensuring transparency and immutability.
6. Smart contracts automatically calculate vote counts.
7. Results are displayed through the administrative dashboard and voter interface.

VII. CONCLUSION

This research presents a Secure Blockchain-Based E-Voting System Using Smart Contracts that addresses several limitations associated with traditional and centralized electronic voting systems. The proposed framework utilizes blockchain technology to provide transparency, security, and tamper-resistant vote storage while maintaining efficient election management.

The integration of Ethereum smart contracts automates critical election operations including vote validation, vote recording, and result generation. The use of FastAPI backend services, MySQL database management, MetaMask wallet integration, and a web-based user interface creates a complete and practical voting platform.

The proposed system improves election transparency, reduces the possibility of vote manipulation, enhances voter confidence, and simplifies election administration. Through decentralized vote storage and smart contract automation, the framework ensures integrity and trust throughout the election lifecycle.

Future enhancements may include advanced voter verification mechanisms, mobile voting support, improved scalability solutions, and integration with larger blockchain networks for broader deployment scenarios.

VIII. REFERENCES

1. Nagesh H. R., Guru Prasad M. S., Shivaraj B. G., Dhawal Jain, Puneeth B. R., and M. Anandkumar, "E-Voting System Using Blockchain Technology," 2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), pp. 1–6, 2022.
2. U. Jafar, M. J. A. Aziz, Z. Shukur, and H. A. Hussain, "Blockchain for Electronic Voting System—Review and Open Research Challenges," *Sensors*, vol. 21, no. 17, pp. 1–35, 2021.
3. M. V. Vladucu, Z. Dong, J. Medina, and R. Rojas-Cessa, "E-Voting Meets Blockchain: A Survey," *IEEE Access*, vol. 11, pp. 1–22, 2023.
4. M. H. Berenjestanaki, H. R. Barzegar, N. El Ioini, and C. Pahl, "Blockchain-Based E-Voting Systems: A Technology Review," *Electronics*, vol. 13, no. 1, pp. 1–28, 2024.
5. M. N. M. Bhutta, A. A. Khwaja, A. Nadeem, H. F. Ahmad, M. K. Khan, M. A. Hanif, H. Song, M. Alshamari, and Y. Cao, "A Survey on Blockchain Technology: Evolution, Architecture and Security," *IEEE Access*, vol. 9, pp. 61048–61073, 2021.
6. H. O. Ohize, A. K. Bashir, S. A. M. Ghaleb, A. Barnawi, M. Alshammari, and G. Srivastava, "Blockchain for Securing Electronic Voting Systems: A Survey of Architectures, Trends, Solutions and Challenges," *Cluster Computing*, vol. 28, pp. 1–38, 2025.
7. M. Al-Madani, A. T. Gaikwad, V. Mahale, and Z. A. T. Ahmed, "Decentralized E-Voting System Based on Smart Contract by Using Blockchain Technology," 2020 International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC), pp. 176–180, 2020.
8. J. Thakkar, N. Patel, C. Patel, and K. Shah, "Privacy-Preserving E-Voting System Through Blockchain Technology," 2021 IEEE International Conference on Technology, Research, and Innovation for Betterment of Society (TRIBES), pp. 1–6, 2021.
9. G. Rathee, R. Iqbal, O. Waqar, and A. K. Bashir, "On the Design and Implementation of a Blockchain Enabled E-Voting Application Within IoT-Oriented Smart Cities," *IEEE Access*, vol. 9, pp. 34165–34176, 2021.
10. M. S. Farooq, U. Iftikhar, and A. Khelifi, "A Framework to Make Voting System Transparent Using Blockchain Technology," *IEEE Access*, vol. 10, pp. 1–15, 2022.