IT 433 Blockchain End Sem Report on

Blockchain-Based Preferential Voting System with Dynamic Re-Voting

Submitted in partial fulfillment of the requirements for the degree of

BACHELOR OF TECHNOLOGY

in

ARTIFICIAL INTELLIGENCE

by

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DECLARATION

We hereby *declare* that the Blockchain End Sem(IT433) entitled ***"Blockchain-Based Preferential Voting System with Dynamic Re- Voting"*** , which is being submitted to the **National Institute of Technology Karnataka, Surathkal**, for the award of the Degree of Bachelor of Technology in Artificial Intelligence, is a *bonafide report of the work carried out by us.* The material contained in this Blockchain End Sem(IT433) Report has not been submitted to any University or Institution for the award of any degree.

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CERTIFICATE

This is to *certify* that the Blockchain End Sem(IT433) Report entitled ***"Blockchain- Based Preferential Voting System with Dynamic Re-Voting"*** submitted by

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as the record of the work carried out by them, is *accepted as the B.Tech. Blockchain End Sem(IT433) report submission* in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Artificial Intelligence in the Department of Information Technology, NITK Surathkal.

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ABSTRACT

In an era where trust in electoral systems is paramount, traditional voting methods often fall short in ensuring fairness, transparency, and efficiency. Ranked choice voting (RCV) offers a compelling solution by enabling voters to express preferences beyond a simple "yes or no" choice, ensuring that the elected candidate has broader support. However, even RCV faces challenges such as vote manipulation and inefficient tallying processes. This paper introduces a revolutionary approach by integrating blockchain technology with ranked choice voting, using Ethereum's decentralized platform to eliminate vulnerabilities inherent in conventional voting systems. Through the use of smart contracts, our system automates the vote tallying, redistributes votes during candidate eliminations, and guarantees that all votes are securely cast and transparently recorded. By decentralizing the voting process, our solution reduces the potential for fraud and manipulation, while enhancing voter confidence and trust. This paper outlines the implementation, methodology, and advantages of blockchain-based ranked choice voting, showcasing how it can redefine election processes for a new era of digital democracy.

Keywords— Blockchain Technology, Preferential Voting

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CHAPTER 1

INTRODUCTION

1.1 Overview

Elections form the backbone of democratic societies, empowering citizens to influence governmental and institutional decision-making. They serve as a vital mechanism through which individuals can voice their opinions and collectively determine their leadership and policy direction. The effectiveness of elections relies heavily on the integrity, fairness, and transparency of the voting process. However, traditional voting systems have often been subject to significant challenges that compromise these principles. Issues such as voter suppression, fraudulent practices, and misrepresentation have plagued conventional elections, eroding public confidence and trust in the democratic process. The need for more reliable, secure, and inclusive voting mechanisms is more pressing than ever.

The First-Past-The-Post (FPTP) voting system, one of the most commonly used methods worldwide, frequently falls short of accurately representing the will of the majority. In FPTP, voters are limited to selecting only one candidate, and the candidate with the highest number of votes wins, even if they fail to secure a majority. This structure creates vulnerabilities, such as the "spoiler effect," where votes for similar candidates split the vote, leading to a winner who may not be preferred by the majority. Additionally, FPTP can discourage voters from choosing their true preference, as they may opt for a less favored but more viable candidate to prevent an undesirable outcome. The limitations of FPTP have led to a growing interest in alternative voting systems that better capture voter intent and enhance the fairness of elections.

Ranked Choice Voting (RCV) has emerged as a robust alternative to the traditional FPTP system. In RCV, voters rank candidates in order of preference rather than selecting just one. This allows for a more comprehensive expression of voter preferences and prevents vote splitting. When the initial tally is conducted, if no candidate achieves a majority, the candidate with the fewest votes is eliminated, and their votes are redistributed to the remaining candidates based on the voters' subsequent preferences. This process continues until one candidate secures a majority. By ensuring that the winner has the broadest support among voters, RCV promotes fairer and more representative election outcomes and reduces negative campaigning, as candidates strive to be the second or third choice of their opponents' supporters. A preferential voting system on Ethereum not only addresses security concerns but also fosters a more inclusive democratic process by providing voters the ability to rank candidates, which can result in a more representative election outcome [1], [2].

The advent of blockchain technology has further transformed the potential for modernizing electoral systems. Blockchain's decentralized, immutable, and transparent nature makes it an ideal foundation for securing and verifying electoral processes. Unlike centralized voting systems, blockchain-based voting is distributed across multiple nodes, making it resistant to tampering and fraud. Every vote is recorded on an encrypted, public ledger that ensures both transparency and voter anonymity. This approach enhances trust in the voting process, as participants can independently verify that their vote was cast and counted as intended. Blockchain-based voting not only safeguards against manipulation but also reduces administrative overhead and enhances accessibility, making elections more inclusive and efficient.

1.2 Motivation

The motivation behind developing a blockchain-based ranked choice voting system is rooted in the pursuit of a fairer, more secure, and transparent electoral process. Traditional voting methods, especially those that rely on centralized infrastructures, are susceptible to vulnerabilities that undermine the integrity of elections. Centralized databases can be targeted by malicious actors, resulting in data breaches or tampered results. Furthermore, the lack of transparency in conventional systems can lead to disputes, decreased voter confidence, and lower voter turnout. In a world where data privacy and security are paramount, adopting an election system that ensures verifiability, anonymity, and resistance to tampering is essential.

Ranked choice voting, with its ability to more accurately reflect the will of the electorate, addresses many of the pitfalls of traditional FPTP voting. By enabling voters to rank candidates in order of preference, RCV mitigates the spoiler effect and supports the election of candidates with genuine majority backing. However, implementing such a system with paper ballots or through centralized digital platforms can be cumbersome, prone to human error, and vulnerable to tampering. This is where the integration of blockchain technology becomes transformative. Blockchain ensures that every vote is secure, immutable, and verifiable, creating a foundation of trust that is crucial for modern elections.

The smart contract developed for this project combines the best features of RCV and blockchain technology to create a secure, transparent, and efficient voting process. This contract is deployed on the Ethereum blockchain, leveraging its decentralized nature to safeguard the election process. The smart contract automates the collection of votes, the elimination of candidates with the fewest votes, and the redistribution of votes according to voter preferences. This not only guarantees an accurate and transparent result but also streamlines the voting process, reducing administrative complexity and potential errors. The inclusion of a candidate-to-name mapping allows voters to cast their preferences using candidate names, enhancing user-friendliness and accessibility.

The use of blockchain ensures that the voting process is tamper-proof, eliminating concerns about centralized control or third-party interference. Each vote is recorded as a transaction on the blockchain, making it immutable and publicly auditable while preserving voter anonymity. This hybrid system offers an innovative solution that addresses both the limitations of FPTP and the security issues associated with centralized voting platforms. The motivation behind this project is to demonstrate that blockchain-based ranked choice voting can be a powerful tool for enhancing democracy by providing secure, transparent, and fair elections. This project, therefore, seeks to strengthen the security and transparency of elections but also to promote trust and engagement in democratic systems, aligning with the broader societal shift toward digital trust and accountability [3].

CHAPTER 2

LITERATURE REVIEW

2.1 Background and Related Works

[4] provides a theoretical commentary on the implementation of Ranked Choice Voting (RCV) and anchors it within a spectrum of voting technologies that have different objectives. The authors discuss the problematic aspects of RCV, observing how theoretical problems such as the lack of monotonicity or the lack of a Condorcet winner can be problematic. Furthermore, by providing examples, they show that even here some irregularities may not be disclosed, but still, it is crucial to comprehend theoretical drawbacks to assess the vote's process. It also highlights over FPP voting such as reducing wasted votes and better reflecting voter preferences.

[5] studies the limitations of conventional voting such as paper ballot and EVM in Bangladesh and believes that a major concern is security and transparency. The paper ballot system requires a great deal of manual operations and the process raises certain questions about other factors in free and fair election but the EVMs which also cannot allow multiple voting through fingerprint recognition face some problems of free and fair elections because many aspects of it involve human interference. According to the same authors, voter fraud, biased actions by officials and major procedural problems characterise Bangladeshi elections, thus undermining democratic processes. To counter these problems, a form of technology has been called for which is the blockchain technology due to its characteristics of decentralised data handling, security and transparency. Blockchain provides decentralised record keeping where the current block includes a hash of the previous block, changes to which will be noticeable.

[6] presents the new improved voting system called ACB-Vote, based on the blockchain technology that is suitable for score voting system, where the voter directly scores the candidates. As mentioned before, traditional privacy-preserving voting schemes face some issues when it comes to score voting especially if computations ought to be made in order to meet score range and sum criteria. This is overcome

by the incorporation of BBS+ signatures and signatures of knowledge (SoK) into the election system to make the ACB-VoteStructure to be anonymously convertible to conceal both voter anonymity and scores. It uses a conversion function in the system architecture to recognize multiple voting episodes as well as maintain the anonymity of each voter by converting their scanned ballots into differently pseudonymous identifiers.

[7] proposes DTACB, a novel Dynamic Threshold Anonymous Credential system with Batch-Showing intended to overcome the drawbacks of existing threshold anonymous credential systems, focused on those following Shamir's protocol. It does not allow continuous flexibility and requires the actual rewinding of the system when issuers are to be added or removed by means of either the Coconut system or the SFY+ system. DTACB improves this by inclusion of dynamic management of the issuers as well as the threshold values attained through one more variant of multi-signature approach, which discloses the set over which signature is being verified and thus eliminate the complication arising from preparation of pre-issued public keys and facilitate the changes in the number of issuers. DTACB also greatly improves the credential showing by cryptographic accumulators and converts it into the membership proof that protects anonymity while proving the membership quantities, so the computation costs of the verifier are reduced from O(n) to O(1) with the proof sizes being sublinear.

[8] outlines an anonymous, blockchain based, ranked-choice voting that is compliant to basic election requisites for scaleability. It builds on anonymity utilizing zero-knowledge proofs; in particular, the Semaphore gadget for AMs. The proposed protocol integrates an identity-based election process that is decentralized yet secure; the voters are able to cast their votes by simply committing, verifying, and tallying their votes and the assurance of cordination against topbiased or duplicate voting result is provided through cryptographic identity. The issue of scalability is resolved with the application of Merkle trees and zk-SNARKs to allow the system to work with large voter numbers with negligible computational overhead.

2.2 Outcome of Literature Review

As identified from the literature survey, there is a remarkable improvement in blockchain integrated voting and credential system for strengthening security, privacy, and efficacy in a Decentralised voting system. The BE-Voting and ACB-Vote systems approach the problem of transparency and privacy in voting using blockchain techniques, with BE-Voting targeting secure and large scale e-voting in Bangladesh while ACB-Vote have score based voting with functions like anonymously convertible ballots and batch verification for massive polls. A new anonymity based credential payment system DTACB has been described that meets dynamic issuer adjustments and also has efficient batch-showing using cryptographic accumulators in order to minimize the amount of computation required to verify the credential.

2.3 Problem Statement

Traditional voting systems, such as First-Past-The-Post, often fail to represent the true majority preference and are susceptible to security and transparency issues. There is a need for a secure, transparent, and fair voting system that ensures voter confidence and accuracy in results.

2.4 Objectives of the Project

The objective is to develop a blockchain-based ranked choice voting system that enhances electoral fairness, secures vote integrity, increases transparency, and automates vote processing through smart contracts, providing a trustworthy and efficient alternative to conventional voting methods.

CHAPTER 3

METHODOLOGY

The methodology for this blockchain-based ranked choice voting system is built around using the Ethereum blockchain, leveraging smart contracts to ensure a secure, transparent, and efficient voting process. The following steps outline the key processes and components that comprise the system but before that below is a simple example of how it works:

3.1 Architecture

The "Blockchain-Based Preferential Voting System" uses blockchain technology to deliver a secure, transparent, and decentralized voting process. At the core of this system is an Ethereum smart contract that governs all aspects of the election, including the initiation and closure of voting, candidate registration, vote recording, redistribution of votes when candidates are eliminated, and final winner announcement. This smart contract enforces all rules automatically, which minimizes the risk of tampering and boosts the system's overall integrity.

The architecture comprises three main entities: the smart contract, voters, and candidates. Each candidate is represented by an Ethereum address mapped to their name, while voters interact directly with the contract to submit ranked preferences for candidates. This "preferential voting model" allows voters to rank all candidates according to their preferences. An added feature is "dynamic re-voting", which permits voters to adjust their votes during the voting phase, ensuring that preferences can be modified as needed.

To implement preferential voting, the contract operates in cycles to determine if a candidate has achieved a majority. If no majority is found, the candidate with the fewest votes is eliminated, and their votes are redistributed to the next-ranked candidate on each voter's list who is still in the race. This elimination and redistribution process continues until a candidate secures more than 50% of the remaining votes, at which point that candidate is declared the winner. This result is then permanently recorded on the blockchain.

Blockchain's "decentralization and transparency" are critical to the security and trustworthiness of the voting system. Decentralization prevents any single entity from exerting control over the election, promoting impartiality. Furthermore, all transactions and updates—such as vote recording, eliminations, and winner announcements—are transparently logged on the blockchain, creating an auditable record that can be reviewed at any time. The system also emits key events for real-time monitoring of the election.

The "Ethereum blockchain" was chosen for its strong security and developer support, as well as its ability to handle complex smart contracts. The contract's design aims to be gas-efficient, balancing transaction costs with accuracy. Ultimately, this Blockchain-Based Preferential Voting System offers a secure, efficient, and transparent solution, ideal for conducting elections that require trust, integrity, and fairness in complex voting situations.

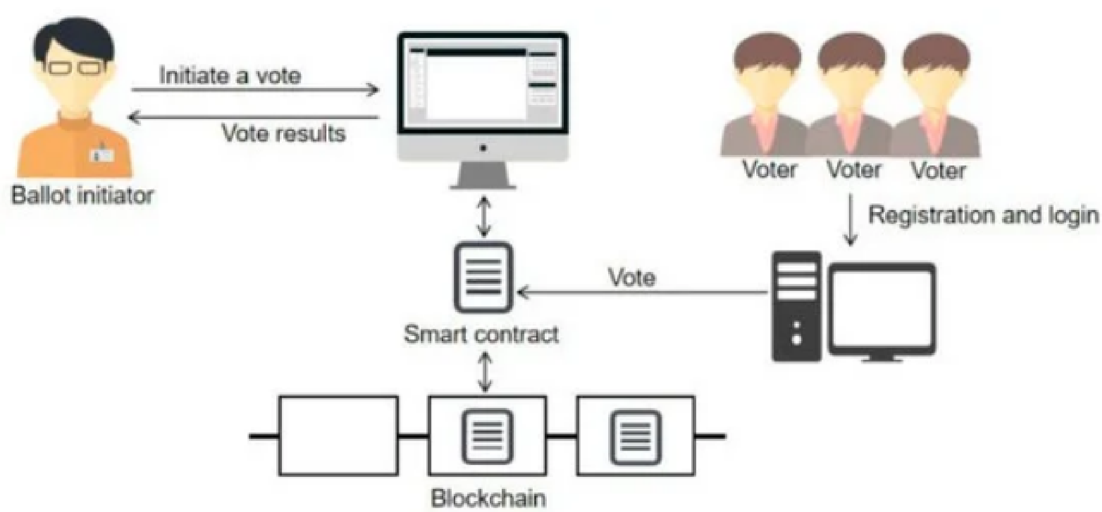

Figure 3.1.1: Blockchain-Based Voting System

3.2 Example of Preferential Voting

The methodology for this blockchain-based ranked choice voting system is built around using the Ethereum blockchain, leveraging smart contracts to ensure a secure, transparent, and efficient voting process. The following steps outline the key processes and components that comprise the system:

Example:

Let's consider a simple election with three candidates: Alice, Bob, and Carol. Voters are asked to rank their preferences in order. Here's how the voting process works:

- Voter 1 ranks the candidates as: Alice >Bob >Carol.
- Voter 2 ranks the candidates as: Bob >Alice >Carol.
- Voter 3 ranks the candidates as: Carol >Bob >Alice.

The smart contract processes the votes in the following way:

1. **Initial Vote Count:** Each voter's first preference is counted.
2. Alice receives 1 vote, Bob receives 1 vote, and Carol receives 1 vote.
3. **Elimination Process:** The candidate with the fewest votes, Carol, is eliminated.
4. **Redistribution of Votes:** Voter 3's vote is redistributed to their second preference, Bob. Now, Bob has 2 votes, while Alice has 1 vote.
5. **Final Check:** After redistribution, Bob has more than 50% of the remaining votes, making Bob the winner.

In this way, the ranked-choice voting process continues until one candidate secures more than 50% of the remaining votes, ensuring a fair and representative outcome.

3.3 Voting System Design

The system is designed as a decentralized application (dApp) on the Ethereum blockchain, which allows participants to vote without relying on traditional intermediaries. This eliminates common issues like tampering, fraud, and bias, ensuring that the process remains fair and transparent. The core of this system is a smart contract that governs all aspects of the election, including candidate registration, vote collection, and winner determination.

3.4 System Components

The system consists of the following main components:

- **Smart Contract:** The Ethereum-based smart contract manages all the logic of the voting process. It handles vote submission, vote counting, candidate registration, vote redistribution, and winner announcement.
- **Blockchain:** The system utilizes the Ethereum blockchain for its decentralized nature. This ensures that votes are securely recorded and cannot be altered after submission.
- **Front-End Interface:** A user-friendly interface allows voters to submit their ranked preferences and view the election results.
- **Admin Control:** The contract includes administrative features, such as the ability to start and stop the voting process and add candidates.

3.5 Voting Process

The voting process follows a ranked choice voting (RCV) mechanism, which ensures that votes are cast in a way that reflects the true preferences of voters. The process consists of the following key steps:

- **Candidate Registration:** Candidates are registered by the election admin, who specifies their name and Ethereum address. Each candidate is added to the system, and their votes are initialized to zero.

- **Voting:** Voters cast their votes by ranking the candidates in their preferred order. Each voter submits their preferences as a list of candidate names, which are then converted into Ethereum addresses.

- **Vote Counting:** The smart contract counts votes based on the first choice preferences of voters. If a candidate is eliminated, their votes are redistributed to the next available choice on the voter's preference list.

- **Elimination and Redistribution:** After each round, the candidate with the fewest votes is eliminated. Votes are redistributed to the remaining candidates based on voters' subsequent preferences. This process continues until a candidate achieves more than 50% of the remaining votes.

3.6 Winner Determination

The winner of the election is determined through an iterative process of elimination and vote redistribution. The following steps are involved:

Algorithm 1 Winner Determination in Ranked Choice Voting

```
While remainingVotes >0
    Find the loser:  loser ← findLoser()
    Eliminate the loser:  eliminated[loser] ← True
    Decrement remainingVotes by voteCounts[loser]
    Redistribute votes:  RedistributeVotes()
    For each candidate:
        If voteCounts[candidate] >remainingVotes / 2
            Declare the winner: winner ← candidate
            Emit AnnounceWinner(winner)
            Return
    End For
End While
```

In this process, the system iteratively eliminates candidates with the fewest votes, redistributes their votes according to the voters' preferences, and checks whether any candidate has secured more than 50% of the remaining votes. The first candidate to surpass this threshold is declared the winner.

3.7 Security and Transparency

One of the major benefits of using blockchain technology for the voting process is the inherent security and transparency it provides. Since all transactions are recorded on the Ethereum blockchain, it is impossible to alter or tamper with the vote data once it has been recorded. Additionally, the use of a decentralized ledger ensures that the election process is open for auditing by all stakeholders, further ensuring the integrity of the election results.

CHAPTER 4

RESULTS AND ANALYSIS

In the Results and Analysis section, we examine the execution of key functions within the Blockchain-Based Preferential Voting System and analyze their impact on the overall voting process. This analysis includes detailed explanations of each function's purpose, along with screenshots from the Remix IDE that illustrate their outputs and how they interact with other components in the system. Through this breakdown, we demonstrate the functionality, security, and adherence to voting protocols, such as candidate registration restrictions, one-vote-per-person enforcement, and winner announcement. Each function's results confirm the system's robustness in maintaining transparency, accuracy, and security across the entire election process.

4.1 addVote Function

The addVote function is essential for casting votes within the system. When called, it allows voters to submit their ranked preferences for all candidates. This function ensures that each voter's choices are recorded and counted according to the preferential voting structure. Voters input a list of candidate names ranked in order of preference, which the contract converts to candidate addresses and stores in a mapping specific to each voter. The screenshot for this function showcases the process of a voter submitting their preferences and verifies the successful storage of this data in the smart contract.

4.2 addCandidate Function

The addCandidate function allows for the registration of candidates by adding them to the election. Each candidate is represented by an Ethereum address mapped to a name, and this function registers both attributes, ensuring that candidates can be easily identified and selected by voters. By calling addCandidate, the contract updates the candidate list and prepares the candidate for the upcoming vote. The screenshot for this function demonstrates how a candidate's details are added to the

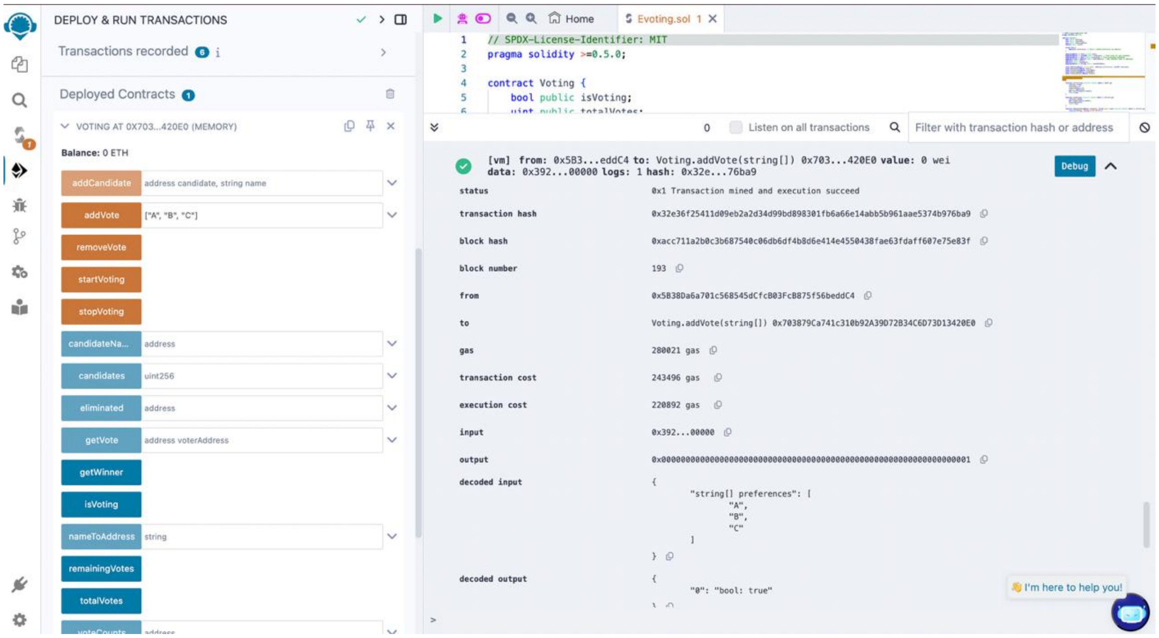

Figure 4.1.1: addVote Function

system, showcasing the initial setup stage of the voting process.

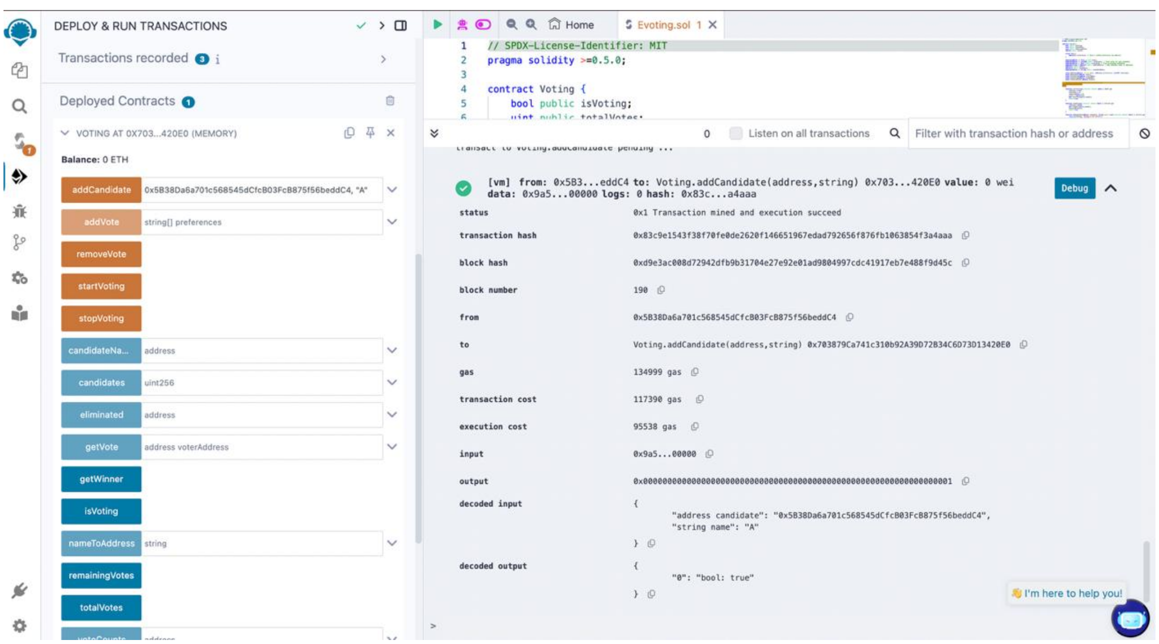

Figure 4.2.1: addCandidate Function

4.3 Admin-Only Restriction for Adding Candidates

To maintain the integrity of candidate registration, only an authorized admin can call the addCandidate function. This restriction ensures that no unauthorized entities can add candidates, preventing potential manipulation of the candidate pool. The screenshot here highlights the admin-only access control, as the Remix IDE displays an error when an unauthorized user attempts to add a candidate. This access control emphasizes the system's security and adherence to proper roles and permissions.

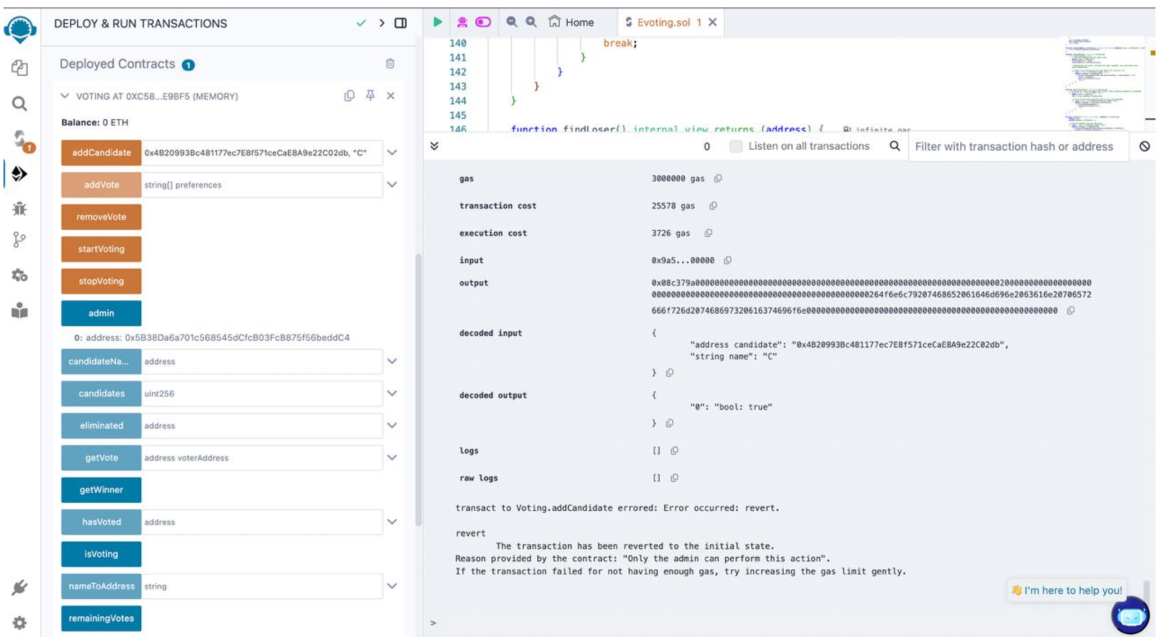

Figure 4.3.1: Admin-Only Restriction for Adding Candidates

4.4 One Vote per Person Restriction

The system enforces a one-vote-per-person rule to prevent multiple votes from a single account, which is managed by checking if the voter's address is already recorded in the voters array. Once a vote is cast, the voter's preferences are stored, and their address is logged, ensuring they cannot vote again in the same election cycle. This restriction is demonstrated in the screenshot, where any attempt to cast a second vote from the same account is blocked, ensuring fair voting practices.

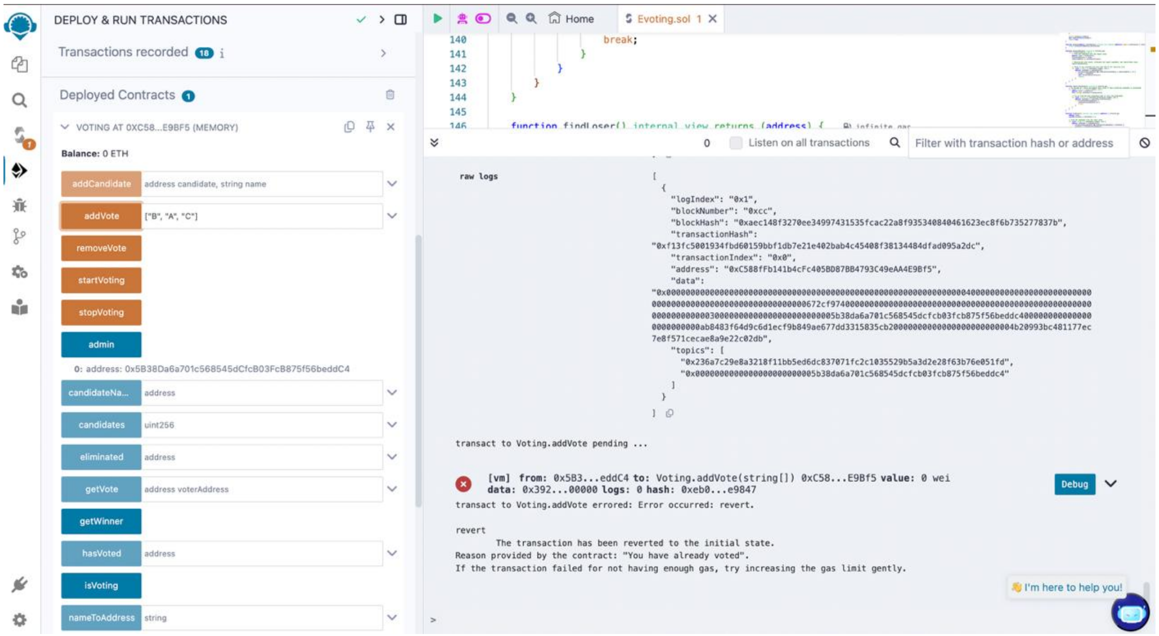

Figure 4.4.1: One Vote per Person Restriction

4.5 getWinner Function

The getWinner function is used to retrieve and display the election winner once voting concludes. This function returns the name of the candidate who has secured a majority, ensuring that the election process can be fully verified. The screenshot shows how calling getWinner provides the final election result, allowing users to confirm the successful completion of the preferential voting process and view the elected candidate's details.

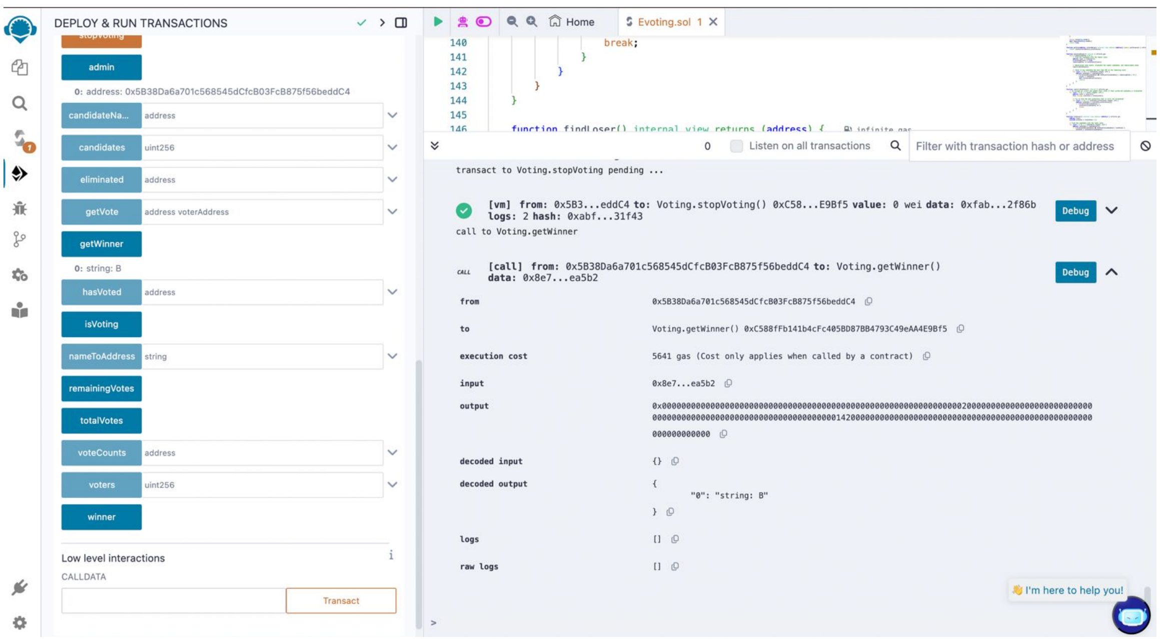

Figure 4.5.1: getWinner Function

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

The implementation of a blockchain-based preferential voting system marks a significant advancement in modernizing electoral processes. By leveraging the decentralized and immutable characteristics of blockchain technology, this system addresses many of the shortcomings of traditional voting methods, such as susceptibility to tampering and lack of transparency. The integration of ranked choice voting (RCV) ensures that elections better reflect the collective preferences of the electorate, promoting fairer outcomes and reducing the potential for vote splitting. Our approach demonstrates that blockchain can provide secure, auditable, and transparent election mechanisms that enhance voter trust and participation. The project's success is validated by the seamless functionality of smart contracts for tasks such as vote recording, candidate elimination, and vote redistribution, showing that blockchain-based systems can be both secure and practical for real-world electoral applications.

Future enhancements to the blockchain-based preferential voting system could focus on scalability improvements to accommodate larger elections by exploring scalable blockchain solutions or Layer 2 protocols. User interface refinements would make the system more intuitive and accessible, encouraging broader voter participation. Security could be further augmented through advanced cryptographic techniques, such as zero-knowledge proofs, to enhance privacy and trust. Additionally, ensuring multi-language support would expand the system's usability in diverse contexts. Finally, conducting pilot tests in real-world election scenarios would provide valuable feedback, enabling refinements that enhance performance and adaptability for widespread use.

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