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Blockchain Voting System

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Abstract: *Democratic elections are essential for governance, but traditional systems like paper ballots, electronic voting machines (EVMs) face challenges such as unpredictability, voter fraud, manipulation, low turnout and security weaknesses. Blockchain technology provides a decentralized, consistent and transparent system for digitally secured transactions The parent provides solutions. This paper presents the development and testing of an e-voting system using blockchain, which has been implemented mainly as a smart contract on the Ethereum network using the Solidity language by distributing a large amount of gas (tokens) to voters each wallet, our system ensures votes can't become duplicates. This decentralized approach removes the need for intermediaries and enhances the security, transparency and integrity of the electoral process. We explore the advantages and limitations of blockchain-based e-voting, including scalability problems and token costs. The results highlight blockchain's potential to transform digital elections and identify areas for further research to increase adoption.*

Keywords: Blockchain technology, e-voting, smart contracts, Ethereum, digital voting security

I. INTRODUCTION

Democracy is next to impossible without elections, but all those systems are crucially reliant on trusted third parties and therefore risk to be either corrupted or cheated. Internet voting (e-voting) is introduced to save cost and manual effort but is still confronted with the issues of security, transparency, and data integrity.

Blockchains are a promising approach for overcoming these challenges. Its decentralized, tamper-proof approach could potentially secure and open online voting. Researchers like Khan et al. (2016) have designed voting systems based on blockchain technology that preserves voter privacy, verifies vote integrity, and mitigates manipulation threats. This demonstrates how blockchain can be used to update elections and restore the trust of the public in the voting process.

Moreover, blockchain allows the verification of votes in seconds, thereby expediting the announcement of the election results. It also reduces human involvement, hence provides more reliable and efficient voting process.

Overview of Blockchain Voting System:

What is a Blockchain Voting System? The concept is in reference to a system that replaces physical voting location in existing voting systems with a digital platform that can provide secure, transparent, and trustworthy voting processes.

In this system, a single vote is logged as a block in a distributed ledger spread among several nodes (computers). When a vote is included it cannot be modified or removed, guaranteeing immutability of records. This makes a central authority unnecessary and eliminates the risk that votes can be tampered with or falsified.

Problem in Current Voting System:

- Lack of Transparency – Voters can't verify if their vote was counted.
- Risk of Fraud – Susceptible to tampering, ballot stuffing, and insider threats.
- High Costs – Expensive logistics: printing, staffing, and transport.
- Limited Accessibility – Hard for remote, disabled, or busy voters to participate

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II. MATERIALS AND METHODS

1. Requirements Analysis

Goal: Develop a secure and transparent voting system using Ethereum.

Features:

- Voter registration
- Secure and anonymous vote casting
- Result tallying
- Transparency and immutability

2. Software and Tools/Technology Purpose

- Ethereum: A blockchain with its own cryptocurrency which supports smart contracts, and is less geared towards being used as a digital currency.
- Solidity: Programming language to write smart contract
- Truffle : Suite Development environment for compiling, migrating and testing smart contracts
- Ganache: Personal blockchain for Ethereum development and testing purposes
- Node. js: A JavaScript runtime for backend logic and Web3 integration
- Web3.; js A JavaScript library to interact with Ethereum on the frontend
- MetaMask: Browser Wallet to access DApps and use of smart contracts with Web3.setRequestHeader:
- HTML/CSS/JavaScript To develop the interface of the frontend user

3. Local Blockchain Setup

- Deployed a private ethereum blockchain with Ganache CLI/Ganache GUI.
- Gave out local accounts for testing with ETH funds.
- Implemented smart contracts through Truffle and Ganache.

4. Truffle Project Configuration Initialized Truffle project from the scratch:

truffle initAdded contract to /contracts/

Truffle-config configured networks. js for Ganache or testnet deployment.

5. Compilation and Migrationtruffle compile

truffle migrate --network development

6. Frontend Development

Used HTML/CSS/JavaScript with Web3.js for interacting with smart contracts.

7. Testing

Wrote automated test cases in Truffle using Mocha and Chai:

Contract deployment

Admin can add candidates

Only one vote per address

Vote counts increment correctlytruffle test

8. Deployment (Optional)

Deployed to Ethereum testnet (e.g., Rinkeby) using Infura and MetaMask.

truffle migrate --network rinkeby

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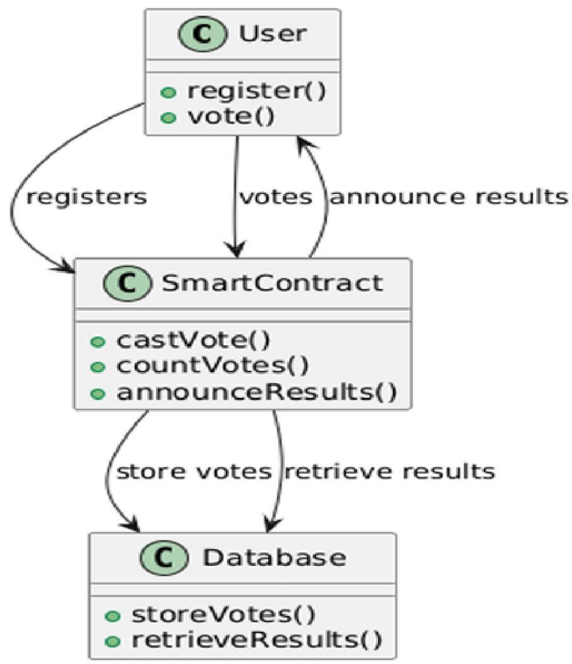
•Security Measures taken Access Control: we allow only admin to add the candidates Double Voting prevention: one vote per address. hasVoted mapping help us to prevent double voting Reentrancy: no external calls made from critical functions Gas Optimization: We effectively use memory and safe storage variables.

Progress Iteration Smart contract versioned and modified per test results. Simulating real-world scenarios by repeated test cycles with Ganache.

9. Unified Modelling Language [UML Diagram]



III. IMPLEMENTATION AND ALGORITHMS

3.1: Implementation Summary

Tools Used: Ethereum, Truffle, Ganache, Solidity, Web3.js, MetaMask, Node.js

- Smart Contract (Voting.sol):
- Admin can add candidates
- Users can vote only once
- Vote counts are stored on the blockchain

3.2 Frontend:

Connects to MetaMask

Allows users to select and vote for candidates via Web3.js

Key AlgorithmsCandidate RegistrationOnly admin can add candidatesEach candidate stored with a vote count = 0Voting Checks if user already votedValidates candidate ID Increments candidate's vote countMarks user as "voted" Tallying Reads vote counts from blockchain (view function).

Security Measures Prevent double voting (hasVoted mapping)

Access control (require(msg.sender == admin))

Input validation for candidate ID

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ADVANCEMENTS OF BLOCKCHAIN VOTING SYSTEM:

1. Advancement:

Integrate decentralized identity (DID) or zero-knowledge proof (ZKP) for anonymous, secure authentication without leaking voter identity.

Use platforms like:

Civic, Polygon ID, uPort, or Worldcoin (for proof of personhood).

ZK-SNARKs to prove eligibility without revealing voter identity.

2. Verifiable and Auditable Voting

Current:

Votes are stored on-chain but not easily auditable by the voter.

Advancement:

Implement end-to-end verifiability where users can:

Verify their vote was counted.

Audit the election without seeing others' votes.

Use Merkle Trees or zk-rollups for scalable, privacy-preserving vote records.

3. Off-Chain Voting with On-Chain Finality

Improvement:

Scale your app by moving voting logic off-chain (e.g., using zkRollups, Optimistic Rollups, or Arbitrum) and record final results on-chain to save gas.

4. Real-Time Tallying and Result Display

Current:

Votes are stored, but tallying is manual or done off-chain.

Advancement:

Add a live dashboard that updates in real-time by reading from the blockchain.

Use The Graph or a similar indexing tool for performance.

5. DAO Integration (Governance Voting)

Expansion:

Adapt your system to function as part of a Decentralized Autonomous Organization (DAO):

Use token-weighted voting (1 token = 1 vote).

Support proposal creation and voting lifecycle.

6. Regulatory & Legal Compliance

Advancement:

Align with local/national voting regulations.

Store hash-based proof of vote for compliance auditing.

7. Cross-Platform Support (Mobile/Desktop/Web3 Wallets)

Enhancement:

Add support for:

Mobile voting using wallet apps like MetaMask Mobile, Rainbow, etc.

WalletConnect integration.

QR-code login to connect wallet.

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8. Security Improvements

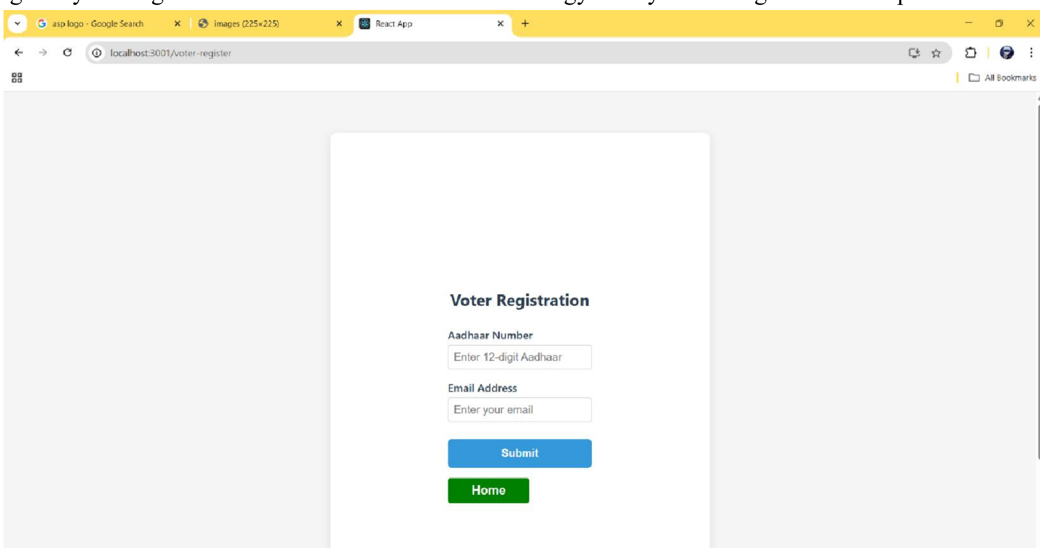
Add time-based voting windows using block.timestamp.
Prevent smart contract reentrancy attacks or front-running.
Consider multi-signature admin rights to prevent unilateral actions.

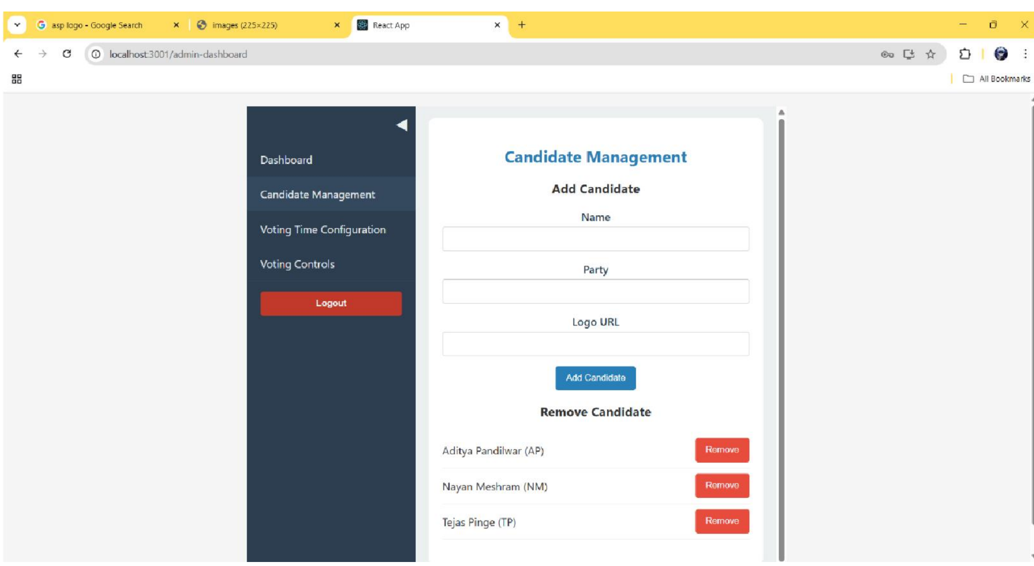
9. Gas Optimization

Refactor code to minimize gas usage.
Consider batch processing, or event-based systems to reduce on-chain operations.

IV. RESULTS

This section presents the results of our proposed blockchain-based electronic voting system's development and testing. We highlight key findings and outcomes based on the methodology and system design detailed in previous sections..





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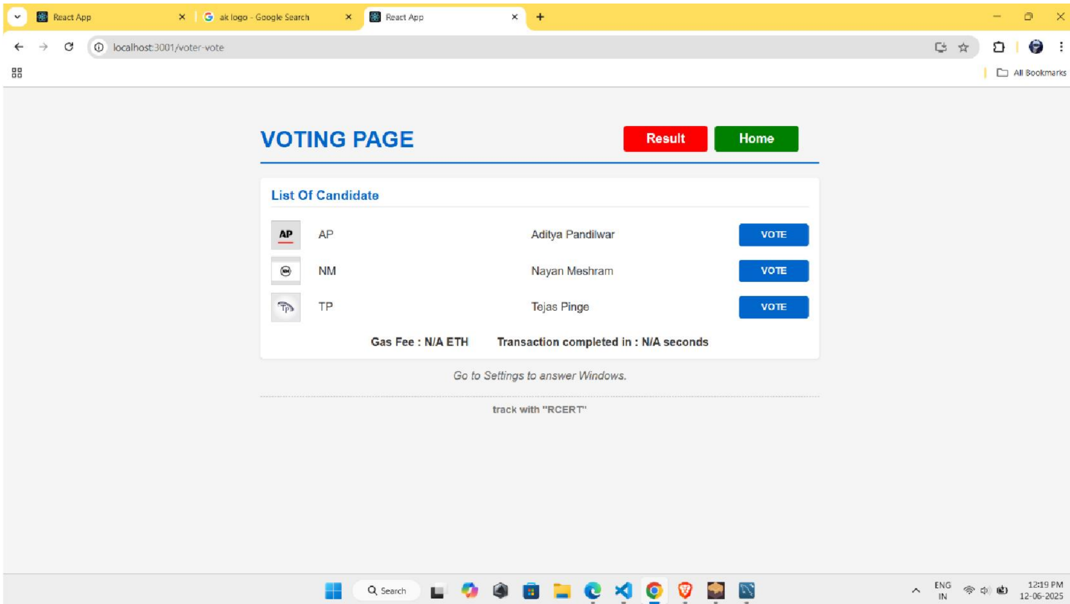

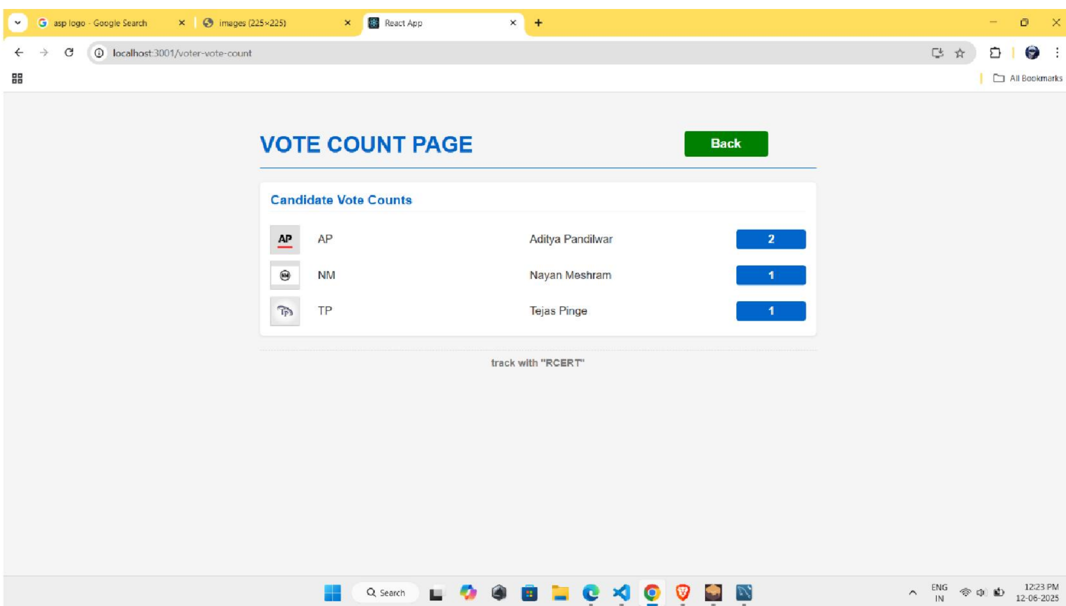

V. DISCUSSION

The results of our research illuminate the transformative potential of blockchain-based electronic voting systems within the specific context of Morocco's electoral process, addressing the fundamental question of whether such a system can enhance the integrity, security, and transparency of elections. These findings contribute to a growing body of evidence that underscores the pivotal role of blockchain technology in redefining conventional processes across various sectors. The multi-layered architecture we have proposed, comprising the Distributed Permission Ledger Technology (DPLT) layer and the Solana blockchain layer, represents a substantial step toward realizing a more secure and accountable electoral system. Our study reinforces the hypothesis that when strategically harnessed, blockchain can significantly enhance elections' integrity and security.

Contrary to concerns voiced by skeptics, our results do not align with the theory that blockchain might introduce more vulnerabilities. Instead, they indicate that blockchain can be a robust safeguard against electoral fraud and manipulation with proper design and implementation. The performance evaluation of our system, showcased in the results, provides a new and compelling insight into the relationship between technology, transparency, and electoral trust. The demonstrated capability to handle a high transaction rate efficiently is a key determinant of the system's success in ensuring the accuracy and integrity of the voting process.

However, it is crucial to acknowledge the intertwining factors of law and politics that influence adopting e-voting systems. The legal and political landscape can either facilitate or hinder the implementation of such systems. Factors such as legislative frameworks, political will, and stakeholder engagement play a significant role in determining the feasibility and acceptance of blockchain-based electronic voting.

The legal aspects of e-voting vary depending on the country and jurisdiction in which the e-voting system is used. A variety of legal and political factors must be taken into account when implementing e-voting systems. Some critical legal considerations include ensuring that the e-voting system complies with relevant laws and regulations governing the electoral process, protecting confidentiality, and ensuring the integrity and accuracy of the voting process. Additionally, specific legal requirements related to using electronic communications and information technology in the electoral process may need to be considered.

VI. CONCLUSION

In this literature review paper, we investigated the implementation of a blockchain-based electronic voting system that uses smart contracts. Our findings suggest that this technology provides a safer, more efficient, and more transparent alternative to conventional voting methods, enhancing both voter privacy and election integrity Despite the benefits, challenges remain, particularly in areas such as individual voter verification, which may require biometric solutions. As blockchain technology continues to evolve, further research and development is needed to address these challenges and facilitate wider adoption for larger e-voting systems.

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