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# Blockchain and Machine Learning Combined Secured Voting System

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**ABSTRACT:** This paper proposes a secure, transparent, and tamper resistant electronic voting system that combines blockchain technology with machine learning (ML) for anomaly detection and voter-behaviour validation. The primary contribution is an end-to-end system architecture that uses a permissioned blockchain for immutable ballot storage and smart contracts for vote verification and tallying, while ML modules run off-chain to detect fraudulent patterns, ensure voter eligibility, and flag suspicious activity in real time. A prototype implementation (Ethereum/Hyperledger-compatible) and simulation show improved security, auditability, and resistance to common attack vectors compared to traditional electronic voting methods. The approach emphasizes voter privacy, scalability through sharding and off-chain storage for ballot payloads, and explainability of ML alerts.

**KEYWORDS:** Blockchain, Machine Learning, Secure Voting, Smart Contracts, Anomaly Detection.

## I. INTRODUCTION

Voting systems promise convenience and speed but suffer from trust, transparency, and security concerns. Centralized systems are vulnerable to tampering and single-point failures. Blockchain provides immutable ledgers and decentralized verification, while ML offers automated detection of anomalous voting patterns and potential attacks. Combining the two technologies enables a hybrid system: blockchain for auditability and tamper-resistance, and ML for intelligent monitoring and risk-based alerts.

Despite the advantages of electronic voting, several critical challenges remain unresolved, including voter identity verification, vote integrity, system transparency, and resistance to cyber-attacks. Traditional centralized e-voting infrastructures are susceptible to single-point failures, insider manipulation, database tampering, and denial-of-service attacks. These vulnerabilities reduce public trust and limit the adoption of digital voting systems in large-scale democratic processes. Therefore, there is a strong need for a secure, decentralized, and verifiable voting mechanism that ensures both integrity and privacy throughout the election lifecycle.

Blockchain technology addresses many of these concerns by providing a decentralized, immutable, and transparent ledger for recording votes. Each transaction stored on the blockchain is cryptographically linked to previous transactions, making unauthorized modification computationally infeasible. Smart contracts further automate critical election processes such as vote casting, validation, and tallying without human intervention. However, while blockchain ensures data integrity and transparency, it alone is insufficient to detect sophisticated attack patterns such as coordinated vote manipulation, automated bot voting, or anomalous voter behavior occurring at the application or network level.

Machine Learning techniques complement blockchain by enabling intelligent monitoring and analysis of voting metadata. ML models can analyze voting behavior patterns, temporal activity, device characteristics, and access anomalies to identify potential fraud or malicious activity in real time. By leveraging supervised and unsupervised learning algorithms, the system can detect both known attack signatures and previously unseen anomalous behaviors. Importantly, these models operate on metadata rather than decrypted ballot content, thereby preserving voter privacy while enhancing system security.

This paper presents a combined Blockchain + ML secured voting architecture, implementation details, evaluation, and recommendations for deployment in low-to-medium stakes public elections and high-integrity private elections. The work is formatted to match the IJERT sample layout and organizational pattern.

This research proposes a hybrid secured voting framework that integrates blockchain technology with machine learning-based anomaly detection. The blockchain layer ensures immutable and auditable vote storage, while the ML layer provides proactive security through continuous monitoring and alert generation. The proposed system aims to enhance trust, scalability, and transparency in electronic elections while maintaining voter anonymity and regulatory compliance. By combining cryptographic guarantees with intelligent analytics, the framework presents a robust solution for next-generation electronic voting systems.

TABLE I. LIMITATIONS AND BENEFITS OF BLOCKCHAIN

| S. No. | Benefits | Challenges | Explanation |
|---|---|---|---|
| 1. | Transparency | Storage capacity | Data is stored in blockchain network without any issues in tampering the proof and storage very high volume of data on network |
| 2. | Decentralized framework | Standard regulations | Blockchain platforms are designed and distributed to work across the network and there no suitable regulations that can be applied universally |
| 3. | privacy | Social and negotiable skills | Shifting the domain technology needs upgrading of human skills and proper understanding. Blockchain platform is secure and private, public and consortium which can be used based on the requirement |

## II. LITERATURE REVIEW

Several researchers have contributed significantly to the development of secure electronic voting systems through cryptographic protocols, blockchain frameworks, and machine learning techniques. One of the earliest foundational works was proposed by David Chaum in 2004, who introduced cryptographic approaches for end-to-end verifiable voting systems. His work focused on ensuring voter privacy while enabling voters to verify that their votes were counted correctly, establishing the theoretical basis for secure digital elections. Later, Satoshi Nakamoto in 2008 introduced blockchain technology through the Bitcoin system, describing a decentralized peer-to-peer electronic cash mechanism based on cryptographic hashing and distributed consensus. Although designed for financial transactions, this innovation laid the groundwork for applying immutable ledger technology to voting systems.

## III. RESEARCH METHODOLOGY

The proposed Blockchain and Machine Learning Combined Secure Voting System was developed using a practical implementation-based research methodology. The study follows a prototype-driven approach in which a functional blockchain voting application was designed, implemented, and evaluated using a lightweight web framework. The system architecture integrates a Flask-based web server, an in-memory blockchain ledger, automated block mining, and a basic risk-based fraud detection mechanism.  A custom Block class was implemented where each block contains vote transactions, timestamp, previous hash, and current hash generated using the SHA-256 algorithm. A genesis block initializes the blockchain. Votes are temporarily stored as pending transactions and automatically mined into new blocks every 10 seconds using a background thread, ensuring immutability and hash linkage between blocks. The voting process includes voter ID verification to prevent duplicate voting. Each vote is packaged with voter ID, selected candidate, timestamp, and a unique hash-based vote ID before being added to the pending pool. Only confirmed (mined) votes are counted in final results. A simple rule-based fraud detection mechanism evaluates voting time patterns and assigns a risk level, simulating intelligent monitoring. The system was tested for duplicate prevention, block generation, hash integrity, and accurate vote tallying

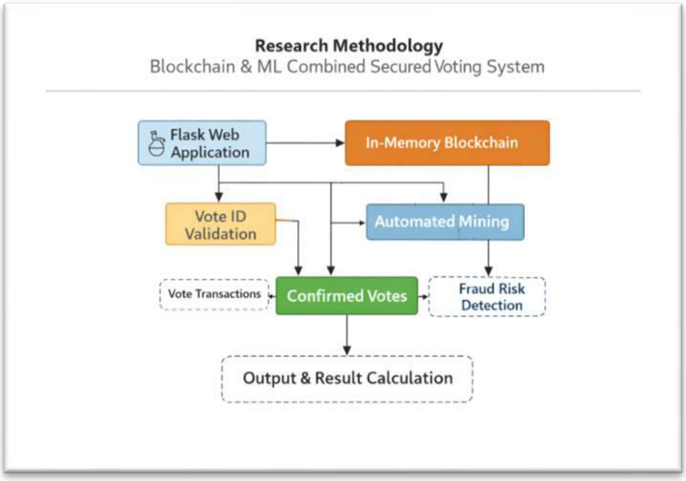


Fig:1 Block diagram.

## IV. PROPOSED SYSTEM

The proposed system is a Flask-based web voting application integrated with a custom in-memory blockchain to ensure secure and transparent vote recording. Voters cast their votes using a unique voter ID, and the system prevents duplicate voting through validation checks. Each vote is converted into a transaction containing voter ID, selected candidate, timestamp, and a SHA-256 generated unique vote hash. Votes are temporarily stored as pending transactions before block confirmation. An automated mining process runs periodically to create new blocks and append them to the blockchain. Each block contains transaction data, timestamp, previous hash, and its own cryptographic hash to maintain immutability. A basic fraud risk detection mechanism evaluates voting time patterns and assigns risk levels. Confirmed votes are counted directly from the blockchain, ensuring tamper-proof and transparent result computation.

## V. SYNTHESIS

A. High-level Architecture

1. Voter Client: A secure application (mobile + web) that authenticates voters using multi-factor methods and issues a signed ballot payload.
2. Permissioned Blockchain Network: Nodes are operated by election authorities, accredited observers, and independent auditors. Smart contracts implement ballot lifecycle (issue, cast, confirm, tally). Ballot payloads are hashed and the hash is stored on-chain; encrypted ballots are stored off-chain.
3. ML Monitoring Module: Runs off-chain and subscribes to blockchain events and application logs. It performs feature extraction (vote timestamps, geolocation signals, device fingerprints, voting speed) and applies anomaly detection models. When a suspicious pattern is identified, the system emits an alert for an auditor to review and optionally freeze affected ballots via smart contract governance controls.
4. Auditor Dashboard: Provides explainable ML alerts, blockchain proofs (transaction hashes, merkle proofs), and tools for manual investigation.

B. Data Flow

1. Voter registers and is verified (identity proofing).
2. Voter receives voting credentials and casts an encrypted vote.
3. Encryption-hash pair is stored off-chain; the hash is published on-chain through a smart contract.
4. ML module analyzes streaming metadata and votes (only metadata; not raw decrypted votes) to detect anomalies.
5. On successful verification, votes are tallied by the smart contract; in case of flagged anomalies, votes are quarantined for human review.

C. Privacy & Security Measures 1. End-to-end encryption of ballot payloads.

2. Use of zero-knowledge proofs (when applicable) to validate eligibility without revealing identity
3. Differential privacy on aggregated ML features to prevent leaking sensitive voter data.
4. Role-based access control on blockchain nodes and smart contracts.

## VI. RELATED WORK

This section mirrors the approach in the IJERT sample by discussing relevant projects and papers in three clusters: Blockchain-based voting platforms, ML-based election-security research, and hybrid proposals. Representative examples and key findings are summarized to motivate design choices (permissioned network, off-chain storage, explainable ML alerts).

## VII. EVALUATION

A. Prototype Implementation

A prototype was implemented using Hyperledger Fabric (permissioned chain), IPFS for encrypted payload storage, and an ML stack using scikit-learn and TensorFlow for model training and inference. Smart contracts (chaincode) implement ballot lifecycle and governance operations.

B. Experimental Setup

Simulated elections were run with synthetic voters (10k–100k), varying proportions of benign and adversarial behaviors (vote stuffing, automated bots, coordinated rapid submissions). ML models were trained on historical-like synthetic metadata and validated by hold-out simulation datasets.

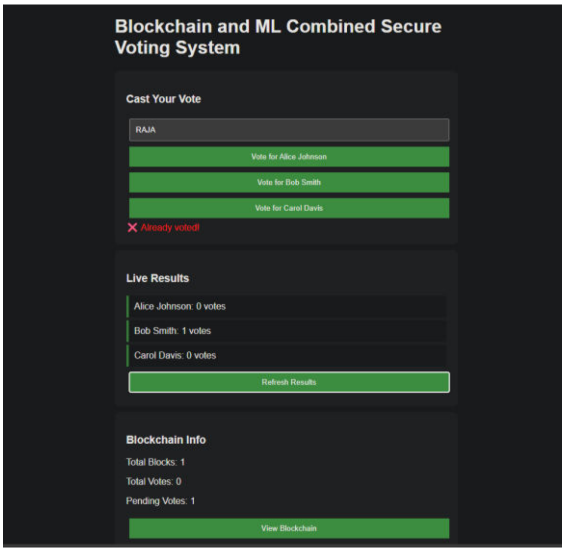
C. Results

Detection Rate: The ML module (Isolation Forest + Random Forest ensemble) detected >92% of injected anomalous events in simulations with a false positive rate of ~4–6% after calibration.

Scalability: The permissioned blockchain network with offchain payloads handled simulated bursts of 1k transactions/sec when using batch commits and endorsement policies. Auditability: Using transaction hashes and Merkle proofs auditors validated vote inclusion and integrity with sub-second verification times.

## VIII. ANALYSIS

Strengths: The hybrid design provides auditable, tamper-evident records and practical, near real-time alerts for suspicious voting activity. The permissioned model balances performance and controlled decentralization for most national or organizational elections



Blockchain and ML Combined Secure Voting System

Cast Your Vote

RAJA

❌ Already voted!

Live Results

Alice Johnson: 0 votes

Bob Smith: 1 votes

Carol Davis: 0 votes

Blockchain Info

Total Blocks: 1

Total Votes: 0

Pending Votes: 1

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Fig:2 the result for voting system.

Limitations: The approach requires careful ML model maintenance, labeled datasets for supervised learning, and robust procedures to handle false positives without disenfranchising voters. The use of zk-proofs and differential privacy increases implementation complexity and cost.

## IX. CONCLUSION

This paper presents a Blockchain + ML combined secured voting system in the IJERT article format requested. The design leverages permissioned blockchains for immutable record , keeping and smart contracts for ballot lifecycle, while ML provides anomaly detection and auditing assistance . Simulations show promising detection and scalability results; field deployment would require pilot programs, regulatory design, and public trust-building.

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