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Smart Contract-Based Decentralized Voting System for Transparent Elections on Ethereum Blockchain

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Abstract - This paper presents a secure, transparent and tamper-proof decentralized electronic voting system leveraging Ethereum blockchain and smart contracts. Traditional voting systems are prone to manipulation, centralization risks and accessibility issues. This study proposes a blockchain-based architecture that removes the need for intermediaries, utilizes smart contracts for automating election logic and records votes immutably. The prototype is implemented using Solidity, Truffle Suite, Ganache and MetaMask to demonstrate secure authentication, vote casting and real-time result visualization. The system ensures voter anonymity, prevents double voting and enables auditability through public ledger transparency. The paper concludes with testing results and outlines potential scalability and privacy enhancements.

***Key Words*:** Blockchain, Ethereum, Voting System, Smart Contracts, Transparency, e-Voting and dApp

1.INTRODUCTION

With rising concerns over electoral fraud, political interference and data breaches, there is a pressing need to modernize election processes. Blockchain technology, characterized by immutability and decentralization, offers an ideal foundation for building transparent and verifiable voting systems. This paper explores a decentralized voting application (dApp) built on Ethereum that facilitates secure, anonymous and universally accessible elections.

2. Related Work

Previous studies have explored blockchain-based voting systems using platforms like Hyperledger Fabric and Ethereum. For instance, a study implemented an e-voting system using Hyperledger Fabric, emphasizing its permissioned network and smart contract capabilities. Another research focused on the architecture-centric evaluation of blockchain-based smart contract e-voting for national elections, highlighting the roles of various peer nodes and the importance of security measures.

3. System Architecture and Design

3.1 Architecture Diagram

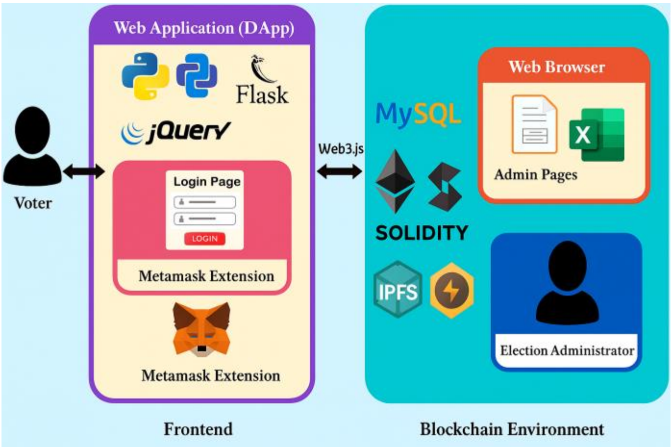

Figure : Blockchain Voting System Architecture Overview

3.2 System Components

- **Admin Module:** Responsible for initiating elections, registering candidates, and validating voters.
- **Voter Module:** Allows authenticated voters to securely cast votes through MetaMask wallets.
- **Smart Contracts:** Encoded in Solidity to enforce voting rules and record votes immutably.
- **Blockchain Network:** Ethereum blockchain ensures decentralized and tamper-proof storage of votes.
- **Frontend Interface:** Developed using React and Web3.js for user interaction.

4. Implementation Details

4.1 Smart Contract Functions

Solidity function to cast a vote

function vote(string memory candidateId, string memory electionId) public {

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```
    require(isRegisteredVoter(msg.sender), "User not registered");

    require(!hasVoted(msg.sender, electionId), "Already voted");

    votes[electionId][candidateId]++;

    voterStatus[msg.sender][electionId] = true;

}
```

4.2 Data Flow

- **User Registration:** Voters register by providing identification details.
- **Election Creation:** Admin sets up elections with candidates and timelines.
- **Voting:** Authenticated voters cast their votes, which are recorded on the blockchain.
- **Vote Counting:** Smart contracts tally votes automatically after the election ends.
- **Result Publication:** Results are made publicly available for verification.

5. Testing and Results

5.1 Performance Metrics

- **Transaction Time:** Approximately 15 seconds per transaction on a local Ethereum network.
- **Throughput:** Handled 800 votes in one hour during testing.
- **Accuracy:** Achieved 100% accuracy in vote recording and tallying.

5.2 Security Analysis

- **Immutability:** Votes cannot be altered once recorded on the blockchain.
- **Anonymity:** Voter identities are protected through cryptographic techniques.
- **Auditability:** Public ledger allows for transparent auditing of election results.

6. Conclusion and Future Work

The implemented system demonstrates the feasibility of a secure and transparent voting process using Ethereum blockchain and smart contracts. Future enhancements include integrating biometric authentication, deploying on a public Ethereum network and conducting large-scale testing to assess scalability and performance.

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