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Literature Review of Blockchain-Based Voting System: Framework and Concept

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Abstract

Interest in changing several industries, including the field of electronic voting systems, has increased as a result of the adoption of blockchain technology. An overview of the current research and advancements in blockchain-based electronic voting systems is given in this study of the literature. The objective is to comprehend the possible advantages, difficulties, and effects of incorporating blockchain technology into the electoral process. This article looks at the technical features of blockchain, how it relates to safe and transparent voting, and more general socio-political issues that come up when putting such systems into place. The assessment begins with a look at the underlying ideas behind blockchain technology before diving into how its decentralized and tamper-resistant features could improve the openness and reliability of electronic voting systems. It is shown how important technological aspects like immutability, cryptographic security, and consensus methods lead to a more dependable and safe voting process. The assessment of the literature evaluates the potential advantages of blockchain-based electronic voting systems, including fraud reduction, improved voter anonymity, and real-time transparency. The talk also covers the difficulties in scaling up such systems, voter authentication, and the special problem of preserving voter anonymity while guaranteeing the accuracy of the vote count. The review also discusses broader sociopolitical issues that come with the introduction of computerized voting systems based on blockchains. It examines the effects on voter confidence, the function of intermediaries, and the potential for higher voting turnout, particularly among people who grew up with digital technology. Also considered are issues of ethics and law, such as the necessity to strike a balance between privacy and openness. This literature review includes a critical examination of case studies and pilot projects that have implemented or experimented with blockchain-based electronic voting systems to provide a complete viewpoint. These case studies provide light on the difficulties of switching from conventional voting techniques to blockchain-based solutions by providing insights into real-world difficulties and accomplishments.

Keywords: Blockchain, Voting, Electronic, Technology, e-voting

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1. Introduction

Elections are the process whereby individuals choose their representatives and express their preferences on how they will be governed by the chosen seeker. However, Elections may be defined in different ways. Naturally, the wholeness of an election process is central to the integrity of democracy itself (Akinbohun & Apeh, 2019).

The emerged technologies have revolutionized the way we live, think, and how things are being done now. The diverse fields like banking, health, Industries, and even government sectors have already transformed in some aspects if not all. This emerging technology has led governments and countries fully or partially adopt Electronic voting systems in their elections, Estonia was the very earliest user of electronic voting fully in their election while Namibia is one of the known African countries that adopted an electronic voting system for their national election, while Nigeria adopted card reader with the biometric system in the election process which was for verification only. Although many other countries like Switzerland, Norway, and India are also making use of electronic voting systems in one way or another other the fact remains the same, this electronic system of voting does not provide consistency, security, or fairness than paper ballot system. This occurred because of the numerous instances where the election was observed with the balloting practice not entirely acceptable for the election exercise because it faced different issues with transparency and fairness, and this makes the masses confused about their right (Ahmed *et al*, 2020). Different research has been done to provide the anonymity and integrity that both traditional and electronic voting system does not provide, this is where emerging blockchain technology with electronic voting comes in to solve. After the announcement of the first blockchain-based voting system, more researchers have shown great interest in this particular field (Ahmed et al, 2020).

Roh and Lee (2020) researched an electronic voting system that uses private blockchain and discovered that blockchain technology provides reliability and data integrity because all untrusted network participants have the same data. (Mahtab *et al* 2020) review the application of blockchain technology to electoral processes in Africa and their finding was that the implementation of electronic voting over blockchain would rebuild a consistent, safe, and accepted election outcome, which eliminates the common challenges encountered by African national elections. Electronic voting is currently identified as one of the valid use cases of blockchain technology and this is just because of the decentralized and distributed nature of blockchain, its attributes of anonymity, and transparency which makes it a suitable approach to handle many of the difficulties associated with conventional electronic voting systems (Osgood, 2020).

A well-structured Blockchain-based electronic voting architecture that potentially addresses the majority of the issues with the conventional voting system and regular electronic voting. Thus, the problems consist of voter validation, votes verification, voter privacy, votes security, high cost of materials and logistics, time of collation, and the integrity of election outcomes in which the stakeholder's engagement for system requirement was considered (Olawande D. & Darren T., 2020).

2. Methodology

In the process of this review of papers on permission blockchain voting systems, we created an exploration approach to categorize relevant literature for this logical search. However, the survey approach focuses on three different sources; Scopus, IEEE Xplore, and Web of Science in which the searched terms applied either "permission blockchain voting system" OR "concept of permission blockchain voting system" OR "permission blockchain voting system evolution". Meanwhile, the searched contents were across the database till 2023 including the conference papers, journals, and review works which were published using English Language only.

The criteria used for the paper selection were according to PRISMA 9 (Kakarlapudi & Mahmoud, 2021). The research exploration only focused on plotting previous literature works on the permissioned blockchain voting system in different areas of study, the results were streamlined to the subject areas in addition to computer sciences and computer engineering. The time frame for searching covered the years 2019 through 2023 as well as an additional 14 items from different sources.

All articles were taken into account because the research was mainly concentrated on all nations, 266 of the 432 publications were still present when duplicate records were eliminated, but 121 had already been discarded following the screening. Following the document screening, 145 further articles were extracted. Thus, only original academic articles, research papers, and conference presentations served as the study's foundation. Each duplicate work was carefully considered to retain the review's standard. So, to ensure the standard and applicability of academic material used in the review process, the abstracts of the papers were carefully examined and purified. Later, each research report underwent a thorough examination. The next exclusion criterion restricted the documents to those that were published in English alone. Six articles written in languages other than English were excluded from the study. Furthermore, 32 publications were chosen as research for the scholarly examination, and the traits they contained were:

i. The considered published articles and research papers had to be novel papers, conference papers, and peer-review papers.
ii. English language should be used in the article and must come from one of the following disciplines: computer science and computer engineering.
iii. Certain external papers from 2019 to 2023 as well as certain extracted pieces were issued between 2015 and 2023.
iv. The documents that were obtained came from different nations.

After evaluating each publication against the criteria for inclusion and exclusion, we chose 11 articles for the data extraction stage, as shown in Figure 1.

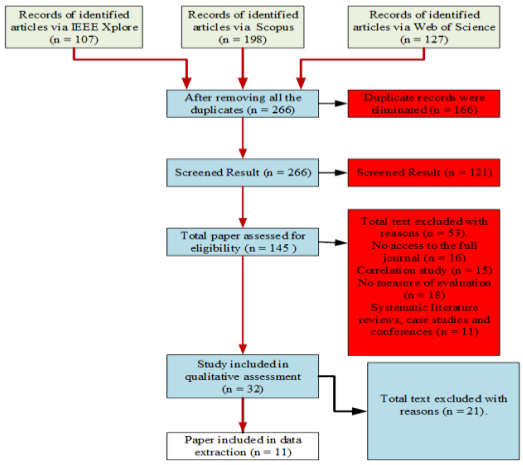

Figure 1. Stages for inclusion and exclusion of literature

3. Results

According to Koibichuk *et al.*, (2022), R is a computer language for complete scientific mapping analytic tools for bibliographic data. The outcomes were reported by the R Bibliometrix tool.

Subject Description: By creating a database of words and an illustration that shows the relationships and internal connections between the concepts of a permissioned blockchain voting system and how they are evaluated and used, we can get useful feedback on our papers. According to Table 1, the terms "Permissioned blockchain voting system concept" and "Permissioned blockchain voting system architecture" occurred in the titles of the publications the most frequently. In the context of our research, we conducted initially papers that produced some terms referring to typical concepts ("Permissioned blockchain voting system concept"). Therefore, after retrieving the data set from the IEEE Xplore, Scopus, and Web of Science databases, we had to perform some preliminary processing tasks, such as ignoring numbers and disregarding case sensitivity, The number of phrases, phrase occurrence metrics for the articles via bibliophily within RStudio, and cloud selection word. The created terms are depicted in Figure

Figure 2: A word cloud created using Rstudio keywords.

Table 1*:* The percentage of the appeared common term title of the papers

Term	Occurrence (%)
blockchain voting system	10
Permissioned blockchain e-voting system	11
E-voting system based on blockchain	12
Multi-ledger voting	10
Permissionless Blockchain voting system architecture	9
An electronic voting system based on Blockchain architecture	8
Online voting based on blockchain technology	6
Blockchain voting system concept	7
Decentralized voting system	9

Blockchain-based e-voting	7
A voting system using blockchain	8
Others	3
Total	100

Dataset: The proportion of study topics for each country and the recentness of the paper's content were represented by a three-field plot of the title, abstract, and publisher of the references that were cited. scholars who study permissioned blockchain voting systems have a lot of interest in Scopus. The architecture of an electronic voting system based on blockchain technology is the most popular study area in Web of Science and IEEE.

4. Review of Voting System Based on Blockchain Technology

The system of voting is very important to democratic societies. Different voting systems are being practiced or used to elect a political representative in different countries around the world. Every voting system has different features, so how a voting system is designed influences how society will be governed (A. J. Feldman et al, 2007).

Baudier *et al.* (2021) investigate by applying a descriptive method of blockchain technology to should be used to support peace engineering in the context of elections. They deduced that this technology (Blockchain) could contribute to developing a peaceful society, offering social and political equality, justice, and integrity. Sharma *et al.* (2021) developed an auditable system to boosting up the cost-efficiency in the voting process and to strengthen the trust of voters in the government. They make use of Proof-of-Stake-Voting as a consensus protocol, in which Ether cryptocurrency will be used by the voters to vote for their choices. Mukherjee *et al.* (2020) presented a paper, Hyperledger Fabric Framework solution and which was just proposed to improve the quality e-voting system. The proposed system was based on FaaS which contains services of three layers that are said to make the system a fail-safe design and to ensure system reliability. Indrason *et al.* (2020) proposed a design of a blockchain-based e-voting system in which a booting center may not be needed and called it Blockchain-Based Bootless E-Voting System. Although the type of blockchain used was not explained and neither mentioned the consensus adopted in design. Khan *et al.* (2020) investigate performance constraints for blockchain-based secured e-voting systems. Experimentation was carried out with both permissioned and permissionless blockchain architectures involving voting the population, the block sizes, the block generation rate, and also the block transition speed. In this work, they observed the impact of these parameters on the overall efficiency and scalability of the electronic voting solution, with the trade-offs between these parameters as well as the security and performance. Latif *et al.* (2020) analyzed recently proposed blockchain-based e-voting systems, one can determine that a mature blockchain-based e-voting system that can meet all criteria has not been proposed yet. Isirova *et al.* (2020) proposed a system and titled it a decentralized e-voting mechanism based on multi-ledger technology development principles. The way to introduce two levels architecture is to deliver a secure voting process with any redundancy of the existing systems but never considered the throughput and also the latency of the system. Roopak and Sumathi (2020), proposed a scheme that provides a secured e-voting system by using biometric details and Virtual ID of voters which was obtained from the Aadhar database to cast the vote and also used digital signature as the key for encryption of the ballots within the block.

Gao *et al.* (2019) presented Anti-Quantum EV Protocol in Blockchain with Audit Function. Although they adapted the code-based Niederreiter algorithm to resist quantum attacks and they also used Ring Signature to protect the anonymity of voters, this has the challenge of controlling and organizing multiple signatory bodies. However, with a small number of votes, security, and efficiency are great for the election, but when the voters are on a larger scale, efficiency and security may not be achieved. Yi (2019) published a paper on securing e-voting based on blockchain in P2P networks by exploiting blockchain technologies. The study was developed on the distributed ledger which is used to prevent the forging of votes, though it needs third-party trustworthy which makes it not very suitable for centralized use in a system environment with numerous agents. Zhou *et al* (2019) propose an improved FOO e-voting scheme using blockchain to deal with the limitation, and distrust attached to the central system, and the fairness and precision of the vote issues in the traditional e-voting system. They replaced traditional trusted third parties with smart contracts and the architecture was implemented with hyper-ledger fabric. With a real implementation, it proved to satisfy the needed requirements for an e-voting protocol; meantime, it reduced the trust assumption significantly. Bao *et al* (2019) proposed a protected and privacy-protective blended solution for Bitcoin anonymity, where they introduced mixed services for users to block hackers from connecting both the inputs and output addresses using a blind signature system and multi-signatures system. Lockmix analysis proved that the scheme could provide Bitcoin compatibility, scalability, privacy, and accountability, the implementation result of this scheme on the Bitcoin network shows the system is efficient. Shufan *et al.* (2019) proposed a novel blockchain-enabled voting system called Chaintegrity, which fulfills the serious issues in terms of scalability, verification, and robustness. However, the data the system used was a hybrid type which was structured with a combination of the counting-bloom filter and Merkel hash tree for faster authentication of votes. This scheme also introduced code-voting techniques to enhance robustness. Based on the analysis, the authors also established that the proposed system achieves high efficiency and enjoys low computational and communication overhead but didn't point out the type of blockchain used. Chaieb *et al*. (2019) proposed a distributed authorizes using the blind signature to effort robust security in e-voting (DABSTERS), the protocol was introduced with the consensus mechanism in the Bitcoin protocol but just for boardroom voting which was written in the code chain. Shahzad and Crowcroft (2019) presented a paper titled "Trustworthy electronic voting applied adjustable blockchain mechanism. In this work, they make use of prove – of – work (PoW) algorithm as a consensus to create and seal the block generated by using SHA–256 hashing algorithms with considering the other securities issues involved.

Table 2*:* Electronic voting system based on Blockchain Technology and their characteristics keys

Names & year	Title	Evaluation					Platform	Decentralization / Authentication	Consensus	Voting Type / Mode	Gas
		S	P	Sc	T	L					
Trishie Sharma et al (2021)	A Cost-Efficient Proof-of-Stake-Voting Based Auditable Blockchain e-Voting System	✔	✔	✔	✔	×	Tomochain	Decentralized / Not Mentioned	Proof-of-Stake	Not specified / Supervised	Yes
Chenchen Li, Jiang X., et al (2021)	AMVchain: authority management mechanism on blockchain-based voting systems	✔	✔	×	✔	×	Multiple	Multiple Administrator/ Ring Signature	Practical Byzantine-Fault Tolerance (PBFT)	Single / Unsupervised	Yes

Ngangbam Indrason et al (2020)	Blockchain-Based Boothless E-Voting System	✔	✔	×	×	×	Not Discussed	Decentralized / Fingerprint	Not Mentioned	Single / Unsupervised	Yes
Prodipta P. M. et al (2020)	A Hyper-ledger Fabric Framework as a Service for Improved Quality E-voting System	✔	✔	✔	×	×	Hyperledger Fabric	Partially Decentralized / Not Mentioned	Not Discussed	Not Mentioned	No
Roopak T. M. and Sumathi R. (2020)	Electronic Voting based on Virtual ID of Aadhar using Blockchain Technology	✔	×	✔	×	✔	Not Mentioned	Not Mentioned / Virtual ID	Not Mentioned	Unsupervised	No
Shufan Z., Lili W. and Hu X., (2019)	Chaintegrity: blockchain-enabled large-scale e-voting system with robustness and universal verifiability	✔	✔	✔	×	×	Independent	Multiple Administrator / Blind Signature	Not Mentioned	Multiple	No
Gao S. et al (2019)	An Anti-quantum e-voting protocol in blockchain with an audit function	✔	✔	×	×	×	Not Stated	Decentralized / Ring Signature	Practical Byzantine Fault Tolerance (PBFT)	Unsupervised / Single	No
Zhou et al (2019)	An improved FOO voting scheme using blockchain	✔	✔	✔	×	✔	Hyperledger Fabric	Partially Centralized / Blind Signature	Not mentioned	Supervised / Multiple	No
Chaieb M. et al (2019)	Verify-your vote: A verifiable blockchain-based online voting protocol	✔	✔	×	×	×	Ethereum	Centralized / Elliptic-Curve Cryptography	Not Mentioned	Unsupervised / Multiple	Yes
Shahzad B. and Crowcroft J. (2019)	Trustworthy electronic voting using adjusted blockchain technology	×	✔	×	×	×	Consortium Blockchain	decentralized / Biometric	Proof of Completeness	Not Defined	No
Yi H. (2019)	Securing e-voting based on blockchain in P2P network	×	✔	×	×	×	Not Mentioned	/ elliptic curve cryptography	Not Mentioned	Unsupervised / Multiple	No Detail

5. Related works

Jafar *et al.* (2022) reviewed the scalability of electronic voting systems based on blockchain. The article discussed flexible blockchain-based voting technologies, their problems, and potential solutions as well as predicting the outcome for years to come. The research was done to assess the financial implications and length of time of widely recognized ideas, their adoption, validation techniques, and different encryption approaches.

Lindmark and Salihovic (2022), carried out a literature review on electronic voting solutions that developed on blockchain technologies and end-to-end (E2E) voting systems. However, the research aimed to distinguish between the two systems, such as to look for similarities in aspects like accountability, voter anonymity /vote confidentiality, honesty, and the inability to scale.

Though, the fundamental variations were seen in terms of how vulnerable each technology is to cyberattacks.

Jafar, Aziz, and Shukur (2021) reviewed the challenges of blockchain-based voting technology. The major objective of this review was to assess the present situation of electronic voting methods and blockchain-based voting study findings, as well as any associated challenges, to forecast future advances. The article offers an overview of the basic structure and properties of the blockchain concerning electronic voting as well as a theoretical explanation for the anticipated ledger-based electronic voting system. The study led to the discovery that some of the problems now plaguing electoral systems may be resolved by blockchain technologies.

Sahib and Al-Shamery (2021), reviewed included a wider range of concepts for e-voting systems based on the distributed ledger and how users engage with the system while it displays the voting procedure from the very first stage of enrollment to the outcome. The study points out the most crucial prerequisites necessary for every electronic voting solution that utilizes distributed ledger technology.

These literature reviews on the blockchain-based voting solution provided substantial knowledge and details on the implementation of blockchain-based voting. As blockchain technology is relatively new to the electronic voting system, then, researchers have been trying to see how it can be properly merged to improve electoral systems. Jafar et al (2021) and Sahib &Al-Shamery (2022) reviewed literature concentrated on the characteristics of blockchain in general and how it can improve the voting system but did not explain the key characteristics of selected papers and neither give details on the method used to select the reviewed papers. While Jafar et al (2022) reviewed the scalability of blockchain-based voting systems which is one of the trade-off properties of electronic voting systems that are based on blockchain technologies but did not give details on what impact scalable properties have on latency and throughput of blockchain technology. Also, Lindmark and Salihovic (2022), reviewed the properties between the E2E voting system and the blockchain-based voting solution and verified the impact on voting. Though, the studies did not give full detail on how their reviewed papers were selected. However, this review article used a well-known procedure of selecting articles from thousands of papers and streamlined the articles to cover the targeted area for review. We also reviewed articles that explained the tradeoff of scalability of blockchain-based voting solutions with privacy, security, latency, and throughput. So, based on this context we have improved on the previously mentioned articles in the related works.

6. Challenges Associated with Blockchain

Numerous advantages of blockchain technology exist, such as decentralization, transparency, and security. It does have some difficulties though. Here are a few of the main issues with blockchain technology.

Many blockchain networks, like Bitcoin, use Proof-of-Work (PoW) consensus processes, which demand a significant amount of processing power and energy. This has prompted questions about how blockchain technology would affect the environment (De-Vries, 2020). Even though blockchain is frequently regarded as secure, smart contract flaws, code problems, and potential

attacks on consensus processes can nevertheless jeopardize the reliability and security of blockchain networks (Xu, Liang & Shao, 2017). Moreso, the blockchain ecosystem may become fragmented in the lack of established protocols, smart contract languages, and interoperability frameworks (Mougayar, 2016). However, due to their constrained capacity for processing transactions, blockchain networks like Bitcoin and Ethereum have scalability problems. The network may get crowded as users and transactions grow, resulting in sluggish confirmation of transactions and greater costs (Tschorsch & Scheuermann, 2016).

7. Conclusion

In conclusion, the adoption of an electronic-voting mechanism developed on blockchain technology can completely alter how elections are conducted and rethink the concepts of transparency, security, and trust in democratic processes. The immutability, decentralization, and cryptographic security that are distinctive to blockchain technology allow this system to address several flaws and vulnerabilities that traditional voting methods frequently experience. Each vote is safely recorded and linked in a sequential chain using the tamper-resistant ledger of the blockchain, ensuring an irrefutable record of voter intent. This not only stops unauthorized changes but also improves the process's openness by enabling both voters and the appropriate authorities to independently verify and auditory the outcomes. The absence of middlemen and reliance on a dispersed network of nodes further decreases the likelihood of single points of failure and malicious manipulation.

Any electronic voting system that is based on blockchain can improve accessibility and inclusivity, especially for people who have trouble getting to polling places or have limited time. By empowering remote and international voters, this technological solution can promote increased involvement and engagement in democratic processes. The installation of such a system is not without difficulties, though. Scalability, energy consumption, and interoperability are a few technical challenges that must be overcome to guarantee the network's effective operation during periods of high voting volume. Furthermore, privacy issues must be carefully handled to protect voter anonymity and stop any voter intimidation or coercion. The integration of blockchain into the voting process necessitates compliance with current electoral laws and regulations, therefore legal and regulatory issues are also essential. To create a framework that guarantees the validity, security, and legality of the system, the involvement of the stakeholders is important, such as governmental organizations, electoral commissions, and cybersecurity specialists.

In summary, electronic voting based on blockchain technology offers a reliable, transparent, and secure way to conduct elections, representing a huge step forward in upgrading democratic processes. Even though there are still issues, the potential advantages of more voter confidence, lessened fraud, and improved accessibility have the power to change the face of election systems all over the world. Collaboration between specialists, decision-makers, and the public will be essential for maximizing blockchain's potential to promote democratic government as technology develops.

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