A SCALABLE AND PRIVACY-PRESERVING BLOCKCHAIN-BASED E-VOTING SYSTEM

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Abstract: The employment of blockchain technology in electronic voting (e-voting) systems is attracting significant attention due to its ability to enhance transparency, security, and integrity in digital voting. This study presents an extensive review of the existing research on e-voting systems that rely on blockchain technology. The study investigates a range of key research concerns, including the benefits, challenges, and impacts of such systems, together with technologies and implementations, and an identification of future directions of research in this domain. We use a hybrid review approach, applying systematic literature review principles to select and categorize scientific papers and reviewing the technology used in these in terms of the above key concerns. In the 252 selected papers, aspects such as security, transparency, and decentralization are frequently emphasized as the main benefits. In contrast, although aspects like privacy, verifiability, efficiency, trustworthiness, and auditability receive significant attention, they are not the primary focus. We observed a relative lack of emphasis on aspects such as accessibility, compatibility, availability, and usability in the reviewed literature. These aspects, although acknowledged, are not as thoroughly discussed as the aforementioned key benefits in the proposed solutions for blockchain-based e-voting systems, whereas the considered studies have proposed well-structured solutions for blockchain-based e-voting systems focusing on how blockchain can strengthen security, transparency, and privacy, in particular, the crucial aspect of scalability needs attention.

Keywords: blockchain; digital transformation; e-voting systems; security; scalability; systematic review

I. INTRODUCTION

Blockchain technology has been recognized as a potential solution for secure and transparent e-voting systems. By leveraging the decentralization, immutability, and transparency of blockchain technology, e-voting systems can prevent fraud and manipulation, improve voter anonymity, and increase trust in the electoral process. Moreover, blockchain-based e-voting systems can reduce the cost and time associated with traditional voting systems.

Traditional voting mechanisms commonly rely on centralized entities, which can give the opportunity for vulnerabilities such as the tampering of results or electoral fraud. The decentralized and immutable features inherent in blockchain technology offer a promising solution to the vulnerabilities related to traditional and other e-voting approaches. Blockchain technology has the ability to create a tamper-proof and transparent platform for conducting e-voting. Blockchain-based e-voting systems provide secure, verifiable, and auditable voting procedures through the integration of cryptographic techniques and consensus protocols.

The growing interest in blockchain-based e-voting systems indicates the importance of a comprehensive and systematic evaluation of the current knowledge in this domain. One of the aims of this review is to identify the main benefits of e-voting systems based on blockchain technology through an in-depth review of the previous research. These benefits include heightened security, transparency, decentralization, and privacy. Additionally, we intend to identify the challenges and limitations that come with these systems, which include privacy and security concerns, scalability issues, and technical limitations.Moreover, a comprehensive understanding of the technologies and

implementations involved in blockchain-based e-voting platforms is imperative in order to evaluate their feasibility and functionality. Furthermore, this systematic review provides technical insight into common blockchain frameworks, consensus algorithms, and security and privacy-enhancing techniques used in these systems. In addition, we aim to conduct an examination of the impacts of proposed blockchain-based e-voting systems in the literature on various aspects of the voting process, including security, privacy, efficiency, and scalability.

Overall, the purpose of this review is to conduct an extensive review of the current state of the literature related to blockchain-based e-voting systems. We look into the benefits, challenges, technological aspects, impacts, and potential research and development areas in the context of e-voting systems using blockchain technology. We conduct a combined review method, employing the principles of systematic literature review to choose and classify scientific papers. Additionally, we examine the technology implemented in these with respect to the already mentioned key concerns. The evaluation follows the PRISMA guidelines [1], which guarantee a rigorous and transparent methodology for the synthesis of available research data. The PRISMA protocol (Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols) is a reporting guideline designed to aid researchers in the preparation and documentation of systematic review and meta-analysis protocols.

II.   LITERATURE SURVEY

Studies exploring potential applications of blockchain technology in the domain of e-voting aim to evaluate its feasibility, security, and efficiency in enhancing the transparency and integrity of the election process.

Taş and Tanrıöver [30] reviewed in 2020 the state of blockchain-based voting research, identifying potential challenges and forecasting future directions. They presented a conceptual description of the desired blockchain-based e-voting application and conducted a review of 63 research papers. The articles that were examined were categorized into five main categories: general, integrity, coin-based, privacy, and consensus. They concluded that, whereas blockchain-based voting systems can prevent data manipulation and

integrity issues, the most frequently highlighted issues are scalability, cost-effectiveness, authentication, privacy, and security in blockchain-based e-voting systems.

Jafar et al. [31] presented a conceptual description of a blockchain-based e-voting application in addition to an introduction to the blockchain's fundamental structure and characteristics in relation to e-voting. They mentioned that whereas blockchain systems could help solve some of the issues that currently affect election systems, the authors conclude that the most frequently mentioned issues in blockchain applications are scalability, user identity, transactional privacy, energy efficiency, immatureness, acceptableness, and political leaders' resistance.

In [32], Pawlak et al. indicated the remaining problems like security attacks, coercion, cost efficiency, and privacy that still need to be solved. The paper serves as a valuable resource for understanding the current trends and challenges in blockchain-based electronic voting systems.

Huang et al. [33] in 2021 provided a comprehensive review of blockchain-based voting systems, discussing their advantages, challenges, and technical innovations. They also provide a taxonomy of blockchain and identify key challenges in blockchain-based voting systems such as authentication, anonymity, coercion-freeness, and auditability.

Jafar and Ab Aziz in [34] emphasized the benefits and challenges of blockchain-based e-voting systems, providing useful details on probable future applications of this technology with regard to democratic processes. They demonstrated how blockchain technology offers security, transparency, and a reduced risk of fraud. However, they brought up issues with scalability, transactional privacy, and immaturity for these systems.

Devi and Bansal [35] provided a comprehensive review of the security requirements and potential threats in e-voting systems. They discuss various cryptographic techniques that can be used to secure these systems.

Benabdallah et al. [36] presented a comprehensive analysis of blockchain solutions for e-voting. They discussed the challenges faced by e-voting systems

and how blockchain technology can address these issues. They also provide a comparison of several blockchain-based e-voting solutions, identifying their strengths and weaknesses. The paper also addressed the limitations and issues raised by this technology, such as scalability, unpredictable attacks, weakness of the identification system, new issues raised using blockchain technology, efficiency and decentralization, the digital divide, and vulnerabilities in smart contracts.

Jafar et al. in their systematic literature review [37] discussed the challenges and solutions for scalable blockchain-based electronic voting systems, in addition to anticipating future developments. To evaluate cost and time, they identified well-known proposals, their implementations, verification methods, and various cryptographic solutions in previous research. They analyzed performance parameters, the primary benefits and limitations of different systems, and the most common approaches to blockchain scalability.

In [38], Vladucu et al. provided a thorough overview of blockchain-based e-voting systems currently in use by various countries and companies, as well as those proposed for academic research. The authors discussed the challenges that blockchain e-voting systems face and identified areas for future research to improve their trustworthiness. Furthermore, they included a detailed explanation of the terminology used in blockchain-based e-voting systems, such as consensus algorithms, cryptography, and system characteristics.

III.   METHODOLOGY

This review follows the PRISMA protocol to ensure a transparent and rigorous review process and applies systematic literature review principles to selected papers. This systematic approach includes a structured review of the current literature on blockchain-based e-voting systems. The objective of this review is to provide a fair analysis of the available information using a systematic approach designed to minimize bias by following common selection, analysis, and validation procedures.

The hypothesis of this study is that by applying the distinct features of blockchain technology, such as decentralization, immutability, and transparency, it is possible to address the weaknesses and constraints related to traditional voting systems. This idea suggests integrating blockchain technology, and this hypothesis implies that this leads toward enhanced democratic procedures.

A search technique is used to discover relevant research, which includes utilizing precise keywords and concepts that relate to electronic voting, such as e-voting, i-voting, evoting, ivoting, electronic voting, internet voting, and election. Furthermore, the search approach encompasses blockchain-related terms such as blockchain, distributed ledger, and DLT. Boolean operators, in particular ("OR", "AND") are used to combine keywords and filter search results, ensuring that only papers that address both subjects are retrieved.

Search query: (evoting OR ivoting OR e-voting OR i-voting OR ((electronic OR internet) AND (voting OR vote OR election))) AND (blockchain OR "distributed ledger" OR DLT)


Blockchain Based E-Voting System - Block Diagram
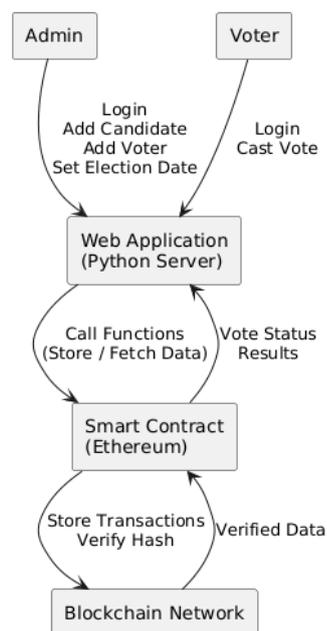
The literature search was conducted using reputable databases (ACM, IEEE, Elsevier, Springer, and Scopus). The process of searching for relevant studies involves initially screening titles to identify potentially relevant ones. This is followed by a thorough review of the full text of the articles to determine whether they answer any of the research questions.
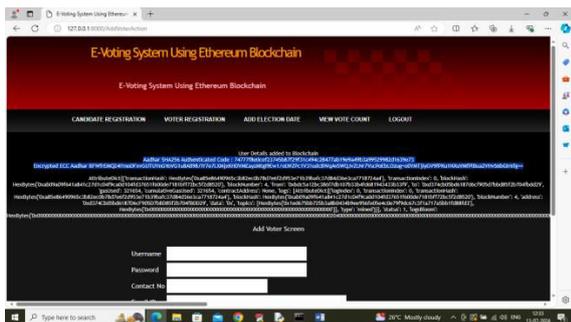
A number of exclusion and inclusion criteria can be established. Inclusion criteria are:

Papers that are directly related to or contribute to the comprehension of blockchain-based e-voting systems are relevant to the title.
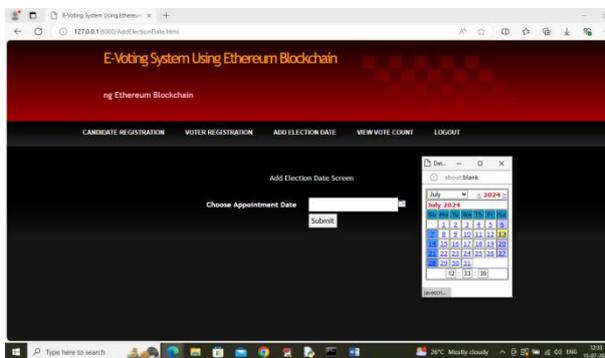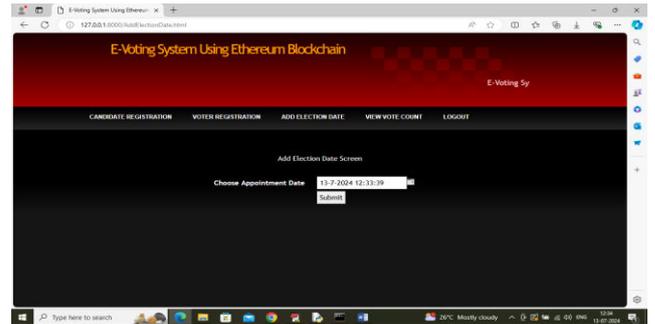
IV. RESULTS
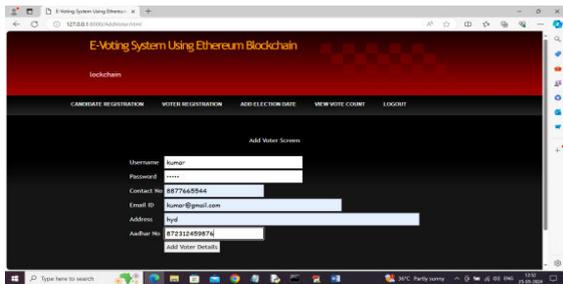
In above screen admin adding voter details along with username and password and then press button to get below page
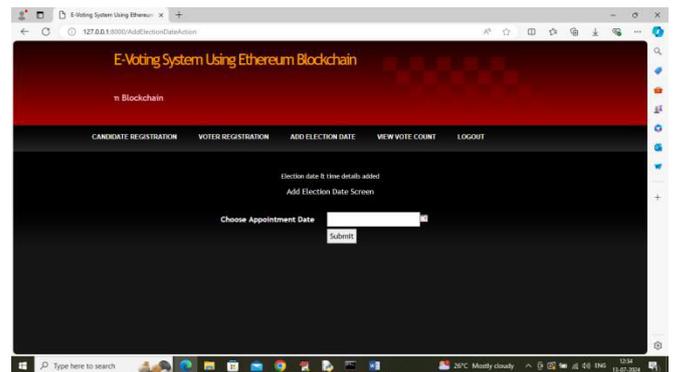

In above screen user details added and similarly you can add any number of users and now click on 'Add Election Date' link to get below page

In above screen admin will select desired date from calendar to get below page
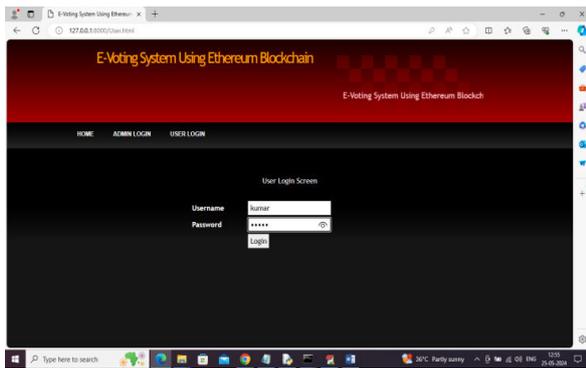

In above screen click on button to add election date and get below page
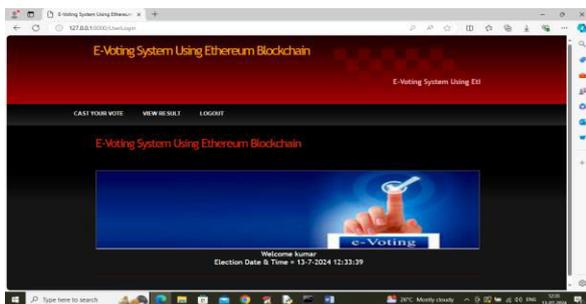

In above screen election date added and now click on 'View Vote Count' link to view all parties and their vote count

In above screen admin can view all candidate details and count is 0 as no vote casted yet and now logout and login as user

In above screen user is login and after login will get below page

In above screen in last two line user can see welcome message along with election date and today is 13th july only so he can cast vote and now click on 'Cast Your Vote' link to get below page

In above screen user can view list of all candidates and then click on 'Click Here' link beside any desired candidate name to cast vote and get below page
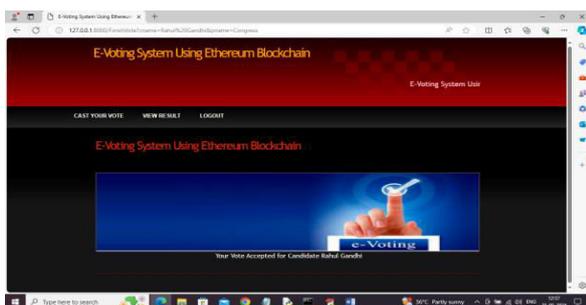
In above screen in last line user can see 'Vote Accepted' and if user try to cast again then will get below error

In above screen user got error as 'Vote already casted' and now user or admin can click on 'View Result' link to get count details

In above screen can see vote count for each candidate and in above screen Rahul Gandhi count increase from 0 to 1.

Similarly by following above screens you can add candidate, voter and cat vote details to manage voting online

V. CONCLUSION

We presented a systematic review of the state of research into blockchain-based e-voting systems. This study is motivated by the need to comparatively assess benefits, challenges, and impacts and open future research in comparison to other types of voting systems. Furthermore, a discussion of technology aspects to address the required properties was lacking.

The evolution of blockchain-based e-voting systems from 2017 to 2023 has been marked by significant advancements, as evidenced by research papers from this period. Significant studies emerged, proposing a novel approach to utilizing blockchain technology for recording votes for different voting scenarios. These systems aimed to

address common limitations in existing voting systems and involved a critical evaluation of popular blockchain frameworks suitable for e-voting applications. During the years, the primary research emphasis shifted towards enhancing security and developing robust frameworks for blockchain-based e-voting systems. In recent years, the other aspects of e-voting systems, scalability and cost efficiency, have received more attention. Moreover, the importance of privacy-preserving protocols grew significantly, prompting the development of coercion-resistant and privacy-preserving e-voting protocols.

This study followed the PRISMA protocol, resulting in a selection of 252 papers. Five research questions centered on benefits, challenges, impacts, and open future research, as well as technology aspects, guided this study. To provide context, we supplemented this study of the literature with a comprehensive definition of voting system types as a framework, but also technology definitions, also extracted from the literature, in order to make the concerns better understood from an implementation perspective.

The results show that blockchain technology has the potential to successfully implement e-voting systems. Transparency and auditability are seen as undisputed benefits. Security and privacy are, as would be expected for voting processes, the central properties. Here, the potential is seen in blockchain technology over other platform technologies, but whereas some specific aspects are acknowledged, both remain serious open problems, which their top rankings in the frequency lists for challenges and future directions show.

An undisputed limitation of blockchains is their lack of scalability, which is the most serious non-security concern. Beyond core platform concerns, usability, verifiability, accessibility, reliability, and acceptability are properties of concern that in the wider voting systems implementation require more attention. Where evident from the studies considered, we supplemented these observations with concrete solution techniques.

Therefore, this study effectively clarifies both the potential and the limitations of blockchain-based e-voting systems. It achieves this by jointly integrating an analysis of fundamental properties with practical technological implementations and

exploring a future roadmap, concluding in a comprehensive discussion that offers a holistic view of the topic.

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