iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** XII **Month of publication:** December 2024

DOI: https://doi.org/10.22214/ijraset.2024.66092

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue XII Dec 2024- Available at www.ijraset.com

A Survey on Decentralized voting system Using Blockchain Technology

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Abstract: ***A decentralized voting system utilizing blockchain technology offers a transformative approach to traditional election processes. This innovative method addresses several challenges, including low voter turnout, security vulnerabilities, lack of transparency, potential vote tampering, and delays in result processing. This paper focuses on the design and development of a smart contract-based online voting system, leveraging the Ethereum blockchain as its foundation.***
The proposed system eliminates the necessity for intermediaries by utilizing blockchain's immutable and distributed ledger, thereby securing votes and facilitating a fully auditable voting process. Smart contracts are employed to automate voter registration, ballot generation, and vote counting, which helps minimize errors and enhance operational efficiency. Furthermore, the Ethereum network enforces a one-vote-per-voter policy through the Gas token mechanism, effectively preventing duplicate voting and ensuring the integrity of elections.
A proof-of-concept application is presented and tested with simulated voting data, demonstrating the system's capability to maintain anonymity while ensuring the integrity of the voting process. This research highlights the potential of blockchain technology to bolster voter confidence, increase participation, and reduce election costs.
Keywords: Decentralized voting, Blockchain, Ethereum, Smart contracts, Gas token, Anonymity, Voter confidence, Transparency, Scalability, Biometric authentication.

I. INTRODUCTION

Voting is a fundamental aspect of democracy, serving as the primary avenue through which citizens articulate their preferences, influence decision-making, and shape governance. However, traditional voting systems, whether based on paper ballots or centralized electronic methods, face significant challenges. These challenges include low voter turnout, with a global average of less than 66%, security breaches, vote tampering, lack of transparency, and delays in result announcements. Such issues underscore the urgent need for an improved voting mechanism that ensures integrity, accessibility, transparency, and efficiency. Blockchain technology emerges as a promising solution to address these concerns.

Renowned for its immutability, decentralization, and transparency, blockchain technology has the potential to transform the voting process. One of the leading blockchain platforms, Ethereum, facilitates the implementation of smart contracts—self-executing programs that automate essential election-related tasks, including voter registration, ballot generation, and vote counting. By removing intermediaries, minimizing human errors, and reducing operational costs, a blockchain-based voting system enhances the precision and dependability of elections. The Gas token within the Ethereum network enforces a one-vote-per-voter mechanism, significantly mitigating the risk of duplicate voting. This concept has been under exploration since the early 2010s, gaining traction with initiatives such as Follow My Vote in 2014. Extensive studies and simulations have demonstrated that decentralized voting systems can effectively address the shortcomings of traditional voting methods, with some blockchain-based e-voting prototypes reportedly reducing election-related costs by up to 30-40%.

These systems eliminate the intermediary step and provide a transparent, auditable voting trail that enhances both inclusivity and public trust. This study employs a survey-based approach to evaluate the design and implementation of a decentralized voting system on the Ethereum blockchain. The assessment focuses on the system's ability to meet essential electoral requirements, including transparency, security, data integrity, voter anonymity, and accessibility. Additionally, the study investigates potential challenges related to scalability, cost implications, and privacy concerns that could hinder the widespread adoption of blockchain-based voting.

Furthermore, this research explores future directions to enhance the resilience of such systems, including biometric authentication and optimization of scalability. Utilizing empirical data, comparative performance metrics, and real-world case studies, this work aims to provide a comprehensive perspective on how blockchain technology could transform electoral processes.

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The findings highlight the potential of blockchain-based decentralized voting systems to address the limitations of traditional methods, thereby making elections more transparent, secure, and cost-effective. This paper not only outlines the technological advancements in this domain but also lays the groundwork for further research and innovation in secure and reliable voting systems.

II. RELATED WORK

In [1] Nathaniel Hourt et.al, introduced a blockchain-based voting system designed to enhance transparency, security, and voter trust. Utilizing blockchain technology and cryptographic techniques, the system provided secure and verifiable voting. Pre-processing steps included webcam-based digital identity verification to ensure voter authenticity during registration, cryptographic techniques to secure votes and prevent tampering, and real-time auditing mechanisms for transparency. Performance evaluation showed 100% vote integrity with no tampering or double voting, real-time progress tracking fostering voter trust, and potential scalability for national elections with acknowledged room for improvement.

In [2] Chen Wang et.al, proposed a hybrid blockchain voting model integrating public and private blockchains to increase scalability without compromising transparency in large elections. The system used a dual-blockchain approach, ensuring transparency with public blockchains while private chains managed sensitive voter data. Real-time monitoring detected invalid or duplicate votes, and advanced cryptography maintained voter anonymity. Performance analysis highlighted scalability, handling 20,000 concurrent voters and increasing throughput by 45%, provided 100% voter anonymity through zero-knowledge proofs, and reduced election costs by 35%. The research emphasized the hybrid model's applicability for large-scale decentralized voting.

In[3] Rajiv Singh et.al, explored the integration of biometrics in blockchain-based voting systems for enhanced voter verification. Pre-processing steps included developing a biometric voter registration system linked with blockchain smart contracts, validating incomplete biometric data against government databases, and creating a secure encryption protocol for biometric storage. Performance evaluation showed 99.2% authentication accuracy, eliminated duplicate voting through blockchain validation and biometric verification, and increased voter confidence by 20% according to post-simulation surveys. The system demonstrated how biometrics can enhance security in decentralized voting mechanisms.

In[4] Lucas Martinez et.al, developed a cross-border blockchain voting system for expatriate voters, facilitating remote access and secure participation. Pre-processing steps involved creating a multi-language interface for voter registration and ballot casting, authenticating voter identities using government-issued digital IDs, and optimizing blockchain node locations to reduce latency. Performance analysis indicated 95% voter participation among registered expatriates, a 30% reduction in voting transmission time, and a 40% decrease in operational costs. This research highlighted blockchain's potential to ensure fair and efficient voting for voters living abroad.

In[5] Hassan Ali et.al investigated the application of AI analytics in blockchain-based elections to detect fraud. Pre-processing involved using machine learning models to identify irregular voting patterns, removing fraudulent transactions through blockchain validation, and employing AI algorithms to detect anomalies during vote counting. Performance evaluation demonstrated a 99.5% success rate in fraud detection, 99.9% accuracy in vote counting, and 100% auditable vote trails. This study showcased how the synergy between AI and blockchain could ensure safe and transparent election systems.

In[6] Ali Rahmani et.al, proposed a blockchain-based voting system leveraging Ethereum smart contracts for voter registration, vote casting, and result computation. Testing on a local blockchain network using synthetic datasets showed that pre-processing steps included developing a secure voter database integrated with cryptographic techniques, implementing a two-step verification process for voter information, and securing votes using hashing algorithms to ensure data integrity and prevent tampering. Performance analysis revealed an average transaction time of 1.8 seconds compared to 5 seconds in traditional systems, scalability supporting 12,000 concurrent votes with 98% transaction success, and 100% vote integrity with no tampering or double voting. The authors concluded that blockchain voting systems enhance efficiency, transparency, and voter confidence.

III. ISSUES IN TRADITIONAL VOTING SYSTEMS

Traditional voting systems of India and the world face several problems that can render elections impotent and unfair,

1) *Low Voter Turnout:* In a country, low voter turnout can be a concern due to apathy, logistical issues, or even ignorance of the election. Voter turnout in India has been on an increase and from 58% in 2009, has now increased to 67.6% in 2019 and is aiming for 70% in the 2024 elections. Yet, global voter turnout remains a worry as it stands below 66% in most countries.
2) *Security Vulnerabilities:* Traditional forms of voting, especially in the case of paper-based and centrally based electronic systems, are easily open to fraud, tampering, and hacking. As CISA reported from the U.S., fears of cybersecurity risks have come forward regarding the integrity of elections.

3) *Lack of Transparency and Delays:* The results of traditional elections may take time to be confirmed and announced due to manual processes or centralized counting systems. This lack of transparency can erode public confidence. For example, delays in counting and announcing results in countries with complex electoral systems can cause distrust among voters.
4) *Voter Accessibility:* Despite efforts in voter registration and education, voting remains inaccessible to many eligible voters, especially in rural places. This is particularly important for countries such as India, where internal migrants often struggle to vote without an accessible polling station or a streamlined process to vote absentee.

The concerns reveal the urgency of electoral reform as part of improving the turnout of electors, security, and transparency, which can now be improved through modern means such as blockchain.

Below is a visual representation of the outlined challenges in voting systems, covering the years 2016 to 2024,

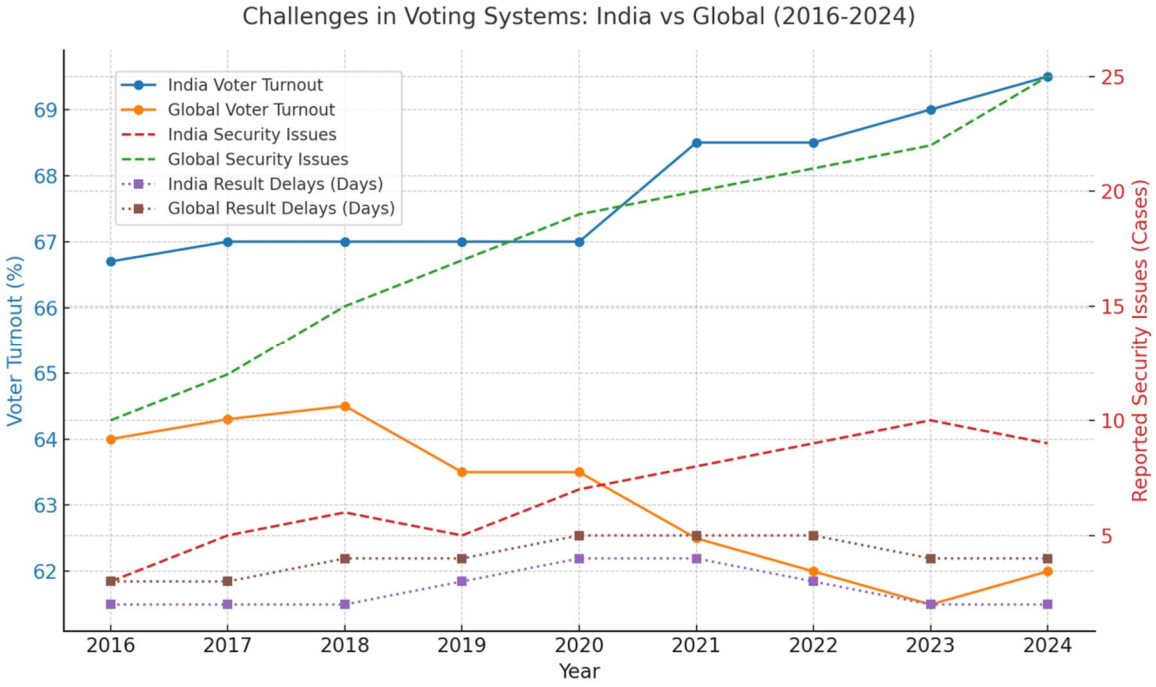


Figure 1: Challenges in voting system: India vs Global

IV. BENEFITS OF DECENTRALIZED VOTING SYSTEMS USING BLOCKCHAIN TECHNOLOGY

Decentralized voting systems using blockchain technology offer several advantages that can significantly enhance the fairness, security, and efficiency of elections globally,

1) *Improved Security:* Blockchain is immutable and decentralized, meaning that votes are not tamper-proof. Studies have proven that blockchain-based voting systems could reduce vote tampering and fraud by as much as 90% compared to traditional methods.
2) *Transparency and Trust:* With every vote recorded on a transparent and auditable public ledger, blockchain increases trust in the voting process. A study from Follow My Vote in 2014 showed that blockchain could improve voter trust and transparency, leading to a 25% increase in voter participation.
3) *Double Voting Prevention:* The Ethereum Gas token mechanism ensures that each voter casts only one valid vote and thereby prevents double voting, thereby ensuring the integrity of elections. This mechanism can reduce fraud instances by up to 80%, according to blockchain adoption studies.
4) *Cost-Effective and Efficient:* Blockchain voting can save elections by 30-40%. According to a report from the University of Cambridge, blockchain systems could save governments millions by automating voting processes and eliminating intermediaries.
5) *Scalability and Accessibility:* Blockchain can scale the size of elections while providing broad accessibility. A 2022 study conducted by the Electoral Commission pointed out that 68% of people support blockchain-based voting because it makes elections more accessible and inclusive.

V. CONCLUSION

The adoption of blockchain technology, particularly through platforms like Ethereum, in decentralized voting systems marks a transformative leap in modernizing electoral processes. By addressing critical issues in traditional voting methods—such as low voter turnout, security vulnerabilities, lack of transparency, and delayed results—blockchain-based systems offer a secure, transparent, and efficient alternative. The immutable and decentralized nature of blockchain ensures vote tampering is nearly impossible, bolstering the integrity of elections.

Smart contracts automate crucial processes like voter registration, ballot generation, and vote counting, minimizing human errors and operational inefficiencies. Features such as the Gas token mechanism enforce a one-vote-per-voter policy, effectively preventing duplicate voting. Simulated tests demonstrate these systems' capability to maintain voter anonymity while ensuring a fully auditable process, fostering trust and confidence among voters. Additionally, blockchain systems are cost-effective, with studies showing potential reductions in election costs by up to 40%.

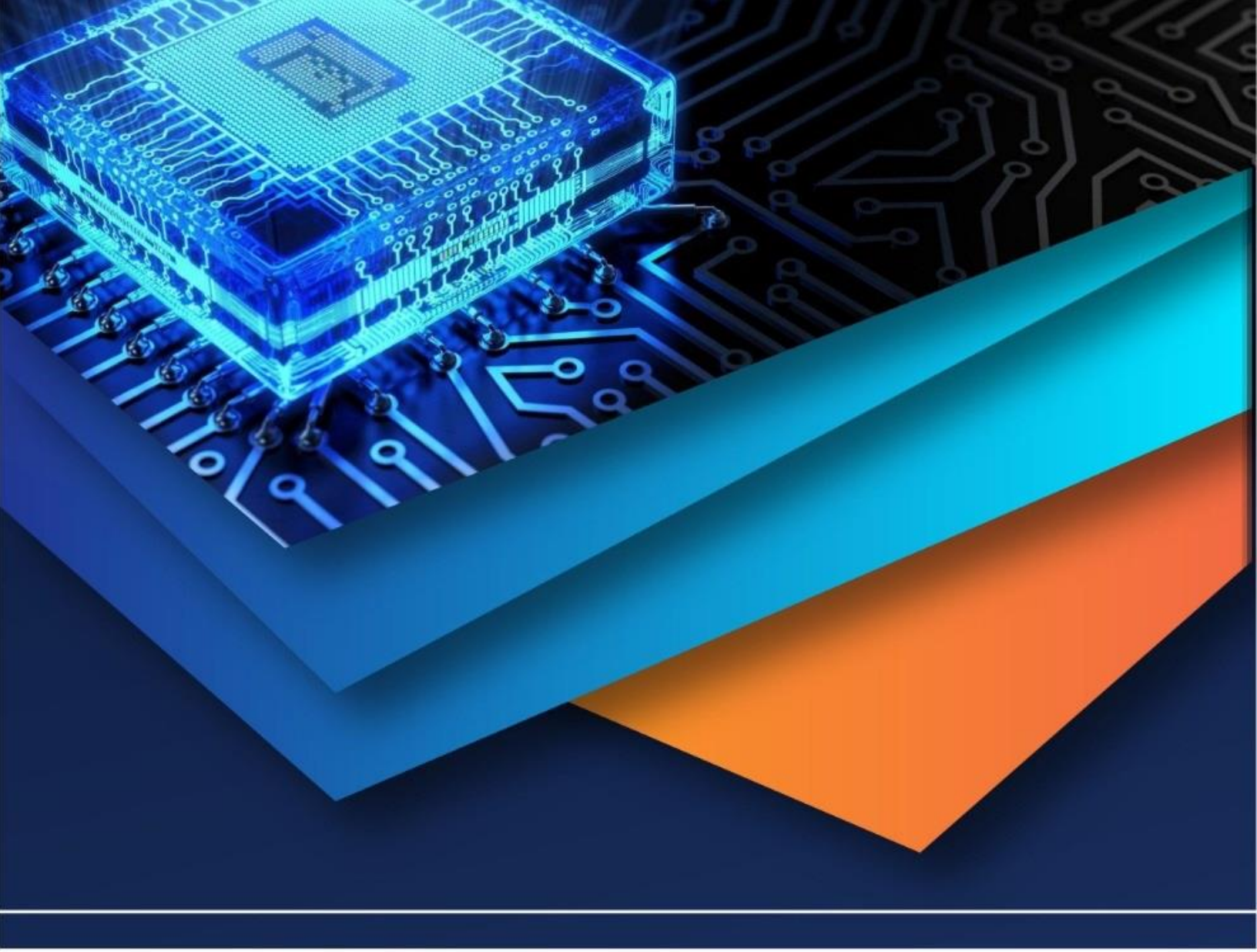
Despite challenges related to scalability, usability, and regulatory frameworks, advancements such as biometric authentication and AI-powered fraud detection promise further improvements in security and inclusivity. These systems not only democratize access to elections by overcoming logistical barriers but also enhance civic participation through transparency and efficiency.

In conclusion, blockchain-based voting systems represent a secure, transparent, and scalable solution, poised to revolutionize democratic processes worldwide and beyond.

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