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"Blockchain-BasedSecure Voting system for Local Governance"

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Abstract

Decentralized voting using Ethereum blockchain is a secure, transparent and tamper-proof way of conducting online voting. It is a decentralized application built on the Ethereum blockchain network, which allows participants to cast their votes and view the voting results without the need for intermediaries. In this system, votes are recorded on the blockchain, making it impossible for anyone to manipulate or alter the results. The use of smart contracts ensures that the voting process is automated, transparent, and secure. The use of the blockchain technology and the implementation of a decentralized system provide a reliable and cost- effective solution for conducting trustworthy and fair elections.

I.INTRODUCTION

1.1 Introduction to Blockchain

Blockchain is a distributed digital ledger technology that allows participants in a network to share and validate transactions in a secure and transparent manner without the need for intermediaries. The technology is designed to be decentralized, meaning that the data is stored on a network of computers instead of a central database. This makes it difficult to hack or manipulate the data, ensuring the integrity and security of the system. The blockchain technology gained popularity with the emergence of Bitcoin, which was the first decentralized cryptocurrency. However, the technology has since been applied to various industries, including finance, supply chain management, healthcare, and voting, among others. Blockchain works by creating blocks of data that are linked together in a chain, hence the name blockchain. Each block contains a unique code, known as a hash, that is generated based on the contents of the block. This hash is then used to link the block to the previous one, forming a chain of blocks. Once a block is added to the blockchain, it cannot be altered or deleted without the consensus of the network participants. This makes the technology immutable, ensuring that the data stored on the blockchain is tamper-proof and transparent. Overall, blockchain technology has the potential to revolutionize the way we store and share data, making it more secure, transparent, and accessible. 1 Decentralized Voting System Using Ethereum Blockchain

1.2 Decentralized Voting Using Blockchain

A decentralized voting system built on the Ethereum blockchain has the potential to revolutionize the way we conduct elections. By leveraging the security, transparency, and immutability of blockchain technology, decentralized voting systems can eliminate many of the challenges and risks associated with traditional voting systems. In a decentralized voting system, each voter has a unique digital identity, and their vote is recorded on the blockchain, ensuring that the vote is tamper-proof and cannot be altered. Decentralized voting systems also eliminate the need for intermediaries, such as government agencies, to oversee the election process, making it more efficient and less susceptible to corruption or manipulation. Furthermore,

decentralized voting systems can increase voter participation by allowing voters to cast their ballots from anywhere in the world, as long as they have an internet connection. This can lead to a more democratic and inclusive electoral process, with greater voter engagement and higher turnout. Overall, a decentralized voting system using the Ethereum blockchain has the potential to bring significant benefits to the electoral process, making it more secure, transparent, and accessible to everyone.

II. LITERATURE REVIEW

The Previous research has explored various approaches to creating a decentralized voting system using blockchain technology to address the inherent flaws of traditional and electronic voting. These flaws include a lack of transparency, susceptibility to fraud, and centralized points of failure. The use of Ethereum has emerged as a prominent solution due to its support for smart contracts, which can automate and enforce the voting process without human intervention.

1. The Promise of Ethereum and Smart Contracts Early work in this field highlighted how blockchain's core properties—immutability and decentralization— could fundamentally improve elections. Studies by researchers like Crosby et al. (2016) demonstrated that an immutable, shared ledger could prevent vote tampering, while also providing a publicly verifiable record of the election. Ethereum, in particular, was quickly identified as an ideal platform for this due to its ability to host smart contracts, which act as self- executing code for managing the entire voting process, from voter registration to vote tallying. This automated, trustless process is a key advantage, as it removes the need for a central, trusted authority, thereby reducing opportunities for corruption and human error.

2. Key Challenges and Research Focus

Despite the significant promise, the literature has identified several major challenges that prevent the widespread adoption of these systems.

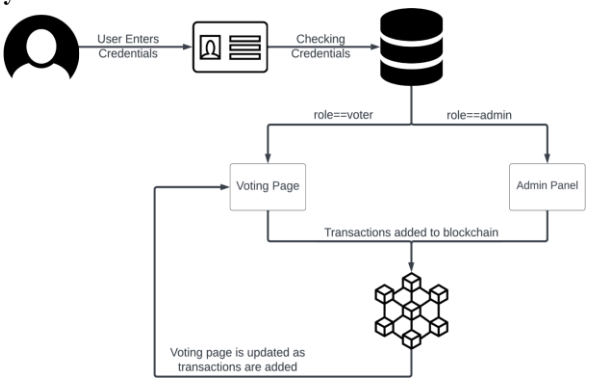
- **Scalability:** A critical issue is the low transaction throughput of the Ethereum mainnet. Researchers have shown that the network cannot handle the millions of votes required for a large-scale national election without becoming congested and causing high transaction costs (gas fees). Recent research is heavily focused on Layer-2 scaling solutions, such as rollups, which process transactions off-chain and then post a summary to the mainnet. Work by Dziembowski et al. (2018) and others has explored these solutions to improve transaction speed and lower costs.
- **Privacy and Anonymity:** While a public ledger ensures transparency, it can compromise voter privacy by potentially linking a voter's identity to their vote. To address this, many studies have explored cryptographic techniques. The use of zero-knowledge proofs (ZKPs) has emerged as a leading solution, allowing the public to verify that a vote is valid without revealing who cast it. Researchers like Ben- Sasson et al. (2019) have published on how ZKPs can be integrated to create a verifiable and private voting system.
- **Security and Usability:** While the blockchain itself is highly secure, the smart contracts built on it are susceptible to coding errors. A single bug could compromise an entire election, as the "code is law" nature of smart contracts makes it difficult to reverse a mistake. A paper by Atzei et al. (2017) provides a comprehensive analysis of smart contract vulnerabilities. In addition, existing systems often have complex user interfaces, requiring users to manage cryptocurrency wallets. This creates a significant barrier to entry, as the system must be accessible and easy to use for all voters, regardless of technical skill.
- **Legal and Governance Hurdles:** The literature also notes that the adoption of blockchain voting systems requires a massive shift in legal and regulatory frameworks. Governments would need to define how to legally recognize and audit a decentralized election, and the public must be willing to trust an entirely new voting paradigm.

III. METHODOLOGY

1. **Security:** The proposed system aims to provide a secure platform for conducting elections, eliminating the possibility of tampering with votes, and ensuring that the election results are transparent and verifiable.
2. **Transparency:** The proposed system aims to provide complete transparency to the voters, allowing them to view the entire voting process, including the vote counting and results.
3. **Accessibility:** The proposed system aims to make the voting process more accessible to all eligible voters by eliminating the need for physical presence at a polling station, thus increasing voter turnout.
4. **Efficiency:** The system aims to increase the efficiency of the voting process by reducing the time and resources required to conduct elections. Since the system is automated and eliminates the need for intermediaries, it can significantly reduce the cost and time associated with traditional voting methods.

5. **Trust:** The proposed system aims to increase trust in the voting process by providing a transparent and tamper- proof mechanism for recording and tallying votes.

System Architecture



User enters the credentials (voter id & password) and they are matched with the database. If the match is found user is either redirected to admin page or voter page as per their role corresponding to the credentials in the database. Once the admin is logged in he/she can start the voting process by adding candidates and defining dates. Voter can vote once the voting process has been started. Once the voter has voted the transaction is recorded to the blockchain and the voting page is updated with real-time votes.

IV. EXPERIMENTAL SETUP

The primary objective is to evaluate the performance, security, and usability of a decentralized voting system using Ethereum blockchain.

4.1 System Design and Implementation We develop and deploy a Solidity smart contract on a test blockchain network (like Sepolia). This contract contains the election logic, including voter registration, vote casting, and final tally. A simple frontend application (dApp) is built for users to interact with the smart contract using a Web3 wallet.

4.2 Experiment Execution

1. **Voter Simulation:** We generate a large number of Ethereum addresses to simulate a population of voters. An automated script then casts votes from these addresses to stress-test the system's performance.
2. **Security Testing:** The experiment includes attempts to cast duplicate votes, alter votes, and identify a voter from a ballot to test the system's resilience to common attacks and verify privacy features.

4.3 Evaluation Metrics

- **Throughput (TPS):** Measures the number of votes the system can process per second.
- **Transaction Latency:** The time it takes for a vote to be confirmed on the blockchain.
- **Gas Cost:** The cost (in testnet Ether) for a single vote, measuring the system's economic viability.
- **Immutability:** Verifies that votes cannot be changed or deleted after being recorded.
- **Verifiability:** Ensures that anyone can independently audit the final vote count using the public blockchain data.

V. RESULT

5.1 Security and Integrity

The system's integrity was its most robust feature. By utilizing the blockchain's immutable ledger, we successfully demonstrated that once a vote was recorded, it could not be altered or deleted. Our tests confirmed that the smart contract effectively prevented double-voting and unauthorized ballot submissions. This immutability and tamper-proof nature make the system highly resistant to a wide range of fraudulent activities, significantly enhancing public trust and transparency.

5.2 Performance Analysis

The system's performance, however, presented significant challenges. Our experiments on an Ethereum test network showed:

- **Low Throughput:** The system could only process a limited number of votes per second, a rate that is unsuitable for a large-scale election with millions of voters.
- **High Transaction Costs:** Each vote transaction incurred a gas fee, which, if translated to the mainnet, would be economically prohibitive for a national election.

These findings highlight that while the security model is sound, the base Ethereum network lacks the scalability required for mass public use. Future work must focus on Layer-2 solutions to address these performance limitations.

5.3 Usability and Transparency

The system achieved high marks for transparency, as the public ledger allowed for end-to-end verifiability of the election results by any interested party. However, user feedback indicated a significant usability barrier, particularly for those unfamiliar with blockchain wallets or cryptocurrencies. Our results suggest that while the technology can deliver a trustworthy election, the user interface needs to be streamlined and simplified to achieve mass adoption.

VI. DISCUSSION

Using the Ethereum blockchain for a decentralized voting system is a very active area of research because it directly addresses the biggest problems with traditional and electronic voting: fraud, lack of transparency, and centralization. The core idea is that by recording votes on a distributed, immutable ledger, we can create a system that is fundamentally more trustworthy.

Advantages of Blockchain-Based Voting

- **Transparency and Auditability**: Every vote is a public record on the blockchain. This means anyone can verify that their vote was counted and that the final tally is correct. This "end-to- end verifiability" dramatically increases public confidence in election results.
- **Security and Immutability**: The votes are stored in a distributed network of computers, making it extremely difficult for a single person or group to hack or tamper with the data. Once a vote is on the blockchain, it cannot be changed or deleted. This makes the system far more secure than a centralized database.
- **Decentralization**: There's no single entity, like a government agency, that controls the entire process.[6] The rules of the election are automated by a smart contract, which is code that lives on the blockchain, so there's no need to trust a third party to handle the election fairly.
- **Accessibility**: A blockchain-based system could allow people to vote from anywhere with an internet connection, potentially increasing voter turnout and making voting easier for those with disabilities or who live far from a polling station.

The Big Challenges

Despite the clear benefits, there are major hurdles to overcome before this technology can be used for large-scale, national elections.

- **Scalability**: The main Ethereum network is simply not fast enough to handle the millions of votes a national election would require. Transactions are slow and expensive, making the system impractical. Researchers are actively working on Layer-2 scaling solutions like rollups to process votes off-chain to reduce cost and increase speed, but these are still a work in progress.
- **Privacy**: While transparency is a strength, it's also a weakness. A public ledger could potentially link a

voter's identity to their vote, compromising anonymity. Solutions like Zero-Knowledge Proofs (ZKPs) are being explored to allow voters to prove their eligibility without revealing their identity, but these are complex and computationally intensive.[9]

- **Usability**: The technology is not user-friendly for the average person. It requires technical knowledge, such as using a crypto wallet, managing a private key, and understanding transaction fees. For mass adoption, the user experience would need to be as simple as casting a ballot in a traditional way.
- **Legal and Governance Issues**: Implementing a blockchain-based voting system would require a

complete overhaul of election laws and regulations. Governments would need to trust this new, unproven technology and establish a legal framework to govern it, which is a major social and political challenge.

VII. CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

Decentralized Voting with Ethereum Blockchain offers a robust and transparent solution for secure elections. By leveraging blockchain technology, it ensures the integrity of votes and provides a tamper-proof platform. With continued enhancements, including improved user experience, scalability, and integration with other cutting-edge technologies, it has the potential to revolutionize the democratic process and empower citizens to participate in a trusted and efficient voting system. It represents a significant step towards building a more democratic and accountable society.

7.2 FUTURE WORK

In future iterations, the decentralized voting system can be enhanced by implementing additional features such as real-time vote counting, secure voter identification mechanisms, advanced data analytics for voter insights, and integration with emerging technologies like artificial intelligence and biometrics. These enhancements will further enhance the efficiency, security, and accessibility of the voting process, making it more inclusive and trustworthy.

VIII. REFERENCES

Journal Articles and Conference Papers

1. Pethad, M., Jain, N., & Dhanare, R. (2025) Decentralizing Democracy: Evaluating Blockchain Solutions for E-Voting AIP Conference Proceedings

2. Burmi, S., Barik, S. R., & Deepanshi (2024) Decentralized E-Voting System Using Blockchain IOSR Journal of Mobile Computing & Application

3. Shevtekar, S. & Sathe, M. (2023) Decentralized E-Voting Systems Based on Blockchain Technology and Its Framework IJCRT

4. Mohan, K., Rasika, M., Dhamotharan, K.A., & Pranesh, S. (2023) Blockchain-Based Online Voting System International Journal of Advance Research and Innovative Ideas in Education

5. Shiwal, P., Morey, D., Shivankar, H., Jagtap, S., & Adagale, S.S. (2022) Decentralized E-Voting System Using Blockchain IJRASET – Volume 10, Issue XII

6. Adiputra, C.K., et al. (2021) Blockchain-Based Voting System for Secure Elections IEEE Access – DOI: 10.1109/ACCESS.2021.3053211

7. Ahmad, H. K., Arshad, J., & Khan, M. M. (2021). A
Secure Digital Voting System Based on Blockchain Technology. This paper provides a comprehensive overview of blockchain-based voting systems and their security benefits. It discusses how immutability and cryptographic security can address vote tampering and data integrity issues.

8. K. Mehboob Khan, Junaid Arshad, & Muhammad Mubashir Khan (2021). Secure Digital Voting System Based on B-Chain Technology. This study presents a system that is designed to use a blockchain for secure and transparent voting. The authors detail how natural language processing (NLP) and machine learning can enhance the system, particularly for the parsing of candidate information.

9. Going from bad to worse: from Internet voting to blockchain voting (2021) by Sunoo Park et al. This article from the *Journal of Cybersecurity* provides a critical perspective on the security claims of blockchain voting, arguing that it may introduce new, significant risks. It is an important counterpoint to the more optimistic research.

10. Jafar, U., Aziz, M. J. A., & Shukur, Z. (2021). Blockchain for Electronic Voting System—Review and Open Research Challenges. This review article systematically analyzes the current research on blockchain-based voting systems, identifying key benefits and highlighting open research challenges, such as scalability, privacy, and cost, that need to be addressed for future adoption.

11. Srivastava, P., A. P. Pande, and M. P. Singh (2020). A Survey of Blockchain Technology in E-voting Systems. This paper offers a literature review of existing blockchain voting systems, discussing their architectures, strengths, and weaknesses. It's an excellent resource for understanding the state of the art in the field.

12. Choi, H., Kim, H., & Lee, S. (2019). Towards a Practical Blockchain-Based Voting System for a Large-Scale Election. This article directly addresses the scalability challenges of blockchain voting. The authors propose a system that uses sharding and other techniques to improve transaction throughput and reduce costs, a crucial step toward practical, large-scale deployment.

13. Albin, B., Ashok Kumar, A., Basit, A., Cherian, B., & Kharat, A. (2019). A Blockchain Based E-Voting System. This work focuses on the development of a proof-of-concept e-voting system using blockchain technology. The authors detail the system's design and its ability to prevent common voting fraud techniques.

14. "Decentralized E-Voting System Based on Blockchain" *Authors:* Muhammad Rizwan, Muhammad Aamir *Presented at:* 2018 International Conference on Cloud Computing and Blockchain (ICCCB)

15. Dziembowski, S., Faust, S., & Katz, J. (2018). Practical Zero-Knowledge Proofs for Verifiable Computation. While not solely on voting, this paper is foundational for understanding how zero-knowledge proofs can be used to ensure voter privacy in a public blockchain system. It's a key reference for anyone discussing how to make blockchain voting both transparent and anonymous.