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A Comprehensive Review of Blockchain-Based Electronic Voting Systems

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Abstract: ***Traditional voting systems have many problems such as vote manipulation, fake voting, lack of transparency, slow result processing, and low public trust. Most of these systems are controlled by a central authority, which increases the chances of tampering and makes verification difficult. To solve these issues, blockchain technology is considered a strong and reliable solution. This paper presents a review of blockchain-based electronic voting systems and explains how blockchain can improve the security, transparency, and trust in voting. In blockchain, votes are stored in a decentralized and secure way, and once recorded, they cannot be changed or deleted. This study reviews different existing approaches and compares their advantages and limitations. It also highlights important benefits such as better security, prevention of duplicate voting, faster results, and increased voter confidence. In addition, some challenges and future improvements are discussed. Overall, blockchain-based e-voting systems can provide a more secure, transparent, and efficient alternative to traditional voting methods.***
Keywords: Blockchain, Electronic Voting, Security, Transparency, Decentralization

I. INTRODUCTION

Voting is an important part of a democratic system. It allows people to choose their leaders and share their opinions. For any election to be successful, the voting process must be fair and transparent so that people can trust the results. However, traditional voting systems have many problems such as vote manipulation, fake or duplicate voting, lack of transparency, and slow result declaration [1]. Because of these issues, people may lose trust in the election process.

Most traditional voting systems are controlled by a central authority. This increases the risk of errors and tampering. Also, voters usually cannot check whether their votes are counted correctly. Therefore, there is a need for a more secure, transparent, and reliable voting system. Blockchain technology is now seen as a strong solution to these problems [1], [2]. It is a decentralized system where data is stored securely and cannot be changed once it is recorded [2]. This helps in building trust, as no single authority controls the system. In voting systems, blockchain can be used to store votes safely, prevent duplicate voting, and provide faster and more accurate results [3], [4]. It also makes the process more transparent, which increases voter confidence. This paper presents a review of blockchain-based electronic voting systems. It studies different existing methods, compares their advantages and limitations, and discusses possible future improvements.

II. BACKGROUND / OVERVIEW OF BLOCKCHAIN

Blockchain is a way to store data safely on the internet. Once the data is added, it cannot be changed or deleted. This makes the system secure and trustworthy. Also, blockchain does not depend on one person or one authority. Instead, many computers store the same data, which makes it more transparent [2].

To understand this easily, let us take a simple example. In a normal system, one person creates a document and sends it to others. Each person edits the document and sends it again. Because of this, many versions of the same document are created. This creates confusion, and it becomes difficult to know which version is correct.

To solve this problem, some systems allow people to work on the same document at the same time. This reduces multiple versions. However, in these systems, users can still change or delete the existing data. This may cause problems if someone changes important information. Blockchain solves this issue in a better way. In blockchain, users can only add new data. They cannot change or delete old data. All changes are saved permanently, and everyone can see the full history. Because of this, the data is secure, transparent, and trusted [2]. In blockchain, data is stored in the form of blocks, and each block is connected to the previous one. This connection makes the system secure, as changing one block will affect all the other blocks. Because of this, it is very difficult to tamper with the data [2].

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Another important feature of blockchain is transparency. All users in the network can view the transaction history, which increases trust among participants. At the same time, security is maintained using cryptographic techniques [2].

Due to these features, blockchain is considered a strong solution for systems where data security and trust are important, such as voting systems [1]. The following figure explains this concept using a simple example.

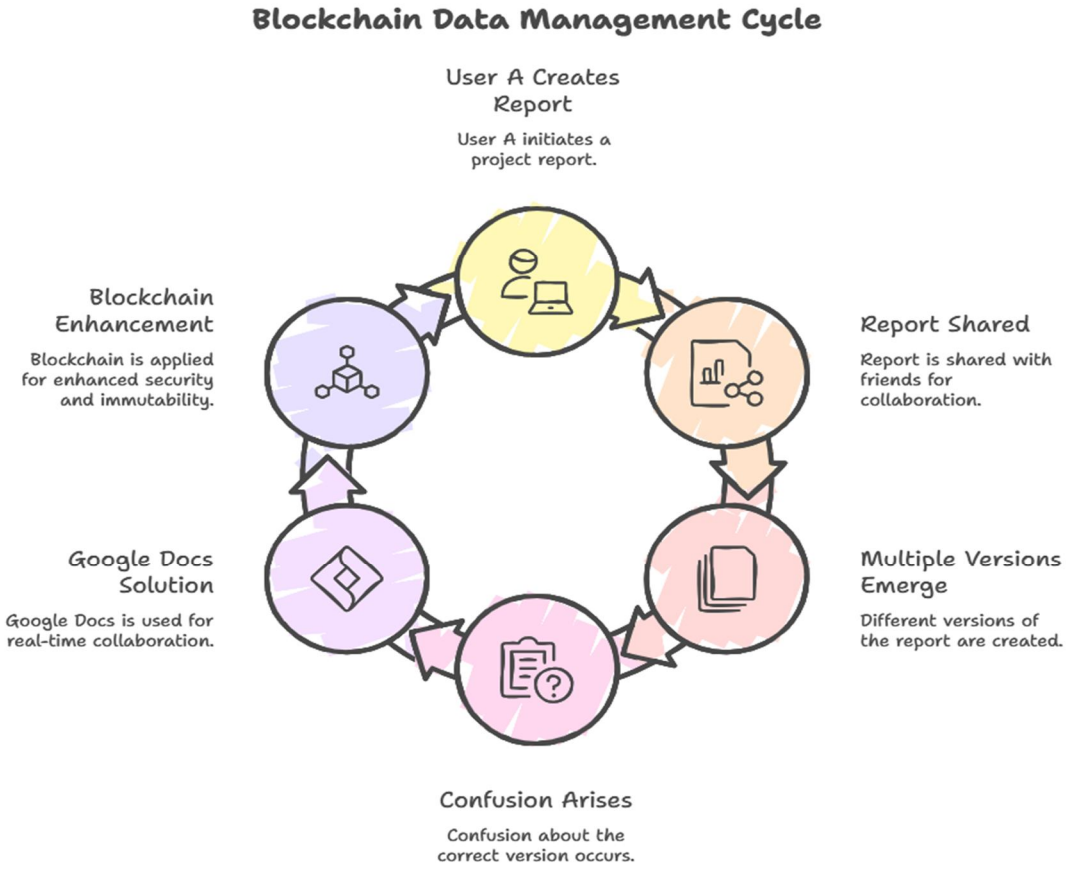


Fig. 1. Simple example showing problems in traditional systems and how blockchain solves them

The figure shows how a document is created and shared with multiple users. When different users edit the document, many versions are created, which leads to confusion and difficulty in identifying the correct version.

It also shows that shared systems reduce this problem by allowing users to work on the same document. However, these systems still allow users to modify or delete existing data, which can affect data reliability.

Blockchain solves this issue by allowing only new data to be added, while keeping previous data unchanged. This ensures that all records are permanent, secure, and transparent. As a result, blockchain provides a more reliable and trustworthy solution compared to traditional systems.

1) Blockchain in Voting — Blockchain technology improves the voting process by making it secure and transparent. In this system, each vote is recorded in the blockchain and cannot be changed or deleted, which prevents manipulation and ensures accurate counting [3], [4]. It also reduces the need for a central authority, increasing trust. Additionally, voters can verify their votes without revealing their identity, ensuring both transparency and privacy.

2) Problems in Traditional Voting Systems — Traditional voting systems have several limitations. These include vote manipulation, fake voting, lack of transparency, and delays in result declaration [1]. In some cases, manual counting may lead to errors. Also, voters cannot easily verify whether their votes are counted correctly. These issues reduce trust in the election process and highlight the need for better solutions like blockchain-based voting.

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3) Importance of Secure Voting Systems — A secure voting system is very important in a democratic country. It ensures that elections are fair and free from fraud. Any error or manipulation in voting can reduce public trust. Therefore, using advanced technologies like blockchain can help in improving the reliability and transparency of elections [1].

4) Role of Blockchain in Improving Voting — Blockchain plays an important role in improving the voting process. It ensures that votes are stored securely and cannot be changed. It also provides transparency by allowing users to verify transactions. By removing the need for a central authority, blockchain reduces the chances of fraud and increases trust in the system [3].

5) Blockchain vs Traditional Database — A traditional database stores data in a centralized system, which is controlled by a single authority. This makes it easier to update or delete data, but it also increases the risk of tampering and unauthorized changes [1].

In contrast, blockchain is a decentralized system where data is stored across multiple nodes. Once the data is recorded, it cannot be changed or deleted. This ensures higher security and transparency.

In voting systems, traditional databases may be vulnerable to manipulation, while blockchain provides a secure and tamper-proof environment. Therefore, blockchain is considered a better option for modern electronic voting systems.

In voting systems, data security and transparency are very important. The following table shows the comparison between traditional databases and blockchain, and explains why blockchain is more suitable for voting applications.

TABLE I
COMPARISON BETWEEN TRADITIONAL DATABASE AND BLOCKCHAIN

Feature	Traditional Database	Blockchain
Control	Centralized	Decentralized
Data Modification	Allowed	Not allowed
Transparency	Limited	High
Security	Moderate	High

The above table shows that traditional databases are controlled by a central authority, which increases the risk of data manipulation. In contrast, blockchain is decentralized and does not depend on a single authority.

In voting systems, this is important because it reduces the chances of fraud and tampering. Blockchain also does not allow modification of data once it is recorded, which ensures that votes remain unchanged.

Additionally, blockchain provides higher transparency and security compared to traditional databases. Therefore, blockchain is more suitable for building secure and reliable electronic voting systems.

III. LITERATURE REVIEW

Several researchers have proposed blockchain-based electronic voting systems to improve the security, transparency, and reliability of elections. Some important research works are discussed below.

1) Paper 1: Blockchain-Based E-Voting System Using Ethereum

Authors: Smith et al. (2020)

This paper presents a blockchain-based voting system using the Ethereum platform. Smart contracts are used to store and manage votes securely. The system ensures that once a vote is recorded, it cannot be changed or deleted.

Advantage: High security and transparency.

Limitation: High transaction cost and scalability issues.

2) Paper 2: Secure Online Voting System Using Blockchain Technology
Authors: Kumar and Patel (2021)
This paper proposes an online voting system that uses blockchain to ensure secure vote storage and voter authentication. The system improves data integrity and reduces the chances of fraud.
Advantage: Secure authentication and reliable data storage.
Limitation: Requires strong internet connection and technical knowledge.

3) Paper 3: Decentralized Blockchain-Based Voting System
Authors: Sharma et al. (2022)
This paper introduces a decentralized voting system where no central authority is required. The system increases transparency and reduces the chances of manipulation.
Advantage: No central control and improved trust.
Limitation: Privacy issues and difficulty in large-scale implementation.

4) Paper 4: Blockchain-Based Secure Voting Using Cryptography
Authors: Lee and Kim (2021)
This study focuses on using cryptographic techniques along with blockchain to ensure secure vote transmission and storage. The system protects voter data and prevents unauthorized access.
Advantage: Strong security and data protection.
Limitation: Increased system complexity and computational cost.

5) Paper 5: Efficient Blockchain-Based Voting System for Fast Results
Authors: Reddy et al. (2023)
This paper proposes a voting system that focuses on fast result generation and user-friendly design. It improves efficiency and makes the system easier to use.
Advantage: Faster results and better user experience.
Limitation: Scalability and adoption challenges.

6) Paper 6: Blockchain-Based E-Voting Systems: A Technology Review
Authors: Berenjestanaki et al. (2024)
This paper provides a detailed review of blockchain-based voting systems. It discusses benefits such as security, transparency, and decentralization. It also highlights challenges like privacy, scalability, and technical complexity.
Advantage: Comprehensive analysis of existing systems.
Limitation: More focus on theory than practical implementation.

7) Paper 7: Blockchain-Based Secure and Transparent Voting System
Authors: K. Zhang et al. (2023)
This paper proposes a secure and transparent voting system using blockchain technology. The system records each vote as a transaction, ensuring that it cannot be modified once stored. It improves transparency and allows voters to verify their votes.
Advantage: High transparency and secure vote storage.
Limitation: Requires high computational resources and may face scalability issues.

8) Paper 8: A Privacy-Preserving Blockchain-Based E-Voting System
Authors: Y. Liu et al. (2022)
This paper focuses on improving voter privacy in blockchain-based voting systems. It uses cryptographic techniques to protect voter identity while maintaining transparency. The system ensures secure and anonymous voting.
Advantage: Strong privacy protection and secure voting process.
Limitation: Increased system complexity and higher implementation cost.

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IV. COMPARATIVE ANALYSIS

The following table compares different blockchain-based e-voting systems based on their methods, advantages, and limitations.

TABLE II
COMPARATIVE ANALYSIS OF BLOCKCHAIN-BASED E-VOTING SYSTEMS

Paper	Method Used	Advantages	Limitations
Smith et al. (2020)	Ethereum + Smart Contracts	High security, transparency	High cost, scalability issue
Kumar & Patel (2021)	Blockchain + Authentication	Secure voting, data integrity	Requires internet, technical complexity
Sharma et al. (2022)	Decentralized blockchain system	No central authority, trust	Privacy issues, scalability problem
Lee & Kim (2021)	Blockchain + Cryptography	Strong security, data protection	High complexity, computational cost
Reddy et al. (2023)	Efficient blockchain model	Fast results, user-friendly	Adoption and scalability challenges
Berenjestanaki et al. (2024)	Systematic review approach	Covers benefits & challenges	More theoretical, less practical
Zhang et al. (2023)	Blockchain-based secure voting	High transparency, secure storage	High computational cost, scalability issues
Liu et al. (2022)	Privacy-preserving blockchain voting	Strong privacy, secure process	High complexity, implementation cost

The above comparison shows that blockchain-based voting systems provide strong security and transparency. However, most systems face common challenges such as scalability, high cost, and technical complexity. It is also observed that no single system is perfect, and further improvements are required to make these systems suitable for real-world implementation.

V. WORKING OF BLOCKCHAIN-BASED E-VOTING SYSTEM

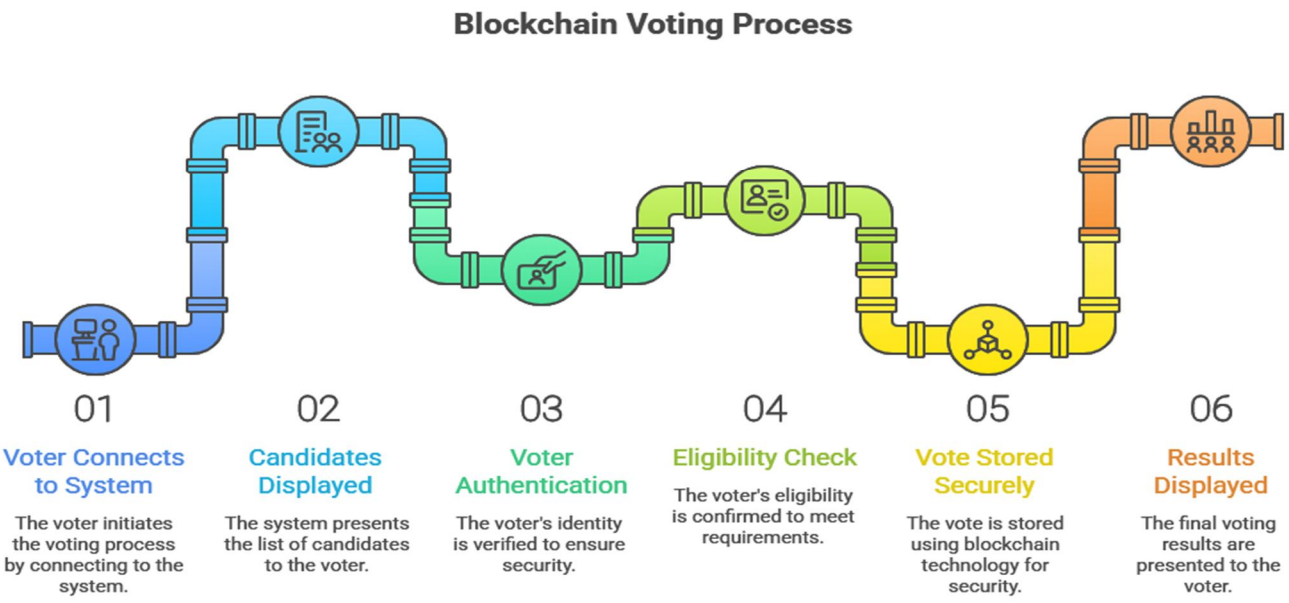


Fig. 2. Flowchart of Blockchain-Based E-Voting System

The above figure shows the working process of a blockchain-based voting system. First, the voter connects to the system and views the list of candidates. The voter is then authenticated to ensure security. After successful authentication, the system checks the voter's eligibility. Once verified, the vote is cast and stored securely in the blockchain. Finally, the system counts the votes and displays the results in a transparent and reliable manner.

VI. ADVANTAGES OF BLOCKCHAIN-BASED E-VOTING

Blockchain technology provides several advantages when used in electronic voting systems. Some of the key benefits are discussed below.

1) Security: Blockchain ensures that all votes are stored securely. Once a vote is recorded, it cannot be changed or deleted, which prevents tampering and fraud.
2) Transparency: All transactions are visible on the blockchain, which allows verification of votes and increases trust in the system.
3) Decentralization: There is no single authority controlling the system. This reduces the risk of manipulation and makes the system more reliable.
4) Prevention of Duplicate Voting: Blockchain ensures that each voter can vote only once, which eliminates duplicate or fake voting.
5) Faster Result Generation: Votes can be counted automatically, which reduces the time required to declare results.
6) Increased Trust: Because of its transparency and security, blockchain increases voter confidence in the election process.

VII. CHALLENGES / LIMITATIONS

Although blockchain-based electronic voting systems offer many advantages, they also face several challenges and limitations. These are discussed below.

1) Scalability Issues: Blockchain networks may become slow when a large number of users participate at the same time. This can affect the performance of the voting system.
2) High Cost: Some blockchain platforms require transaction fees, which can increase the overall cost of the system.
3) Privacy Concerns: Even though blockchain is secure, maintaining voter privacy while keeping transparency is still a challenge.
4) Technical Complexity: Blockchain technology is complex and requires technical knowledge to develop and maintain the system.
5) Internet Dependency: Blockchain-based voting systems require a stable internet connection, which may not be available in all areas.
6) Adoption Challenges: It may be difficult to implement blockchain voting systems in real-world elections due to legal and organizational issues.

VIII. DISCUSSION

Blockchain-based electronic voting systems can improve security, transparency, and reliability of elections. From the review, most systems help prevent vote tampering and ensure correct vote recording. Decentralization also increases trust by reducing dependence on a central authority.

However, these systems still have some challenges such as scalability issues, high cost, and technical complexity. Privacy is also a concern, as it is difficult to maintain both transparency and voter confidentiality.

Although blockchain has strong potential, it is not yet widely used in large-scale elections. More improvements are needed to make it practical and easy to use.

Overall, blockchain can improve voting systems in the future, but further research and development are required.

IX. FUTURE SCOPE

Blockchain-based electronic voting systems have a strong future and can improve the voting process. However, some improvements are needed before they can be used in real-world elections.

In the future, better solutions can be developed to improve voter privacy while maintaining transparency. Researchers can also work on improving scalability so that the system can handle a large number of voters without slowing down.

Another important area is reducing the cost of blockchain systems so that they can be used easily in government elections. Efforts can also be made to simplify the system, making it more user-friendly and accessible to all people.

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In addition, governments and organizations can work on creating proper rules and regulations to support the use of blockchain in voting. With these improvements, blockchain-based voting systems can become a reliable and widely accepted solution in the future.

X. CONCLUSION

Blockchain-based electronic voting systems provide a secure, transparent, and reliable solution for modern elections. This paper reviewed different existing systems and analyzed their advantages and limitations. It is observed that blockchain technology helps in preventing vote tampering, ensures data security, and increases trust in the voting process.

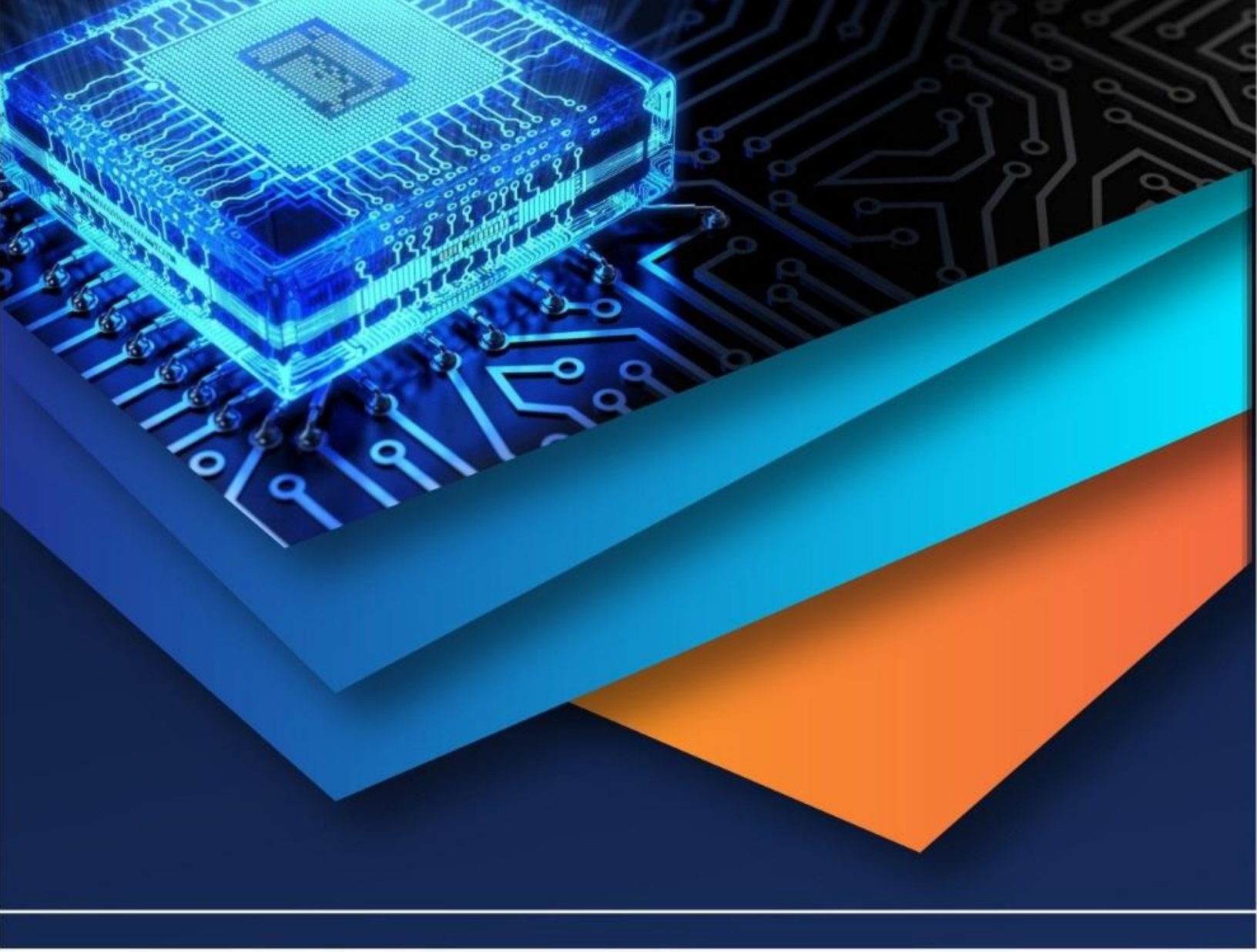
However, some challenges still exist, such as scalability issues, high cost, privacy concerns, and technical complexity. These issues must be addressed before large-scale implementation is possible.

Overall, blockchain-based e-voting systems have strong potential to improve the election process. With further research and development, these systems can become a practical and effective solution for future voting systems.

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