Gov. Chain: A Research paper on reinventing Government Operations with Blockchain Technology and Transparency

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Abstract
Electronic voting systems face numerous challenges related to authentication, data privacy, integrity, transparency, and verifiability. Blockchain technology offers innovative solutions to address many of these issues. However, the scalability of Blockchain has emerged as a significant obstacle, especially in the context of electronic voting. This study aims to highlight scalable Blockchain-based electronic voting system solutions while also addressing associated challenges and anticipating future developments. We conducted a systematic literature review (SLR) and selected 76 English-language articles from well-known databases, spanning from January 1, 2017, to March 31, 2022. This SLR aimed to identify established proposals, their implementations, verification methods, cryptographic solutions explored in prior research, and their associated costs and time considerations. Additionally, it outlined performance parameters, primary advantages, and challenges of different systems, and common approaches for addressing Blockchain scalability. Furthermore, the study outlines various potential research directions for the development of scalable electronic voting systems based on Blockchain technology. By taking into account voting requirements and considering the pros and cons of proposed solutions, this research offers valuable insights and guidelines for future scalable voting solutions.

Keywords: Bitcoin, Blockchain, Cryptography, Electronic Voting, Ethereum, Smart Contract

1. Introduction

1.1 Technology in Electoral Processes

In many nations, technology plays a crucial role in electoral processes, encompassing various aspects such as voter registration, delineating electoral boundaries, staff management and training, ballot printing, voter education initiatives, recording and counting of votes, as well as the compilation and dissemination of election results. When employed correctly, technology can enhance the efficiency of election administration, reduce long-term costs, bolster political accountability. technology used in elections can vary from traditional tools like printing presses and ballpoint pens to more modern solutions like computers, optical scanners, digital mapping, and the Internet. In some cases, a combination of both traditional and modern technologies is employed. In regions lacking access to modern technologies, organizing large-scale elections can be a formidable challenge. However, this could change if blockchain technology becomes the foundation for electronic voting systems.

1.2 Ensuring Electoral Integrity

Ensuring electoral integrity is crucial for fostering public confidence and trust among voters, not only in democracies but across all societies. From a government perspective, electronic voting technologies have the potential to increase voter participation and trust, rekindle interest in the voting process, and enhance security. When determining whether to adopt an electronic voting system, it is imperative to research the factors that offer advantages over traditional paper ballots. It is anticipated that this will enhance the effectiveness and efficiency of democracy while addressing various problematic issues. Additionally, it can improve election accessibility, enable elderly and disabled individuals to vote, boost voter turnout, and provide a user-friendly and swift voting process. However, it is widely acknowledged that robust security measures are essential for running electronic voting systems, especially with the use of modern encryption techniques. Electronic voting was initially proposed as a solution to issues associated with paper ballots, aiming to ensure fair and accessible elections. Security concerns related to electronic voting systems have been extensively studied in the literature. According to research findings, electronic voting may present various challenges, including issues concerning data integrity, dependability, transparency, ballot secrecy, security, fraud implications, failure consequences, voter knowledge, IT skills, equipment storage, and cost.

1.3 Blockchain Technology and Voting Systems

In the context of information systems, electronic voting is becoming an increasingly important and widespread topic. The unique features of Blockchain, including decentralization and immutability, are vital for ensuring that the voting system adheres to the same principles as traditional elections and voting domains. This line of research has gained prominence due to recent allegations of electoral fraud, such as those raised during the U.S. presidential election. Trust in the voting system is fundamental to the functioning of democracy; even a mere rumor can erode this trust. Traditional paper-based voting methods posed significant health risks during the COVID-19 pandemic, underscoring the need for secure, impartial, and confidential electronic voting solutions. The reliability, speed, and security of electronic voting systems have not yet reached a level that can instill voter trust. Researchers are actively working on methods and procedures to create a more secure and efficient electronic voting system, ensuring anonymity in a fair and risk-free environment. The integration of Blockchain technology into voting systems may pique the interest of researchers seeking effective solutions. Protocols can be implemented in voting systems to ensure private, public, and impartial voting, potentially boosting trust in voting systems and democracy as a whole.

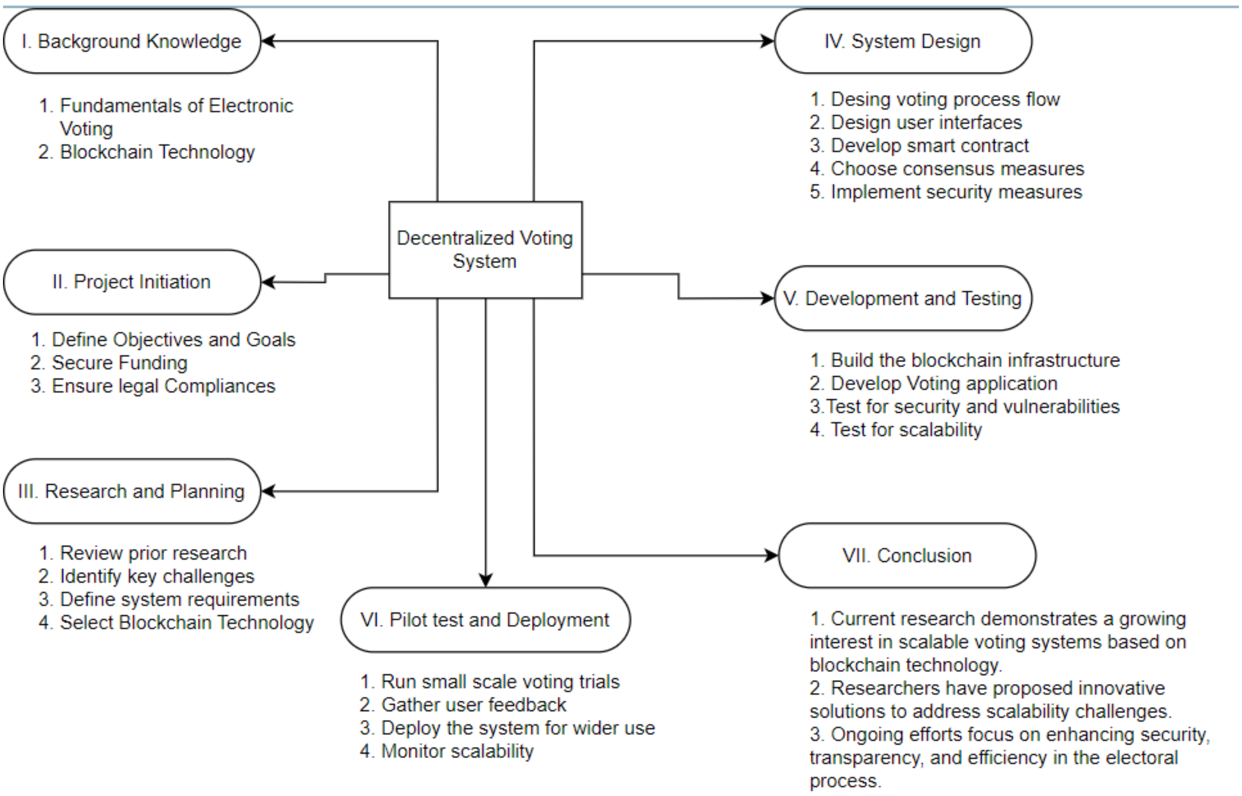

Figure 1. Road map of Blockchain-based electronic voting.

2. Background Knowledge

This section is divided into two segments, discussing the theoretical foundations of both Blockchain technology and electronic voting. Separate subsections are dedicated to exploring these characteristics in greater detail.

2.1 Electronic Voting

Electronic voting refers to the use of electronic technology in the process of voting during political elections or referendums, as defined by the European Council. This method incorporates specialized electronic voting machines, including:

1. Optical scanning devices.
2. Electronically printed ballots.
3. Centralized and decentralized software or applications for Internet-based voting.

Electronic voting machines employ various input devices, such as keyboards and touch screens, to register voters. These devices enable rapid vote counting and the collection of voter data while improving ballot presentation, ultimately reducing the incidence of spoiled votes [20,21].

Electronic ballot printers produce legible paper receipts or voting tokens that can be deposited in vote boxes and subsequently counted by machines. This approach provides transparency and verifiability due to the physical evidence it generates [23]. However, it is worth noting that this method can be costly, with its primary advantage being the prevention of ballot spoilage.

Furthermore, the adoption of new, more accessible, and user-friendly technologies has the potential to reduce voting-related costs and enhance participation in democratic processes. However, electronic voting methods are not without their challenges. The most common issues encountered by such systems include:

1. Limited understanding and comprehension of these systems among non-experts.
2. A lack of established standards and norms.
3. Security threats
4. posed by system suppliers, malicious users, and privileged insiders, with the potential for these individuals to compromise and manipulate the system.
5. Increased costs associated with the necessary information and communication technologies (ICT), including infrastructure, maintenance, and power consumption.

In electronic voting systems employing computer equipment and software, ballots are either recorded or counted electronically. "Electronic voting" denotes a voting process facilitated by computer technology and software, encompassing a range of operations, from election planning to the storage of vote records [9,10]. Various types of devices, including laptops, tablets, and smartphones, fall under this system category. electronic voting system typically includes voter registration, identification, voting, and tallying components.

The electronic voting process follows these steps: First, a voter registration list is created (registration). On election day, officials verify the credentials of voters (verification and authentication). Eligible voters proceed to cast their ballots (casting and collation). It is crucial to implement encrypted and verified voting [9], ensuring that votes remain confidential, anonymous, accurate, and immutable, without the possibility of alteration or deletion. Computerized voting systems are designed to calculate votes by default (counting and presentation of results).

In general, computerized voting applications often rely on centralized authority control. These systems come with a range of inherent drawbacks and risks [11], including the absence of established electronic voting system standards, security and reliability concerns, susceptibility to hacking and fraud, the potential for malicious software development, high equipment costs, and secure data storage for transaction.

2.2 Blockchain Technology

Blockchain technology is characterized by immutable distributed ledger systems that store data in a digital ledger without a central point of authority and without the risk of failure. Each transaction within the system is confirmed by a defined consensus algorithm and permanently recorded on the public ledger. Once a transaction is completed, it becomes unalterable. The responsibility of checking and verifying the published data on the system rests with every node [12].

A Blockchain-based platform operates continuously on a peer-to-peer (P2P) network, where anyone can connect and receive incentives for running their

software as a node. The concept of a cryptographically linked chain of blocks was initially explored by Stuart Haber and W. Scott Stornetta in 1991. Subsequently, in 1992, Bayer, Haber, and Stornetta introduced Merkle trees to enhance the efficiency of consolidating multiple documents into a single block [13,14,15].

The term "Blockchain" refers to a sequence of timestamped and cryptographically connected blocks. As more blocks are added, the chain continues to expand. The hash of the first block is included in each subsequent block, as illustrated in Figure 2. Blockchain technology safeguards both sensitive and general data from tampering or manipulation [16,17]. Essentially, Blockchain is a decentralized ledger that records all direct transactions between users and vendors within the system, maintaining a distributed network of nodes responsible for validating these transactions. This architecture allows trust to be established without reliance on a central authority [18,19,20].

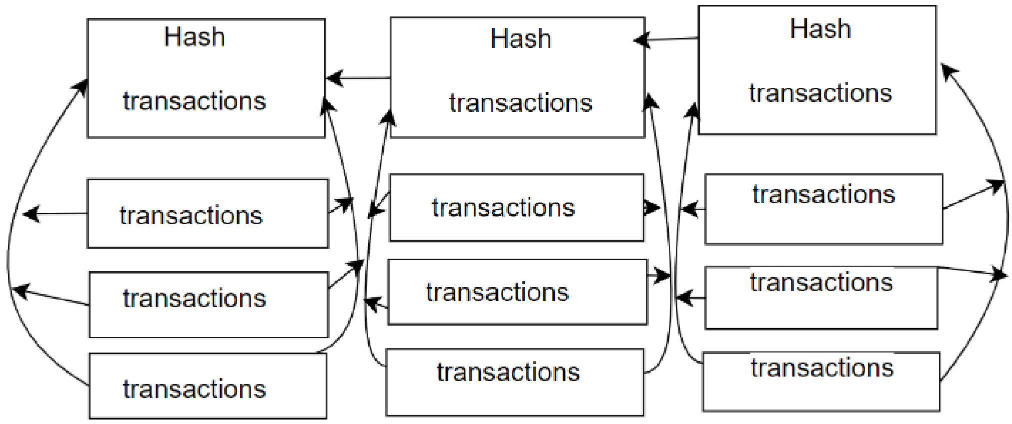

Figure 2. Blockchain Data Structure

Some experts have proposed that Blockchain technology could ultimately surpass the Internet in significance. Blockchain innovation bolsters information capacity and trade on a peer-to-peer (P2P) organize. Structurally, Blockchain data can be presented, shared, and linked through consensus-based algorithms [21]. It operates in a decentralized manner, eliminating the need for "trusted third parties" or intermediaries in the process [22,23].

Blockchain systems use asymmetric cryptography, which, though slower than symmetric cryptography, offers enhanced security. In a distributed system, components on various networked computers collaborate by exchanging messages. Asymmetric cryptography enables users who are not acquainted with each other to securely transmit encrypted data [25].

Presently, electronic voting technologies and solutions are often criticized for being unreliable, insecure, and fraught with risks. In response, many academics have turned to Blockchain technology for more efficient methods and protocols for electronic voting systems that can deliver secure, anonymous, and fair voting.

Our research has led us to conclude that scalability is a multifaceted concept with various interpretations in the literature. In this study, we adopt a recent definition of scalability, where it can be categorized as:

- Horizontal scalability, achieved by adding or increasing the number of computers in an existing network.
- Vertical scalability, achieved by enhancing resources such as memory, processing power, and storage in an existing resource pool. These core concepts are used to describe scalability in the context of Blockchains.

2.3. Scalability Trilemma in Blockchain

In later a long time, Blockchain innovation has picked up critical consideration. However, one of the major challenges facing Blockchain-based electronic voting systems is scalability, which has the potential to limit its role as a disruptive technology. This study aims to explore and assess existing efforts aimed at enhancing the scalability of Blockchain-based electronic voting systems. To frame our discussion on scalability in the context of this study, we adopt a definition based on recent research.

3. Related Work

Blockchain innovation has found applications over different businesses, counting keeping money and back, IoT, media, vitality, healthcare, coordination's, and more. Ongoing exploration continues to uncover new fields and use cases for this technology. A comprehensive evaluation of articles on Blockchain

technology in information systems was conducted by the authors of [28], resulting in a comprehensive list of applications categorized by the problems addressed by Blockchain technology.
This segment embraces a crucial examination of earlier inquire about that has inspected adaptable Blockchain innovation for electronic voting. To conduct a efficient audit of these endeavors, our investigate made utilize of advanced libraries, counting IEEE Xplore Advanced Library, Scopus, ScienceDirect, SpringerLink, and ACM Computerized Library. We specifically focused on efforts aimed at addressing the challenges of achieving scalable Blockchain solutions for electronic voting, as outlined in Table 2. This exploration has unveiled numerous potential options [29,30,31]. While these studies provide broad insights into Blockchain technology, they do not specifically delve into the issue of scalability. Consequently, these studies were not within the scope of the current research.

Table 1 Paper discussed in Pre researched work

ID	Question	Description
1	What are a few of the foremost well-known proposition for adaptable Blockchain-based electronic voting?	This theme highlights the foremost broadly utilized Blockchain usage utilized as the establishment for electronic voting frameworks. It empowers the comparison and differentiating of a few Blockchain and their traits.
2	Were those arrangements tried in a real-world situation?	It may well be conceivable to move forward upon existing solutions by looking at how they were actualized within the genuine world.
3	What are the confirmation strategies utilized to test those arrangements?	This address tries to discover out how a arrangement was tried against the determinations of an electronic voting framework
4	What are the distinctive cryptographic arrangements utilized in past inquire about?	Numerous cryptographic primitives and methods are utilized in today's electronic voting frameworks. The essential objective of this examination is to find them so that data approximately them may be joined into other potential arrangements.
5	Were the cryptographic operations utilized in earlier	Within the current situation, cryptosystems are utilizing as

	arrangements as well expensive and time-consuming?	well much control to unravel the confuse. Investigation of those arrangements that claim to decrease the computational fetched.
6	What are the most recent Blockchain applications centered on adaptability?	Blockchain applications are not constrained to Bitcoin. Understanding the genuine impact of Blockchain innovation on adaptability will need an examination of the foremost later viable employments.
7	What parameters test the execution and versatility of the constituent prepare on a huge scale?	This address points to test the current versatile Blockchain arrangements on a expansive scale to check the execution of these arrangements on a national-based electronic voting framework.

4. Research Methodology

To address our study questions, we opted for a Systematic Literature Review (SLR) approach, adhering to the guidelines outlined in [33]. Our aim was to perform a comprehensive analysis of the SLR by iteratively progressing through the planning, execution, and reporting phases. The forthcoming sections detail our systematic literature review methodology and provide an overview of the studies related to scalable Blockchain electronic voting.

4.1. Systematic Literature Overview and Process

A Systematic Literature Review (SLR), often referred to as such, is a secondary research approach designed to systematically locate, assess, and evaluate published research pertaining to a specific topic, problem, or phenomenon [35]. The SLR process typically comprises five key stages:

1. **Planning the Review:** In this initial stage, the focus is on establishing research topics and defining the overall review strategy. It sets the boundaries and scope of the research.
2. **Selection Process:** The objective here is to design a systematic search process, put it into action, and analyze as many relevant primary papers as possible.
3. **Conducting the Review:** This phase involves the practical execution of the search process and the examination of the gathered primary papers.
4. **Screening and Refinement:** After conducting the review, the next step is to select a collection of pertinent articles from the pool of available research papers. These selected papers are then further evaluated to address the research questions.
5. **Reporting the Review:** The final phase encompasses the presentation of the findings in an appropriate manner. This process culminates in the creation of a comprehensive research report, usually in the form of a research paper.

4.2. Research Questions

This article aims to uncover the predominant trends in electronic voting by scrutinizing existing scalable Blockchain-based voting systems. Based on our research, we evaluate the findings in the literature to assess their feasibility, significance, novelty, ethical considerations, and relevance to this study. While conducting our literature examination, we ensured that the questions we formulated adequately demonstrated their pertinence and that the analysis methods employed were appropriate [34].

4.3. Selection of Primary Study

To underscore the significance of primary research, we systematically categorized specific keywords for use in journal or search engine search functions. These carefully chosen keywords were intended to facilitate the discovery of research outcomes that would contribute to addressing our research questions [34,35,36].

In this inquire about, differing look terms were utilized to gather information. This approach was adopted to ensure that no essential articles were overlooked, as some authors utilized word variants to distinguish their work from others. The platforms utilized for our search included:

1. Scopus;
2. ScienceDirect;
3. IEEE Xplore Digital Library;
4. SpringerLink;
5. ACM Digital Library.

4.4. Compilation of Results

There are various challenges related to the research's validity. First and foremost, there is the possibility that not all pertinent sources have been uncovered. To mitigate this, we conducted a thorough search across multiple databases using the most comprehensive search query available. This approach aimed to ensure that an extensive amount of research was included. Furthermore, the search process was designed to prevent bias and uphold internal validity. By utilizing reputable databases and exclusively focusing on peer-reviewed literature, we maintained the study's external validity. As mentioned earlier, the comprehensive search query was meticulously executed to gather the most pertinent information from database search engines.

5. Result Presentation

In this section, we present the results of the systematic literature review conducted on the 76 selected papers. Table 2 provides a comprehensive list of the chosen papers. Each research question is addressed in its respective subsection. Additionally, the initial subsection provides the outcomes of the research's quality assessments

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Table 2. Papers about Blockchain voting selected for analysis

ID	Article Title	Research Method	Research Result	Research Gap
1	A secure large-scale electronic voting system based on blockchain contracts using a hybrid	PSC-B chain hybrid consensus proposal	Security, performance, and scalability of blockchain-based electronic voting systems	Freedom to resist and accept coercions proposal

ID	Article Title	Research Method	Research Result	Research Gap
	consensus model combined with sharding simulation			
2	COVID-19: Implementation of the e-voting blockchain concept	Quantitative: SUS test analysis to process elections under COVID-19	ensuring effectiveness and efficiency, authentication, and e-voting	Enabling improvements to the voting blockchain process
3	On the design and implementation of a blockchain-enabled e-voting application as part of an IoT-oriented smart city simulation	Developing a new system model for e-voting applications	Privacy, trust, and security	Real-time data
4	Empirical analysis of transaction malleability in blockchain-based electronic voting	Experiment: Transaction malleability process model diagram	Network delay and block generation rate	New mechanisms and methods need to be developed to mitigate malleable attacks
5	Towards the realization of a privacy-preserving voting system using blockchain experimental	technology: Proposal of a privacy-preserving voting algorithm	Political racial regulation, control hacking of electronic democracy machines, cost-effective	Adaptability, coercion resistance, and scalability
6	Efficient, non-coercion and universally verifiable blockchain-based voting experiments	Proposed algorithm using zkSNARK	Resistance to coercion, freedom from receipt, universal verifiability	trusted election authorities
7	Architecture-Centric Assessment of Blockchain-Based Shrewd Contract E-Voting for National Decisions.	Design trade-off examination strategy (ATAM).	Security assaults, inside vote control, and supported straightforwardness.	Need of security and agreement convention
8	An upgraded security component through Blockchain for E-	Recreation: Proposed e-voting format with IoT gadgets.	Improved security through Blockchain in	Inadequately prove to handle pernicious IoT gadgets

ID	Article Title	Research Method	Research Result	Research Gap
	polling/counting handle utilizing IoT gadgets.		e-voting applications utilizing IoT gadgets.	
9	AttriChain Decentralized traceable mysterious personalities in privacy-preserving permissioned Blockchain.	Recreation: Proposed AttriChain convention for security in permissioned Blockchain.	Increments client protection and independence in a permissioned arrange and empowers examining.	Failure to bargain with money related scenarios, open Blockchains are not bolstered
10	Blockchain voting Freely irrefutable online voting convention without trusted counting specialists.	Recreation: Proposed a novel encryption plot.	Voters can store, confirm, and count all submitted votes.	Twofold encryption and zero-knowledge/partial-knowledge proofs are shortcomings
11	Blockchain-based voting rules for self-aggregation in decentralized IoT.	Retrieval: A proposal for self-aggregating voting agreements using IoT.	Self-tallying innovation scrambles votes for a indicated length to ensure voting privacy.	Yes/no voting does not work in meeting rooms or classrooms
12	Mysterious and Coercion-Resistant Conveyed Electronic Voting.	Recreation: Proposed conspire safe to twofold voting.	Improved the judgment, proficiency, and voter turnout of the decision handle.	Disregards security and protection
13	Blockchain Innovation based Appointive Establishment.	Recreation: Proposed design BCT-based electronic establishment.	Unchanging and distributable to play down voting framework ambushes.	Needs trusted third-parties, information judgment, and confirmation
14	A hyper-ledger texture system as a benefit for progressed quality e-voting framework.	Proposed system as a benefit.	A exceedingly viable, large-scale, cost-effective arrangement for personalized private Blockchain.	Private Blockchain compromised information keenness and security
15	E-Voting Framework utilizing Hyperledger Sawtooth.	Exploratory: Utilizing Sawtooth with Strength dialect.	Large-scale execution, unwavering quality, as well as security.	Nontransparent; framework may be imperfect based on agreement

ID	Article Title	Research Method	Research Result	Research Gap
16	Electronic voting based on virtual id of aadhar utilizing Blockchain innovation.	Proposed framework: virtual ID based on UIDAI	Secured e-voting framework by utilizing biometric subtle elements.	Producing and analyzing fingerprints is difficult
17	Blockchain-Based Self-Tallying Voting Framework with Computer program Upgrades in Decentralized IoT.	Recreation: It employments IoT. The algorithm's effectiveness and normal runtime are inspected.	A self-tallying voting framework with program upgrades in decentralized IoT.	Failure to bargain with client security and security
18	Advanced Voting A Blockchain-based E-Voting Framework utilizing Biohash and Shrewd Contracts.	Reenactment: Shrewd contract and bio hash.	Information keenness and secrecy, protection, security.	Proprietary fingerprint authentication is costly and inaccurate
19	A Blockchain-based Traceable Self-tallying E-voting Convention in AI Time.	Recreation: AI-based self-tallying e-voting plot.	Fulfills namelessness, time-bounded security, linkability, and full traceability.	Nonappearance to real-world applications on huge scale
20	Decentralized E-voting framework based on Keen Contract by utilizing Blockchain Innovation.	Recreation: Ethereum with shrewd contract on neighborhood blockchain Dependable, secure, adaptable, and able to bolster real-time administrations.	Inactivity throughput issues emerge.	Ethereum's speed limits large-scale sending.
21	Productive, coercion-free and generally unquestionable Blockchain-based voting.	Recreation: Ethereum with keen contract with a center to decrease the gas charge.	Versatile and commonsense for large-scale decisions.	A dependable director registers voters and an aggregator compile comes about
22	TrustVote On Decisions We Believe with Conveyed Records and Savvy Contracts.	Reenactment: Ethereum with Hyperledger.	Compares permissioned and open Blockchain for way better execution, exchange speed, and protection.	Coercion-resistant, needs trusted specialists

ID	Article Title	Research Method	Research Result	Research Gap
23	Proficient Privacy-Preserving Electronic Voting Plot Based on Blockchain.	Recreation: Ethereum with multicandidate electronic voting conspire.	Great execution and the achievability and rightness of the voting conspire.	Permissioned Blockchain requires trusted specialists, versatility issues on expansive scale
24	Provotum A Blockchain-based and End-to-end Irrefutable Inaccessible Electronic Voting Framework.	Recreation: End-to-end unquestionable farther private Blockchain conspire.	Commonsense plan and design of open bulletin sheets, vote mystery, and end-to-end unquestionable status.	Does not back multiway races, need of secure communication channels
25	Examining execution imperatives for Blockchain based secure e-voting framework.	Reenactment: Permissioned and permissionless blockchain to degree execution.	Effectiveness, execution, and versatility.	It does not expressly state security perspectives such as uniqueness and poll gathering
26	A Savvy Contract Framework for Decentralized Borda Tally Voting.	Reenactment: A decentralized, multicandidate, public-verifiable voting framework.	Self-tallying decentralized and ranked-choice voting framework.	Large-scale voting is additionally incomprehensible. No convention considers voter security

6. Analysis and Discussion

Researchers anticipate that electronic voting systems will reap substantial benefits from the integration of Blockchain technology. The immutability of data and the decentralized nature of the system stand out as the primary advantages. Notably, researchers have been closely monitoring the issue of Blockchain's scalability, recognizing it as a significant concern. To accommodate the increasing adoption of Blockchain technology across financial and non-financial sectors, there is a growing need for strategies and processes to enhance both horizontal and vertical scalability.

In the context of scaling a Blockchain for extensive, nationwide elections, the key focal points include simplifying data storage, augmenting throughput, and minimizing latency.

6.1. Sharding

Sharding is a technique that holds promise for enhancing Blockchain scalability. Notable examples of sharding-based solutions aimed at achieving low-level latency and high throughput in distributed databases are Graph chain [38] and Omniledger [39], both of which were introduced in 2018. While several approaches have been proposed to address similar issues, Graph Chain has emerged as a particularly efficient and secure solution. It's important to note that these methods are primarily applicable to permissionless cryptocurrencies.

Conversely, some alternative approaches have been extended to cover all workloads, relying solely on trusted hardware to minimize communication overhead.

6.2. Block Size Increase

The study has enabled us to recognize the role that function block size and generation play in the scalability of Blockchain. Specifically, increasing the maximum block size is often referred to as a block size increase. In Blockchain networks, blocks are regularly generated, each containing a record of transactions. Given that the block size sets a limit on the number of transactions that can be accommodated, enlarging the block size results in an enhanced throughput [40,41].

6.3. Directed Acyclic Graph

An alternative form of Blockchain, distinct from the traditional model, is the Decentralized Autonomous Group, often referred to as a DAG. In a DAG network, individual transactions are connected to multiple other individual transactions. Unlike Blockchain, the DAG structure resembles a tree, with transactions branching out from one to another, creating a network of interconnected transactions [42].

7. Conclusions

The primary objective of this paper is to conduct a comprehensive review and analysis of the current state of research in scalable voting systems, primarily centered around Blockchain technology. However, it's important to acknowledge that the development and implementation of an electronic voting system is a complex undertaking. Electronic voting systems face numerous challenges, encompassing aspects like authentication, privacy, data integrity, transparency, and verifiability.

What parameters test the execution and versatility of the constituent prepare on a huge scale? This address points to test the current versatile Blockchain arrangements on a expansive scale to check the execution of these arrangements on a national-based electronic voting framework. One of the key obstacles preventing the widespread adoption of Blockchain technology across various application domains, including electronic voting, is the challenge of scaling Blockchain to accommodate growing user bases. Recent events, such as the global pandemic and an uptick in election fraud cases, have underscored the urgent need for an efficient, scalable, secure, and reliable voting information system. As a result, ongoing efforts to explore novel and enhanced Blockchain-based solutions continue.

The essential objective of this investigate is to shed light on the assorted cluster of Blockchain-based voting options as of now accessible. This paper marks the initial systematic attempt to identify and consolidate existing initiatives related to Blockchain scalability within these contexts. It encompasses leveraging Blockchain to attain scalable applications, mechanisms, and strategies to enhance Blockchain scalability by contributing to core Blockchain functions, and endeavors to outline the scalability challenges through an analysis of Blockchain-based electronic voting solutions.

Numerous research gaps in the field of scalability have been highlighted, warranting further investigation. Potential drawbacks include resistance to coercion, scalability vulnerabilities, reduced transparency, and untrustworthy systems, all of which necessitate mitigation. Testing electronic voting systems can be executed in multiple ways, akin to testing any software, involving assessments of acceptability, performance, and security. However, there is no universally accepted method for verifying the accuracy or reference data of such systems, and no single authoritative reference is cited in existing literature.

Furthermore, there is limited evidence of practical implementation, making comprehensive studies challenging. While many of the selected papers offer viable solutions, a primary challenge in the realm of electronic voting is achieving verifiability. Other concerns that are frequently addressed encompass safeguarding ballot confidentiality and determining voter eligibility. Nevertheless, numerous solutions come with trade-offs, including the lack of coercion resistance and receipt freeness, the expenses associated with operating on a public Blockchain, and susceptibility to specific types of attacks.

References

1. Khan K.M., Arshad J., Khan M.M. Investigating performance constraints for blockchain based secure e-voting system. Futur. Gener. Comput. Syst. 2019;105:13–26. doi: 10.1016/j.future.2019.11.005. [CrossRef] [Google Scholar]
2. Gritzalis D.A. Secure Electronic Voting. Springer Science & Business Media; Berlin/Heidelberg, Germany: 2012. [Google Scholar]
3. Taş R., Tanrıöver Ö.Ö. A Systematic Review of Challenges and Opportunities of Blockchain for E-Voting. Symmetry. 2020;12:1328. doi: 10.3390/sym12081328. [CrossRef] [Google Scholar]
4. Noizat P. Handbook of Digital Currency. Elsevier; Amsterdam, The Netherlands: 2015. Blockchain electronic vote; pp. 453–461. [Google Scholar]
5. Garg K., Saraswat P., Bisht S., Aggarwal S.K., Kothuri S.K., Gupta S. A Comparitive Analysis on E-Voting System Using Blockchain; Proceedings of the 2019 4th International Conference on Internet of Things: Smart Innovation and Usages (IoT-SIU); Ghaziabad, India. 18–19 April 2019; pp. 1–4. [Google Scholar]
6. Febriyanto E., Rahayu N., Pangaribuan K., Sunarya P.A. Using Blockchain Data Security Management for E-Voting Systems; Proceedings of the 2020 8th International Conference on Cyber and IT Service Management (CITSM); Pangkal Pinang, Indonesia. 23–24 October 2020; pp. 1–4. [Google Scholar]
7. Adiputra C.K., Hjort R., Sato H. A proposal of blockchain-based electronic voting system; Proceedings of the 2018 Second World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4); London, UK. 30–31 October 2018; pp. 22–27. [Google Scholar]
8. Pawlak M., Poniszewska-Marańda A. Trends in blockchain-based electronic voting systems. Inf. Process. Manag. 2021;58:102595. doi: 10.1016/j.ipm.2021.102595. [CrossRef] [Google Scholar]
9. Roh C.-H., Lee I.-Y. A study on electronic voting system using private blockchain. J. Inf. Process. Syst. 2020;16:421–434. [Google Scholar]
10. Vivek S., Yashank R., Prashanth Y., Yashas N., Namratha M. E-voting systems using blockchain: An exploratory literature survey; Proceedings of the 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA); Coimbatore, India. 15–17 July 2020; pp. 890–895. [Google Scholar]
11. Jafar U., Ab Aziz M.J., Shukur Z. Blockchain for Electronic Voting System—Review and Open Research Challenges. Sensors. 2021;21:5874. doi: 10.3390/s21175874. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
12. Abuidris Y., Hassan A., Hadabi A., Elfadul I. Risks and opportunities of blockchain based on e-voting systems; Proceedings of the 2019 16th International Computer Conference on Wavelet Active Media Technology and Information Processing; Chengdu, China. 16–18 December 2019; pp. 365–368. [Google Scholar]
13. Zheng S., Huo R., Huang T., Liu J., Wang S., Feng W. Survey of blockchain: Principle, progress and application. J. Commun. 2020;41:134. [Google Scholar]
14. Pawade D., Sakhapara A., Badgujar A., Adepu D., Andrade M. Data Management, Analytics and Innovation. Springer; Berlin/Heidelberg, Germany: 2020. Secure Online Voting System Using Biometric and Blockchain; pp. 93–110. [Google Scholar]

15. Aysan A., Bergigui F., Disli M. Blockchain-Based Solutions in Achieving SDGs after COVID-19. J. Open Innov. Technol. Mark. Complex. 2021;7:151. doi: 10.3390/joitmc7020151. [CrossRef] [Google Scholar]
16. Aysan A.F., Bergigui F. Blockchain paths in rebooting the global response to the sustainable development goals after COVID-19. Preprints. 2020:2020100074. doi: 10.20944/preprints202010.0074.v1. [CrossRef] [Google Scholar]
17. World Health Organization A Year without Precedent: WHO's COVID-19 Response. [(accessed on 15 November 2021)]. Available online: https://www.who.int/news-room/spotlight/a-year-without-precedent-who-s-covid-19-response
18. Nakamoto S. Bitcoin: A Peer-to-Peer Electronic Cash System Bitcoin: A Peer-to-Peer Electronic Cash System. [(accessed on 23 November 2021)];Bitcoin. Org. 2009 Available online: https://bitcoin.org/en/bitcoin-paper [Google Scholar]
19. Crosby M., Pattanayak P., Verma S., Kalyanaraman V. Blockchain technology: Beyond bitcoin. Appl. Innov. 2016;2:71. [Google Scholar]
20. Deep G., Mohana R., Nayyar A., Sanjeevikumar P., Hossain E. Authentication Protocol for Cloud Databases Using Blockchain Mechanism. Sensors. 2019;19:4444. doi: 10.3390/s19204444. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
21. Çabuk U.C., Adiguzel E., Karaarslan E. A survey on feasibility and suitability of blockchain techniques for the e-voting systems. arXiv. 2020 doi: 10.17148/IJARCCE.2018.7324.2002.07175 [CrossRef] [Google Scholar]
22. Ravikumar S., Antony Kumar K., Sathana V. E-voting system using blockchain with network security. Turk. J. Comput. Math. Educ. (TURCOMAT) 2021;12:19–22. [Google Scholar]
23. Nicolas K., Wang Y., Giakos G.C., Wei B., Shen H. Blockchain System Defensive Overview for Double-Spend and Selfish Mining Attacks: A Systematic Approach. IEEE Access. 2020;9:3838–3857. doi: 10.1109/ACCESS.2020.3047365. [CrossRef] [Google Scholar]
24. Yi H. Securing e-voting based on blockchain in P2P network. EURASIP J. Wirel. Commun. Netw. 2019;2019:137. doi: 10.1186/s13638-019-1473-6. [CrossRef] [Google Scholar]
25. Twesige R.L. A simple explanation of Bitcoin and Blockchain technology. Comput. Sci. 2015;1:1–5. [Google Scholar]
26. Zhang Y., Li Y., Fang L., Chen P., Dong X. Privacy-protected Electronic Voting System Based on Blockchin and Trusted Execution Environment; Proceedings of the 2019 IEEE 5th International Conference on Computer and Communications (ICCC); Chengdu, China. 6–9 December 2019; pp. 1252–1257. [Google Scholar]
27. Moher D., Liberati A., Tetzlaff J., Altman D.G., Group P. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann. Intern. Med. 2009;151:264–269. doi: 10.7326/0003-4819-151-4-200908180-00135. [PubMed] [CrossRef] [Google Scholar]
28. Kitchenham B., Brereton O.P., Budgen D., Turner M., Bailey J., Linkman S. Systematic literature reviews in software engineering—A systematic literature review. Inf. Softw. Technol. 2009;51:7–15. doi: 10.1016/j.infsof.2008.09.009. [CrossRef] [Google Scholar]
29. Verwer M.B., Dionysiou I., Gjermundrød H. TrustedEVoting (TeV) a Secure, Anonymous and Verifiable Blockchain-Based e-Voting Framework; Proceedings of the International Conference on e-Democracy; Athens, Greece. 12–13 December 2019; pp. 129–143. [Google Scholar]

30. Draper S.W., Brown M.I. Increasing interactivity in lectures using an electronic voting system. J. Comput. Assist. Learn. 2004;20:81–94. doi: 10.1111/j.1365-2729.2004.00074.x. [CrossRef] [Google Scholar]
31. ND Institute Common Electronic Voting and Counting Technologies. [(accessed on 12 March 2022)]. Available online: https://www.ndi.org/e-voting-guide/common-electronic-voting-and-counting-technologies
32. Kiayias A., Zacharias T., Zhang B. An Efficient E2E Verifiable E-voting System without Setup Assumptions. IEEE Secur. Priv. 2017;15:14–23. doi: 10.1109/MSP.2017.71. [CrossRef] [Google Scholar]
33. Shahzad B., Crowcroft J. Trustworthy Electronic Voting Using Adjusted Blockchain Technology. IEEE Access. 2019;7:24477–24488. doi: 10.1109/ACCESS.2019.2895670. [CrossRef] [Google Scholar]
34. Braghin C., Cimato S., Cominesi S.R., Damiani E., Mauri L. Towards Blockchain-Based E-Voting Systems; Proceedings of the International Conference on Business Information Systems; Seville, Spain. 26–28 June 2019; pp. 274–286. [Google Scholar]
35. Kumar D.A., Begum T.U.S. Electronic voting machine—A review; Proceedings of the International Conference on Pattern Recognition, Informatics and Medical Engineering (PRIME-2012); Tamilnadu, India. 21–23 March 2012; pp. 41–48. [Google Scholar]
36. Alam A., Rashid S.Z.U., Salam M.A., Islam A. Towards blockchain-based e-voting system; Proceedings of the 2018 International Conference on Innovations in Science, Engineering and Technology (ICISET); Chittagong, Bangladesh. 27–28 October 2018; pp. 351–354. [Google Scholar]
37. Jefferson D., Rubin A.D., Simons B., Wagner D. Analyzing internet voting security. Commun. ACM. 2004;47:59–64. doi: 10.1145/1022594.1022624. [CrossRef] [Google Scholar]
38. Kshetri N., Voas J. Blockchain-Enabled E-Voting. IEEE Softw. 2018;35:95–99. doi: 10.1109/MS.2018.2801546. [CrossRef] [Google Scholar]
39. Han G., Li Y., Yu Y., Choo K.-K.R., Guizani N. Blockchain-Based Self-Tallying Voting System with Software Updates in Decentralized IoT. IEEE Netw. 2020;34:166–172. doi: 10.1109/MNET.001.1900439. [CrossRef] [Google Scholar]
40. Springall D., Finkenauer T., Durumeric Z., Kitcat J., Hursti H., MacAlpine M., Halderman J.A. Security analysis of the Estonian internet voting system; Proceedings of the 2014 ACM SIGSAC Conference on Computer and Communications Security; Scottsdale, AZ, USA. 3–7 November 2014; pp. 703–715. [Google Scholar]
41. Serdult U., Germann M., Mendez F., Portenier A., Wellig C. Fifteen years of internet voting in Switzerland [history, governance and use]; Proceedings of the 2015 Second International Conference on eDemocracy & eGovernment (ICEDEG); Quito, Ecuador. 8–10 April 2015; pp. 126–132. [Google Scholar]
42. Iqbal M., Matulevičius R. Blockchain-based application security risks: A systematic literature review; Proceedings of the International Conference on Advanced Information Systems Engineering; Rome, Italy. 3–7 June 2019