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DEVELOPMENT AND RESEARCH OF AN ELECTRONIC VOTING SYSTEM BASED ON BLOCKCHAIN TECHNOLOGY

РАЗРАБОТКА И ИССЛЕДОВАНИЕ СИСТЕМЫ ЭЛЕКТРОННОГО ГОЛОСОВАНИЯ, ОСНОВАННОЙ НА ТЕХНОЛОГИИ БЛОКЧЕЙН

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Аннотация. Внедрение систем электронного голосования получило широкое распространение во всем мире, что обусловлено стремлением усовершенствовать процесс голосования и снизить уровень мошенничества. Однако традиционные системы электронного голосования страдают от уязвимостей в системе безопасности, которые делают их уязвимыми для взлома и

манипуляций. Интеграция технологии блокчейн в системы электронного голосования предлагает многообещающее решение, обеспечивающее повышенную безопасность и прозрачность. Целью данной статьи является изучение применения технологии блокчейн в системах электронного голосования, ее преимуществ и потенциальных проблем.

Abstract. The adoption of electronic voting systems has gained significant traction globally, driven by the desire to enhance the voting process and mitigate fraud. However, traditional electronic voting systems suffer from security vulnerabilities that make them susceptible to hacking and manipulation. The integration of blockchain technology into electronic voting systems offers a promising solution, providing increased security and transparency. This paper aims to explore the application of blockchain technology in electronic voting systems, examining its advantages and potential challenges.

Keywords: electronic Voting, blockchain technology, decentral- ization, transparency, security, cryptography, trustless system, smart contracts voter privacy, authentication

Ключевые слова: электронное голосование, технология блокчейн, децентрализация, прозрачность, безопасность, криптография, система, не требующая доверия, смарт-контракты, конфиденциальность избирателей, аутентификация.

Introduction

Blockchain technologies open up new opportunities for improving the efficiency of public administration. Blockchain allows you to create decentralized, transparent and reliable accounting and data exchange systems. This provides a number of advantages for the public sector:

• Increasing transparency and trust of citizens. The data in the blockchain cannot be forged, this increases people's trust in the authorities.

• Fight against corruption. Blockchain eliminates the possibility of data manipulation, which makes corruption schemes more difficult.

• Automation of processes. Smart contracts in the blockchain allow you to automate routine processes and reduce bureaucracy.

• Cost reduction. Decentralized registries are cheaper than traditional databases, saving money.

In general, blockchain provides the potential for digital transformation of the public sector. The first projects are already being implemented in the areas of public procurement, registration of property rights, voting, taxation, etc.

One of the promising areas of blockchain application in the public sector is the sphere of public procurement and contracts. The technology allows to increase their transparency and efficiency.

Firstly, the blockchain ensures the immutability of procurement and contract data. This eliminates the possibility of falsification of trading results and contract terms.

Secondly, the use of smart contracts automates the procurement process from start to finish. The terms of delivery and payment are specified in the smart contract and are executed automatically upon the occurrence of certain events.

Thirdly, all data on purchases and contracts in the blockchain is public and transparent. This allows anyone to monitor the procurement process and conditions.

Thus, an effective system of public control is being created, and corruption in public procurement is being reduced. Similar solutions are already being implemented in a number of countries, including the UAE, Chile, and Georgia.

Blockchain is also used in e-government systems for the identification of citizens, registration of property rights, voting and many other tasks that require transparency and immutability of data.

Despite the great potential, the introduction of blockchain in the public sector also faces a number of problems.

Firstly, there is a lack of knowledge and competencies among civil servants in the field of new technologies. Staff training and involvement of IT specialists are required.

Secondly, the need to change existing business processes and the regulatory framework for new technological solutions. This is a difficult and time-consuming job.

Thirdly, the issues of ensuring confidentiality and data security when using public blockchain networks. Hybrid solutions using private blockchains are required.

Nevertheless, as blockchain technology improves and the above problems are solved, its use in the public sector will only grow. In the coming years, we will see the large-scale implementation of blockchain solutions in such areas as e-government, public control, citizen identification and much more.

Electronic voting systems have attracted considerable attention as a potential solution to improve the efficiency, security and transparency of the electoral process. However, traditional electronic voting systems still face problems related to security vulnerabilities, voter confidentiality and lack of trust.

Blockchain-based electronic voting offers several advantages that resonate with the goals and challenges faced by Kazakhstan's electoral process. Firstly, it ensures the integrity of the voting process by leveraging cryptographic techniques to secure transactions and prevent tampering or fraud. This addresses concerns about the transparency and trustworthiness of election results, fostering confidence among citizens in the democratic process.

Secondly, the decentralized nature of blockchain technology eliminates the need for reliance on a central authority, mitigating the risks associated with single points of failure or manipulation. By distributing voting records across a network of nodes, the system enhances resilience against cyberattacks or external interference, safeguarding the sanctity of elections.

Furthermore, blockchain-based electronic voting systems offer unparalleled transparency, enabling real-time access to verifiable voting data while preserving the anonymity of individual voters. This transparency fosters accountability and facilitates independent audits, contributing to the overall credibility of the electoral process.

Moreover, the adoption of electronic voting aligns with Kazakhstan's broader agenda of embracing digital transformation and innovation across various sectors. By investing in state-of-the-art technology for electoral purposes, Kazakhstan demonstrates its commitment to modern governance practices and civic engagement, positioning itself as a progressive leader in the region. Blockchain, a decentralized and immutable digital ledger, has revolutionized various industries by providing transparency, security, and trust without the need for intermediaries. By leveraging blockchain technology, an e-voting system can ensure tamper-proof and auditable transactions while preserving voter anonymity and privacy. Traditional electronic voting systems have been criticized for their vulnerability to hacking, manipulation, and vote tampering, which can lead to doubts about the legitimacy and accuracy of election outcomes [2]. The conditions need to be satisfied for blockchain based voting electronic systems

Traditional e-voting systems are susceptible to hacking, manipulation, and data breaches. The paper will focus on designing a blockchain-based e-voting system that provides robust security mechanisms, such as cryptographic protocols, decentralized consensus, and immutable record-keeping, to protect against cyber threats and ensure the integrity of the voting process [3], [4].

Lack of transparency in traditional e-voting systems often leads to suspicions of fraud and doubts about the accuracy of results. The paper will explore how blockchain technology can enable a transparent and verifiable voting process, allowing all participants to independently verify the authenticity of votes and the integrity of the overall system [4].

Preserving voter privacy is a critical requirement in any voting system. The paper will address the challenge of ensuring anonymous voting while utilizing blockchain technology. It will investigate privacy-enhancing techniques, such as zero-knowledge proofs or homomorphic encryption, to protect the confidentiality of votes and prevent the identification of individual voters.

Blockchain technology faces scalability limitations, particularly concerning transaction throughput and network consensus. The paper will examine techniques, such as sharding, sidechains, or layer-2 solutions, to overcome scalability chal- lenges in a blockchain-based e-voting system and ensure its practical viability for large-scale elections.

The adoption of blockchain-based e-voting systems requires careful consideration of legal and regulatory frameworks. The paper will explore the legal challenges associated with implementing such systems, including compliance with data protection laws, electoral regulations, and privacy regulations. It will provide insights into the necessary legal frameworks and propose strategies to ensure compliance while leveraging the benefits of blockchain technology correctly [2].

The comparison between traditional voting process and electronic voting system based on blockchain is presented on the table below:

Table 1. Comparison between traditional voting process and electronic voting system based on blockchain.

	traditional voting	*blockchain-based e-voting*
Security	Relies on physical ballot papers which can be susceptible to tampering, counterfeiting, or loss during transportation and storage. Security measures are	Utilizes cryptographic algorithms and decentralized ledger technology to ensure the integrity and security of votes. Each vote is encrypted and

	primarily enforced by human oversight	recorded as a tamper- proof transaction on the blockchain, reducing the risk of fraud or manipula- tion
Transparency	Transparency is limited, as the process of counting and tallying votes is typically conducted behind closed doors by election officials. Results may not be immediately accessible to the public	Offers unparalleled transparency by providing real-time access to the voting process and verifiable results. Every transaction on the blockchain is transparent and auditable, allowing for independent verification by all stakeholders
Accessibility	Requires voters to physically visit polling stations during designated hours, which may pose challenges for individuals with mobility issues, those living in remote areas, or citizens residing abroad	Enhances accessibility by allowing voters to cast their votes remotely us- ing internet-enabled de- vices such as smartphones or computers. This enables broader participation and reduces barriers to entry for marginalized or geographically dispersed communities
Anonymity	Offers anonymity through the use of secret ballot papers, ensuring that individual voting choices remain confidential	Preserves voter anonymity by encrypting voting transactions on the blockchain. While the vote itself is recorded publicly,

		the identity of the voter remains anonymous, thereby protecting privacy.
Trust	Trust in the electoral process relies heavily on the integrity of election officials and the transparency of manual counting procedures. Suspicions of fraud or misconduct can undermine trust in the outcome	Builds trust through the use of decentralized consensus mechanisms and cryptographic protocols, which eliminate the need for trust in centralized authorities. The transparent and auditable nature of blockchain technology enhances trust among stakeholders, including voters, candidates, and election observers
Cost and Efficiency	Involves significant costs associated with printing and distributing paper ballots, staffing polling stations, and manual counting processes. It is also time-consuming and prone to delays in tallying results	Offers potential cost savings by streamlining the voting process, reducing the need for physical infrastructure, and automating counting procedures. It also provides faster and more efficient results tabulation, enabling timely announcement of election outcomes.

Literature review

Therefore, the aim of this paper is to investigate the feasibility of using blockchain technology to develop an electronic voting system that addresses these challenges and provides a secure and trustworthy platform for democratic elections.

There are several studies which have explored the potential of blockchain-based electronic voting systems. For example, Bohme et al. proposed a blockchain-based voting system that uses smart contracts to automate the voting process and ensure its honesty [6].

Some of the other studies have investigated the potential of blockchain technology in electronic voting systems. For example, Kshetri [7] conducted a systematic review of blockchain-based electronic voting systems and identified key challenges and opportunities for their adoption. The study concluded that blockchain-based electronic voting systems have the potential to increase transparency, security, and trust in the voting process.

Another study by Dagher et al. [8] proposed a blockchain-based electronic voting system called ”Follow My Vote” that uses a combination of cryptographic protocols and smart contracts to ensure transparency, privacy, and security in the voting process. The system was evaluated using a prototype implementation and showed promising results in terms of performance and usability [5].

Literature review suggests that blockchain-based electronic voting systems have the potential to solve the challenges of security, privacy, and transparency in electronic voting [9].

The first problem of the currently available electronic voting systems us the security, proposed systems are not strong enough to secure from DoS attacks because

there is no third-party authority on the scheme responsible for auditing the vote after the election process.

Another problem is that electronic voting systems based on blockchain experience scalability issues. These systems can be used on a small scale. This systems are not efficient for the national level to handle millions of transactions because they use current blockchain frameworks such as Bitcoin, Ethereum, Hyperledger Fabric, etc. [10].

All of the reviewed systems use PoW consensus, which has significant drawbacks such as energy consumption: the "supercomputers" of miners monitor a million computations a second, which is happening worldwide. Because this arrangement requires high computational power, it is expensive and energy-consuming.

There is a need for more research to determine the effectiveness and practicality of blockchain-based electronic voting systems, particularly in developing countries where there is a high prevalence of electoral fraud.

Methodology

The utilization of mobile communication in the elecronic voting system enables individuals to take part in process of voting by installing the dedicated mobile software on their devices (Fig 1).

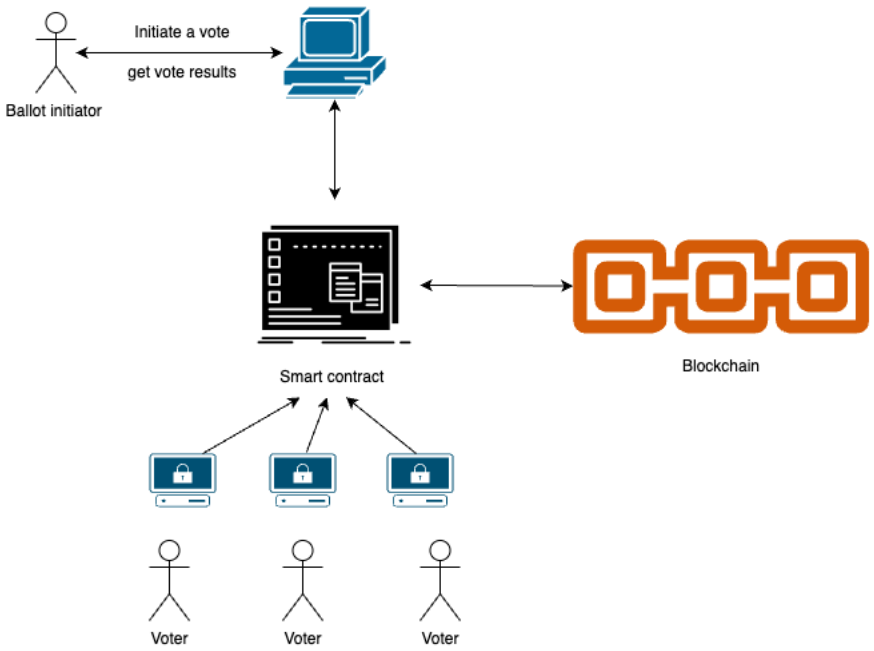

Figure 1. Methodology

The proposed framework for the remote electronic voting process, which incorporates blockchain technology, comprises next steps:

In order to participate in mobile voting, citizens must firstly confirm their citizenship within the jurisdiction. This entails visiting an identity verification point where they present a valid identification document to the Operator, an independent third party authorized to verify the user's identity and voting eligibility within the mobile application (Fig.2).

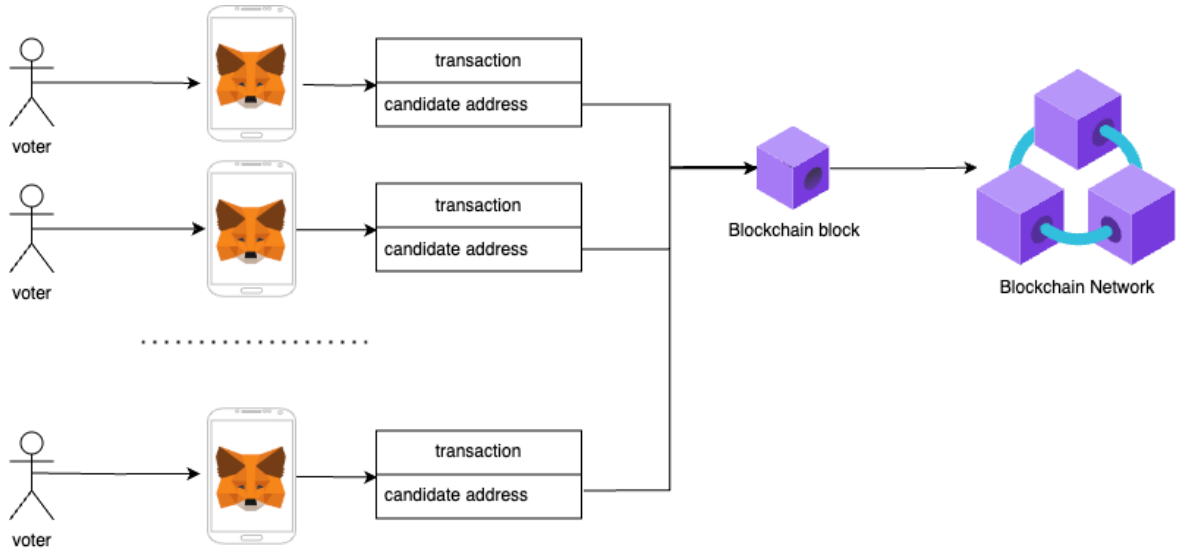

Figure 2. Voting algorithm

This process ensures that only eligible voters gain access to the voting system. While this step is necessary for voters to get an access to an e-voting system, it should be noted that the process is not fully automated as it relies on the physical appearance of voters at the identity verification point. However, this physical verification aligns with the transparency aspect of identity authentication and is performed by the election organizers (Operators) during a specific timeframe set by the Central Election Commission (CEC), such as during the election campaign period. In order to achieve this, users must possess an electronic private address of a wallet that is registered on a specific blockchain. The mobile phone establishes a connection with the blockchain ledger by scanning a QR code generated by the voting system. This QR code serves as a means to generate a token, which enables users to cast their votes.

The functionality of the making a vote and chainging your vote buttons in the mobile application is directly influenced by the voting period. When users log into the mobile application before the start of the voting period, the make a vote button remains inactive. Once the voting period commences, the make a vote and chainging your vote buttons become active. When the voting period concludes, the chaiging vote tab is disabled. If a user fails to cast their vote within the voting period, the make a vote button becomes inactive.

This approach ensures that voters can actively participate in the elections on the designated date by receiving their voting token prior to the start of voting. Furthermore, each vote is associated with a specific address within the blockchain network, which is specified during the token issuance process.

The remote electronic voting system securely stores received votes within the Blockchain, enabling voters to verify the accuracy of their vote allocation in real-time by clicking the link which leads to your transactions page in the mobile application. In case of indecision, coters can make abother vote and this won’t be written to a

blockchain. Their vote at any time before the voting period concludes by selecting their preferred candidate and confirming their choice. The corresponding token will then be sent to the chosen candidate's wallet.

Once a person who make a vote has cast their vote, they can access interim online voting results and review the public transaction register to ensure their vote has been accounted for. This can be done by following the "All transactions" link in the mobile application. After the voting deadline, the final voting results can be obtained online through the mobile application [11].

The user interface of the mobile application simplifies and automates the process of sending tokens to specific addresses. Voters are presented with a straightforward interface where they can select their preferred candidate from a list and click the make a vote button [12]. The remote electronic voting system leverages the power of smart contracts, which play a crucial role in ensuring the integrity and transparency of the voting process. Smart contracts are self executing contracts with the terms of the agreement directly written into the code. In the context of the e-voting system, smart contracts serve as the backbone of the decentralized and automated voting process [13]. Within the smart contract, the voting structure is defined to store and organize the relevant data. It acts as a container for vital information, ensuring the proper functioning of the voting process. By utilizing this structure, the system can efficiently manage voter registration, vote recording, candidate tallies, and other essential aspects of the electoral process [14].

The transparency and immutability of smart contracts make them ideal for ensuring the integrity of the voting system. Every action, such as voter registration, vote submission, and result calculation, is recorded on the blockchain, providing an indelible audit trail that can be independently verified by stakeholders, including voters, election officials, and auditors [15].

By incorporating smart contracts into the e-voting system, the process becomes more secure, transparent, and efficient. Voters can have confidence in the accuracy of the results, as the tamper-proof nature of the blockchain prevents any unauthorized changes to the recorded data. Furthermore, the automated execution of smart contracts reduces the likelihood of human error or manipulation in the voting process.

Results

As part of the research and development process, significant progress has been made in the area of smart contract development. The focus has been on implementing voter information deployment to smart contracts using Solidity, a programming language for Ethereum smart contracts. Through experimentation in the Ethereum testnet environment, the feasibility and functionality of the smart contract deployment process have been successfully demonstrated.

Moving forward, the next steps involve implementing the voter process algorithm within the smart contract. This algorithm will outline the specific steps and rules for conducting the voting process, ensuring that it is fair, transparent, and secure. By incorporating this algorithm into the smart contract, the system will be able to autonomously handle various aspects of the voting process, such as verifying voter eligibility, recording votes, and calculating the final results.

To validate and refine the developed prototype, a Friends and Family Test will be conducted. This test will involve a small group of participants who will simulate the voting process using the developed e-voting system. The objective of this test is to evaluate the usability, functionality, and performance of the system in a controlled environment. Feedback and insights gathered from the test participants will be invaluable in identifying any potential issues or areas for improvement before scaling up the system for larger-scale implementations.

By implementing the voter process algorithm and conducting the Friends and Family Test, the research project aims to validate the effectiveness and practicality of the

developed e-voting system based on blockchain technology. The findings from these activities will inform the further development and refinement of the system, bringing us closer to a secure and reliable solution for electronic voting.

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