Implementation of Student Voting Platform on ICP Blockchain

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Abstract

In this comprehensive exploration, our paper delves into the intricate implementation of robust authentication and transaction management within the realm of educational blockchain systems. Our innovative project stands as a testament to the commitment to privacy and integrity, safeguarding student and administrative interactions through the adept application of advanced cryptographic techniques—all achieved without reliance on a centralized authority. The multifaceted capabilities of blockchain technology are showcased through the seamless maintenance of student records, the facilitation of secure voting processes, and the optimization of token transfers, collectively contributing to an ecosystem characterized by enhanced security, transparency, and efficiency. Beyond the immediate applications, our study uncovers profound insights into the transformative potential of blockchain within the education sector, redefining conventional paradigms by introducing unparalleled security measures and transparency to the intricate dynamics of student-admin interactions. This research not only underscores the feasibility of blockchain in addressing the unique challenges of educational institutions but also offers a roadmap for leveraging its capabilities to create a more secure, accountable, and streamlined educational ecosystem. The paper thus serves as a pioneering contribution, illuminating the path towards a future where blockchain technologies play a pivotal role in shaping the educational landscape.

Key Words: Blockchain, Internet Computer Blockchain (ICP), Student Voting, Decentralized, Consensus, Cryptography, SHA-256 Algorithm, Encryption

1. Introduction

Democracy and trust in electoral processes are fundamental to the stability and prosperity of any society [1]. Transparent, secure, and equitable voting systems are at the heart of this democratic ethos. Traditional voting methods have their limitations, including the potential for tampering, scalability issues, and concerns related to transparency. Recent developments in blockchain technology have presented promising solutions to address these challenges.

Blockchain technology, with its decentralized and immutable nature, is revolutionizing the way we approach voting systems. It offers the potential to create transparent, secure, and tamper-resistant voting processes. However, while blockchain-based e-voting systems have shown immense potential, they have also faced their share of criticisms and challenges [2].

At the national level, implementing blockchain-based voting systems, with their inherent complexities and scalability concerns, remains a formidable task [3]. The scale of such elections, coupled with the significance of their outcomes, makes them vulnerable to interference and security risks. While the adoption of e-voting in
universities has shown promising results in terms of increased voter turnout and efficiency, university-level elections can also benefit from more reliable and secure e-voting systems [4].

This paper introduces a novel approach to student voting, focusing on the university level. Leveraging the power of blockchain technology, specifically the Internet Computer Protocol (ICP) blockchain, and adopting a decentralized Web3 approach, we propose an innovative and secure e-voting system tailored for the unique needs of student elections. In this context, we aim to draw upon the valuable insights from two key papers in the field.

Our paper implements decentralized application built on ICP blockchain, Student Voting system designed to provide transparency and anonymity for student voters, comprising two essential stages: the voting process itself and the subsequent validation. This approach aligns with the evolving landscape of e-voting technologies, offering increased security and efficiency. By utilizing blockchain tables and a centralized database, our solution eliminates the need for complex consensus algorithms, enhancing practicality while maintaining privacy and security.

The proposed architecture emphasizes separation of layers and roles to prevent any undue influence on the voting process. A unique hash ensures the anonymity of voters while guaranteeing the integrity of the vote, with no link between voters and their choices stored in the ICP Canisters. With this approach, we uphold the principles of transparency and auditability, free from hidden components or potential fraud.

We aim to contribute to the ongoing evolution of e-voting systems, particularly in university contexts. This paper outlines the development of a practical and secure e-voting solution for students, taking advantage of blockchain technology and the decentralized Web3 approach to provide a trustworthy and efficient platform for university-level elections.

2. Literature Survey

Numerous studies and initiatives have explored the integration of blockchain technology into voting systems to address the challenges inherent in traditional voting methods. In this section, we review notable research efforts in this field and emphasize their contributions.

S. -V. Oprea et al. proposed solution suggests a conceptual architecture for e-voting in universities, employing encrypted functions and a two-stage process (voting and validation) based on blockchain tables. The design incorporates innovative interactions between voters, the voting committee, and software components, depicted through Unified Modeling Language (UML) diagrams for replicability. Initial steps in implementing the proposed solution are also showcased to provide a proof of concept. [1]

M. S. Farooq et al. addresses widespread mistrust in traditional and digital voting systems due to concerns about transparency and exploitation. It advocates for the use of blockchain technology to enhance fairness and reduce injustice in elections. The proposed platform, based on blockchain, ensures maximum transparency and reliability, fostering trust between voters and election authorities. It introduces a scalable blockchain with a Chain Security Algorithm, smart contracts, and encryption to secure voting transactions, providing a framework for digital voting without physical polling stations and demonstrating potential for large-scale implementation. [2]

S. S. Hossain et al. highlights widespread mistrust in traditional and digital voting systems, emphasizing the need for a solution to secure democratic rights. It proposes a blockchain-based platform to address transparency issues and build trust between voters and election authorities. The platform offers a framework for digital voting without physical polling stations, incorporating scalable blockchain, flexible consensus algorithms, and a Chain Security Algorithm for enhanced transaction security. The article also discusses smart contracts, encryption methods, and measures against a 51% attack on the blockchain, demonstrating the potential for large-scale implementation through performance evaluation. [4]
B. Shahzad et al. addresses the shortcomings of electronic voting systems by proposing a framework that utilizes effective hashing techniques for enhanced security. The concept of block creation and sealing is introduced, allowing the blockchain to adapt to the polling process. The use of a consortium blockchain, owned by a governing body like the election commission, is suggested to prevent unauthorized access. The framework aims to improve the security and data management challenges in electronic voting, presenting an advanced manifestation of the process. [5]

F. P. Hjálmarsson et al. addresses the challenge of creating a secure electronic voting system that balances fairness, privacy, transparency, and flexibility. The focus is on implementing a distributed electronic voting system using blockchain as a service. The paper proposes a novel blockchain-based e-voting system, addressing limitations in existing systems, and evaluates popular blockchain frameworks. A case study on the election process demonstrates how the implementation of a blockchain-based application enhances security and reduces the cost of hosting nationwide elections. [6]

N. Mohd. Suki et al. investigates the determinants influencing students' decision-making and satisfaction in campus e-voting, employing self-administered questionnaires among university students with past electronic voting experience. Using the PLS-SEM approach, the study identifies voters' commitment as the strongest determinant of decision-making and satisfaction in campus e-voting. High satisfaction is linked to students' commitment and the university's voting requirement, with compulsory voting seen as beneficial for campus development. [7]

M. A. Specter et al. scrutinizes claims that "voting over the Internet" or "voting on the blockchain" would enhance election security and finds them misleading. It emphasizes the heightened risk of undetectable, nation-scale election failures with Internet- and blockchain-based voting. While online voting may seem convenient, studies suggest it may not significantly increase turnout and could exacerbate disenfranchisement. The article underscores persistent security risks in electronic voting, including blockchain-based systems, and highlights the need for critical assessment of security in new voting system proposals. [9]

K. M. Lewis et al. addresses the lack of scholarly literature on the marketing activities of students' governments, aiming to fill the existing gap. Drawing on participatory observations and experiences within a Polish university's student government, the authors identify three key determinants of effective marketing communication: student attitude and engagement, content and promotion tool selection, and available financial resources. It introduces a typology of individuals engaged in promotional activities for students' organizations and defines the contents to be conveyed to diverse groups within the environment of students' governments. It serves as an introductory exploration of this under-researched subject, laying the groundwork for future theoretical and research endeavors. [10]

The current landscape of blockchain-based voting systems reveals that while several endeavors have aimed to create secure, efficient, and transparent voting mechanisms, a comprehensive solution encompassing all these requirements has yet to be realized.

### 3. Gaps in literature

While various studies have explored the integration of blockchain technology into voting systems, there are distinct gaps in the existing literature that your paper aims to address. Notably, the majority of previous research, suggested a conceptual architecture for e-voting at the university level was presented, but it primarily relied on a centralized database for vote storage and management. While this approach may work in certain scenarios, it falls short of leveraging the full potential of blockchain technology, particularly in the context of voting systems.
In contrast, our paper offers a decentralized approach that leverages the Internet Computer Protocol (ICP) blockchain. The decentralized nature of the ICP blockchain brings significant advantages to the forefront. By deploying our project within the ICP blockchain, our Decentralized Application (Dapp) runs in a canister, accessible through HTTP requests and responses. This eliminates the need for a centralized authority or intermediary entities that are traditionally involved in blockchain voting systems.

One of the key contributions of our paper is the removal of intermediaries in the practical implementation of the voting system. By utilizing the ICP blockchain, we establish a trustless environment where votes are securely recorded and counted without the need for trust in external entities. This not only enhances transparency but also minimizes the risk of manipulation, as the immutability of the blockchain ensures the integrity of the voting process.

Furthermore, while previous research, including [1], encountered challenges in terms of scalability and voter privacy, our proposed system addresses these concerns. The ICP blockchain's built-in consensus mechanism and cryptographic hashing optimize latency, ensuring efficient management of a large number of voters. The blockchain's decentralization and immutability strengthen user trust, addressing the limitations found in centralized databases.

In summary, the existing literature primarily relies on centralized databases, introducing vulnerabilities and limitations in digital voting systems. Our paper bridges this gap by offering a decentralized approach that leverages the ICP blockchain, eliminating intermediaries and enhancing the security, transparency, and scalability of the voting process. This contribution represents a significant step forward in the field of blockchain-based voting systems.

4. Proposed System

The proposed system aims to revolutionize the conventional voting methods by harnessing the exceptional capabilities of the Internet Computer Protocol (ICP) blockchain. It utilizes the decentralized nature and immutability of the ICP blockchain to establish a secure, efficient, and transparent voting process. This blockchain-based voting system is designed to overcome the critical challenges associated with traditional voting systems, ensuring a resilient and trustworthy electoral process.

4.1 Voting System Architecture

The architecture of our innovative voting system begins with a user-friendly interface developed using React Admin. Students can effortlessly log in to the system, facilitating a seamless and intuitive voting experience. What sets our system apart is the robust security measures implemented for user verification. Each user is verified using SHA-256 cryptography, ensuring the integrity of their identity and preventing unauthorized access. This cryptographic layer adds an extra dimension of security, crucial for maintaining the trust and integrity of the voting process.

Once verified, students gain access to the Decentralized Application (Dapp) hosted on the Internet Computer Protocol (ICP) blockchain's canister. This Dapp is the core component of our system, facilitating the entire voting process through HTTP requests and responses. Leveraging the ICP blockchain, data regarding updates is stored in respective canisters distributed across the system, ensuring data integrity and availability. An essential element of our architecture is the use of the Motoko programming language, the built-in language for ICP's smart contract development. The use of Motoko simplifies the process of creating secure and efficient smart contracts, guaranteeing that votes are accurately recorded and counted, making our voting system both secure and reliable.
This architecture combines user-friendly interfaces, strong cryptography, blockchain technology, and smart contract development, creating a comprehensive and trustworthy voting system for students.

![Fig. 1. Student Voting System Architecture](image.png)

### 4.2 Workflow of the Proposed Model

#### 4.2.1 Decision Proposal
- The administrative staff (Admin) proposes decisions with a set of voting options.

#### 4.2.2 Voting Process
- Students actively participate by casting their votes on the available decisions.
- To cast a vote, students should have a minimum number of tokens in their account.
- When a student casts a vote, a constant amount of tokens are deducted from their account.
- The system ensures that students cannot vote again for the same decision.

#### 4.2.3 Vote Counting
- The Admin can access the system to view the number of votes cast for each option within a specific decision.
- The voting system keeps a tally of the votes for each option.

#### 4.2.4 Decision Making
- When the voting period concludes or at the discretion of the Admin, the system determines the option with the majority of votes for each decision.
- The option with the most votes is declared the winner.
- After a decision is made, the voting data for that particular decision can be cleared from memory.

### 4.2 System Advantages

Our proposed system stands out by capitalizing on the immutability of blockchain technology. This makes the entire voting process resistant to tampering and secure against any single point of failure. Notable advantages of the proposed system include:

- **Transparency**: Every transaction is recorded and accessible on the blockchain, providing voters with a transparent view of the voting process.

- **Security**: Through cryptographic hashing, secure networks, and robust consensus algorithms, the
system minimizes the risk of intrusion.

- **Efficiency**: The flexibility of consensus algorithms and smart contracts optimize the system's efficiency, ensuring that votes are counted accurately and in a timely manner.

- **Accessibility**: Voters can participate from anywhere in the world, and the system maintains the integrity of their votes.

- **Trust**: By enhancing voter trust through end-to-end verification, our system ensures that voters have confidence in the voting process.

Our proposed system offers a comprehensive solution to the challenges faced by traditional and digital voting systems. It combines the benefits of blockchain technology with a flexible and adaptable architecture to create a highly secure, efficient, and transparent voting management system.

### 5. Technologies Used

#### 5.1 Internet Computer Protocol Blockchain

The Internet Computer Protocol (ICP) functions as a communication protocol employed for the transmission of data across the internet. This reliable and connection-oriented protocol enables applications to initiate, sustain, and conclude connections between devices. In contrast, Blockchain stands as a decentralized and distributed ledger technology designed to facilitate the secure, transparent, and immutable documentation of transactions. Although frequently utilized in cryptocurrencies like Bitcoin, Blockchain finds application in diverse sectors such as supply chain management and voting systems. While there are certain parallels between them, these technologies diverge in their intended functions and operational mechanisms.

#### 5.2 Motoko Programming Language

The Motoko programming language emerges as a contemporary and type-safe language tailored for developers aspiring to construct the forthcoming wave of distributed applications intended for execution on the Internet Computer blockchain network. Specifically crafted to accommodate the distinctive attributes of the Internet Computer, Motoko furnishes a programming environment that is both familiar and resilient. In its capacity as a nascent language, Motoko undergoes continual refinement, incorporating support for novel features and various enhancements.

#### 5.3 React Js

ReactJS stands as a JavaScript library dedicated to constructing user interfaces. Originating from the labs of Facebook, it currently undergoes joint stewardship by Facebook itself and a collaborative community comprising individual developers and various companies. This library empowers developers in crafting reusable UI components, thereby simplifying the intricate process of constructing dynamic and interactive web applications.

### 6. Design and Implementation

In this section, we present the design and implementation details of our blockchain-based voting system. Our system leverages the Internet Computer Protocol (ICP) blockchain and a React-based frontend to provide a secure and user-friendly voting platform. We describe the algorithms for student creation, casting votes, secure login, and additional critical functionalities.
6.1 Algorithms

6.1 Student Account Creation

The student creation algorithm allows eligible students to register for voting. Students are verified against the Canister data (ICP Blockchain decentralized data storage unit) before they can participate in the voting process.

![Algorithm: Student Creation](image)

6.1.2 Cast Vote

The casting vote algorithm records a student's vote and ensures that they can only vote once.

![Algorithm: Casting Vote](image)

6.1.3 Secure Login

The secure login algorithm ensures that only authorized users gain access to the system, preventing unauthorized access.
6.2 System Workflow

6.2.1 User Login

- Students register using their StudentID.
- Eligible students are assigned a unique StudentID.
- Student data is stored in the blockchain.

Figure 2. User Login
6.2.2 Create Decision

- Admin proposes a decision and provides options for which students have to participate.
- Decision ID specifies the decision and options for that decision should be entered in Options input, they should be separated using commas.

![Figure 3. Creating Decision](image)

6.2.3 Student Voting

- Eligible students cast their votes using their StudentID.
- Votes are recorded on the blockchain, ensuring transparency and immutability.

7. Performance Evaluation

In the performance evaluation of our paper, we employ response time as a crucial evaluation metric for our voting system. To provide a comprehensive assessment, we present two key graphs. The first graph illustrates the response time in relation to the number of queries, ranging from 1 to 1000. This graph vividly demonstrates how our system handles varying levels of user queries, showcasing its responsiveness. The second graph highlights the relationship between the number of updates, i.e., write operations on the blockchain, and the associated response time, also spanning from 1 to 1000. These graphs collectively offer a clear and quantitative representation of our system's performance, emphasizing its efficiency and scalability.
As the graph shows, on the x-axis, we have the "Number of Queries," which represents the quantity of interactions or requests made to our DApp. On the y-axis, we have "Time Taken (seconds)," which indicates the amount of time it takes for our DApp to respond to these queries.

Analysis of the performance based on the graph:

1. Consistency: One notable aspect is the consistency in response time. Even as the number of queries increases from 1 to 1000, the response time remains relatively stable. This suggests that our DApp maintains a consistent level of performance, which is a positive sign.
2. Scalability: Our DApp seems to handle an increase in the number of queries quite well. The slight increase in response time as the number of queries grows suggests that our system is scalable, which is essential for accommodating more users or transactions in the future.
3. Efficiency: The response times, ranging from 0.026 to 0.029 seconds, indicate that our DApp is responding quickly to user queries. This efficiency is crucial in providing a smooth and responsive user experience.
4. Reliability: The consistent response times across different query quantities reflect the reliability of our DApp. Users can rely on it to perform consistently, regardless of the workload.
Overall, based on this analysis, our DApp demonstrates good performance in terms of consistency, scalability, efficiency, and reliability. This bodes well for providing users with a seamless and dependable voting experience.

Table 2. Number of queries and Time taken

<table>
<thead>
<tr>
<th>S.No</th>
<th>No. of Queries</th>
<th>Time taken(seconds)</th>
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<td>0.026</td>
</tr>
<tr>
<td>2</td>
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<td>0.026</td>
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<td>0.028</td>
</tr>
<tr>
<td>6</td>
<td>1000</td>
<td>0.029</td>
</tr>
</tbody>
</table>

Graph 2. Time taken for Updates vs. Number of Queries

In this graph:
- On the x-axis, we have "Number of Updates," representing the quantity of updates or changes made to our DApp.
- On the y-axis, we have “Time Taken (seconds),” indicating the time it takes for our DApp to process these updates.

Analysis of the performance based on the graph:
1. Incremental Time Increase: As the number of updates increases, we can observe a gradual and incremental increase in the time taken for these updates. This suggests that our DApp's performance remains relatively stable as the update load grows. The increase in processing time is consistent and predictable.

2. Predictable Scalability: The predictable and incremental nature of the time increase indicates that our DApp is scalable. It can accommodate additional updates without experiencing sudden spikes in processing time, which is vital for maintaining a smooth user experience during periods of high activity.

3. Consistency: The performance of our DApp is consistent, which is a positive sign for users. They can expect a uniform experience regardless of the number of updates, as there are no sudden spikes or dips in processing time.

4. Stability: The stable and gradual increase in processing time suggests that our DApp is stable and capable of handling a growing number of updates without causing disruptions.

In summary, this analysis indicates that our DApp exhibits consistent and predictable performance when dealing with various numbers of updates. It demonstrates scalability, maintaining stable processing times as the update load increases. This reliability ensures that users can rely on our DApp for efficient and consistent interactions, which is crucial for the success of a voting application.

8. Conclusion

In conclusion, this project has successfully leveraged the power of blockchain technology and modern web development to create a secure, transparent, and efficient platform for enhancing governance within educational institutes. By utilizing the Internet Computer Protocol (ICP) blockchain, we have achieved an unprecedented level of decentralization and data integrity. This technology has empowered students to actively participate in decision-making through a token-based voting system, thereby fostering a culture of involvement and accountability.

The custom authentication system ensures that students and administrators can securely access the platform, while orthogonal persistence guarantees that vital student data remains tamper-proof. React, a versatile JavaScript library for building user interfaces, has provided a seamless and responsive user experience. The integration of these elements has culminated in a solution that promotes academic excellence and empowers students to contribute to extracurricular activities, making governance within educational institutes more inclusive and dynamic.

As this project demonstrates, the convergence of blockchain and web technologies holds immense potential for revolutionizing governance systems across various domains. By embracing this innovative approach, we have taken a significant step towards enhancing transparency, accountability, and student participation in educational institutions, which are the cornerstones of effective governance. In the ever-evolving landscape of technology and education, this project sets a promising precedent for the future.

9. Future Work

The blockchain-based decentralized voting system designed for educational institutes, as presented in this report, marks a significant advancement in the modernization and security of the voting process. Nevertheless, several avenues for potential future work and enhancements are identified. Firstly, it is imperative to focus on enhancing the system's security through continuous research, vulnerability assessment, and the development of robust countermeasures. Secondly, optimizing the user experience (UX) by conducting user studies and feedback analysis will ensure an intuitive and user-friendly interface. Thirdly, exploring methods to seamlessly integrate the decentralized voting system with existing educational platforms can provide a more comprehensive solution. Additionally, adapting the system for mobile accessibility, including the development of mobile applications, can cater to users who prefer voting via smartphones or tablets. Finally, it is essential to
remain abreast of blockchain advancements, particularly within the ICP ecosystem, and evaluate how these innovations can be integrated to augment the system's capabilities. These ongoing efforts reflect the commitment to continually enhance and expand the blockchain-based decentralized voting system for educational institutes, ensuring it remains adaptable to the evolving needs and expectations of educational institutions and their voting processes.

10. Bibliography