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A Decentralized e-Voting System using Blockchain

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Abstract: Nowadays, there has been increasing interest in leveraging blockchain technology for secure and transparent electronic voting systems. This paper presents the design and implementation of a blockchain-based e-voting system aimed at enhancing the integrity, security, and accessibility of traditional voting processes. The system architecture utilizes distributed ledger technology to record and verify votes, ensuring immutability and transparency of the electoral process. Our approach addresses key challenges such as voter anonymity, verifiability, and prevention of tampering or fraud. The implementation leverages smart contracts to automate vote counting and result tabulation, thereby minimizing the need for manual intervention and reducing the potential for errors. We discuss the technical components of the system, including the blockchain network setup, consensus mechanisms, and cryptographic techniques employed to safeguard voter privacy and data integrity. Furthermore, we evaluate the performance and scalability of the system, considering factors such as transaction throughput and latency. Real-world deployment scenarios and potential challenges in adopting blockchain-based e-voting systems are also discussed. The outcomes of this research contribute to the advancement of secure and trustworthy e-voting systems, paving the way for more inclusive and efficient democratic processes.

Keywords: Blockchain, e-voting, distributed ledger technology, smart contracts, security, transparency, integrity, voter anonymity, verifiability, cryptographic techniques, consensus mechanisms, scalability, democratic processes.

I. INTRODUCTION

The conventional e-voting framework, in spite of its potential for comfort and proficiency, endures from a few noteworthy disadvantages. One of the essential concerns is the defenselessness to cyber assaults and control, as centralized databases can be focused on by noxious performing artists looking for to modify or disturb race comes about. Moreover, conventional e-voting frameworks frequently need straightforwardness, making it troublesome for voters to con rm that their votes were precisely recorded and numbered. In addition, these frameworks may not satisfactorily secure voter protection, as centralized specialists have to get delicate voter data, raising concerns around information security and potential abuse. Generally, these disadvantages highlight the pressing require for more secure, straightforward, and privacy-preserving arrangements such as decentralized e-voting frameworks leveraging innovations like blockchain to upgrade the judgment and dependability of appointive forms.

The significance of a decentralized e-voting framework lies in its capacity to address essential challenges confronted by conventional voting frameworks, such as straightforwardness, security, and openness. By leveraging blockchain innovation, decentralized e-voting frameworks can guarantee tamper-resistant recording of votes, straightforward conformation of decision astuteness, and expanded believe in law based forms. Decentralization diminishes the dependence on centralized specialists, moderating dangers of control and improving by and large inclusivity by empowering inaccessible and portable voting alternatives. These frameworks hold the potential to revolutionize majority rule hones, cultivating more prominent cooperation, straightforwardness, and certainty among voters and partners in discretionary results.

The integration of blockchain innovation in e-voting frameworks offers various benefits that can altogether upgrade the constituent prepare. Firstly, blockchain guarantees straightforwardness and auditability by recording all voting exchanges permanently on a conveyed record, subsequently diminishing the chance of altering and extortion. Besides, the utilize of cryptographic strategies in blockchain ensures the security and security of votes, keeping up namelessness whereas empowering unquestionable status. Thirdly, decentralization inalienable in blockchain kills the dependence on a central specialist, decreasing the potential for control and improving believe among voters.

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Besides, blockchain-based e-voting frameworks can move forward openness by empowering inaccessible and portable voting choices, subsequently expanding voter interest and engagement in equitable forms. Generally, the selection of blockchain in e-voting frameworks advances keenness, security, straightforwardness, and inclusivity, fortifying the majority rule standards of reasonable and reliable races.

II. LITERATURE SURVEY

TABLE 1 LITERATURE SURVEY

Sl.No	Year of Publication	Project Titles	Description
1.	2024	A Blockchain Architecture for Secure Decentralized System and Computing.	The authors delve into the challenges faced by decentralized systems, particularly concerning security vulnerabilities and trust issues inherent in distributed networks. Traditional centralized systems are prone to single points of failure and susceptibility to malicious attacks, prompting the need for robust solutions to ensure data integrity, confidentiality, and availability.
2.	2024	A Survey of Decentralized Digital Voting System Using Blockchain Technology	By providing a systematic survey and analysis of existing literature and implementations, the paper aims to contribute valuable insights to researchers, practitioners, and policymakers working in the domain of electronic voting systems and blockchain technology. It helps in identifying gaps in current approaches and suggests potential avenues for further research and development to create robust, scalable, and user-friendly decentralized digital voting systems that uphold the integrity of democratic processes.
3.	2024	Advancing Democratic Governance with AIoT-Enabled E-Voting	Key aspects discussed in the paper include the design and implementation of the AIoT-enabled e-voting system tailored specifically for departmental associations within Covenant University. The system's features likely include secure authentication mechanisms, real-time data monitoring, encrypted transactions on a distributed ledger (potentially utilizing blockchain technology), and user-friendly interfaces for voters and administrators.
4.	2024	Design of Blockchain-based Secured Election Voting System	The authors likely present results from simulations or real-world implementations to demonstrate the effectiveness and efficiency of their proposed system in terms of security, transparency, scalability, and user experience. They may also discuss challenges faced during implementation and propose future research directions to improve and extend the capabilities of blockchain-based election voting systems.
5.	2024	Secure Keyword Search over Encrypted Cloud Data Using Blockchain in Digital Document Sharing	The increasing adoption of cloud storage and sharing services has brought significant convenience but also raised concerns regarding data privacy and security. Traditional encryption techniques ensure data confidentiality but hinder the ability to perform keyword searches directly on encrypted data without decryption, compromising security. In this context, Verma and Kanrar introduce a solution that integrates blockchain technology with encrypted cloud data to enable secure keyword search operations while preserving data privacy and integrity.
6.	2023	A Decentralized and Immutable E-Voting System using Blockchain	The project aims to create a secure and transparent electronic voting system, addressing trust issues in global elections. It explores blockchain's potential to enhance security and integrity while detailing its application on the Multichain network for reliable e-voting.

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7.	2023	Implementation of Smart Contract on Autonomous Decentralized Voting Blockchain	The paper proposes a secure non-fungible tokens (NFT) exchange marketplace system leveraging smart contracts on a decentralized voting blockchain. It emphasizes high availability and security for peer-to-peer transfers, showcasing the architecture and smart contract implementation using Geth code for blockchain transactions.
8.	2023	A Secure Decentralized E-Voting with Blockchain & Smart Contracts	The model proposes a secure, cost-effective e-voting system leveraging Blockchain and Smart Contracts, surpassing traditional methods. It ensures transparency, reduces costs, and enhances security through End-to-End Encryption and smart contract-driven immutability. Implemented as a MERN-based web app, it offers robust authentication and utilizes Blockchain for secure, immutable voting data storage (MERN stands for MongoDB, Express, React, Node)
9.	2023	Blockchain-based Voting System in a Democratic Environment	The electronic voting system ensures secure, efficient, and flexible voting processes, eliminating paper and enabling remote voting. Utilizing Blockchain enhances security, preventing fraud and multiple votes, addressing concerns in current voting systems while offering cryptographic functionalities and decentralization.
10.	2022	E-Matdaan: A Blockchain based Decentralized E-Voting System	The paper introduces a Blockchain-based e-voting system to tackle issues in current electronic voting like transparency, credibility, and speed. Implementing a proof-of-work consensus algorithm, it aims to enhance reliability and security in voting processes, highlighting the potential for further advancements in this field.
11.	2022	De-Centralized Voting System using Blockchain	Revolutionizing voting through Blockchain, our prototype E-Voting app on Ethereum ensures secure, transparent, and tamper-proof elections. Utilizing smart contracts, it offers a decentralized alternative to traditional, vulnerable methods, enhancing accessibility and reliability.
12.	2022	A Decentralized Digital Voting System Based on Block chain Architecture	Blockchain-based elections ensure safe, convenient voting, vital in the digital age and during crises like Covid-19. With personalized IDs and secure keys, it minimizes threats like hacking and chaos, offering unified modules for Election Commission oversight and citizen participation, all safeguarded on the blockchain.

III. METHODOLOGY

Steps followed for the project is as given below:

1. Candidate Registration
2. Preprocessing and Feature Extraction
3. Storing in Database
4. Transaction Process

1. Candidate Registration

Candidate information such as name, address, and other specific details, along with a facial capture for registration in the blockchain-based voting system, is securely stored in a database. This process ensures the integrity and transparency of the electoral process, with candidate details including identification, eligibility, and platform stored as encrypted records within the decentralized ledger. This setup allows for efficient and auditable access to information while maintaining the immutability and security features inherent to blockchain technology.

2. Preprocessing and Feature Extraction

Initially, facial detection algorithms like Haar cascades or deep learning models are employed to locate and identify faces within captured images. Subsequently, normalization techniques ensure that all facial images are resized and oriented consistently for uniformity. To enhance data quality, noise reduction filters are applied, refining the images for clarity.

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Further, facial alignment algorithms adjust key landmarks (e.g., eyes, nose, mouth) to a standardized position. For feature extraction, geometric measures such as distances between landmarks, texture features like local binary patterns, and deep learning-based features extracted from pre-trained CNN models are utilized.

3. Storing in Database

Storing facial features and candidate information securely in a database for future login purposes within a blockchain-based voting system is crucial for maintaining the integrity and accessibility of user data. By storing encrypted facial features and candidate details (such as name, address, and eligibility) in the database, the system can authenticate users during subsequent logins, ensuring secure access to voting functionalities. Additionally, enabling the admin to create election polls and define political parties within the system provides flexibility and customization for electoral processes. These election-related configurations, along with associated data like candidate lists and voting options, are stored in the database to facilitate efficient management and execution of elections. This approach enhances the overall functionality and reliability of the blockchain-based voting platform while safeguarding sensitive user and election-related information.

4. Transaction Process

First, when a voter logs in using their credentials (which could include facial recognition for candidate verification), the system verifies their identity against stored data in the database. Upon successful authentication, the voter can access the ballot and select their preferred candidate or vote on specific issues. Once a vote is cast, the transaction details, including the voter's identity and chosen options, are bundled into a block. This block is then broadcasted to the network of nodes (computers participating in the blockchain network) for verification. The nodes validate the transaction based on predefined consensus rules. If the transaction is valid, the new block containing the vote is added to the blockchain, ensuring immutability and transparency of the voting record.

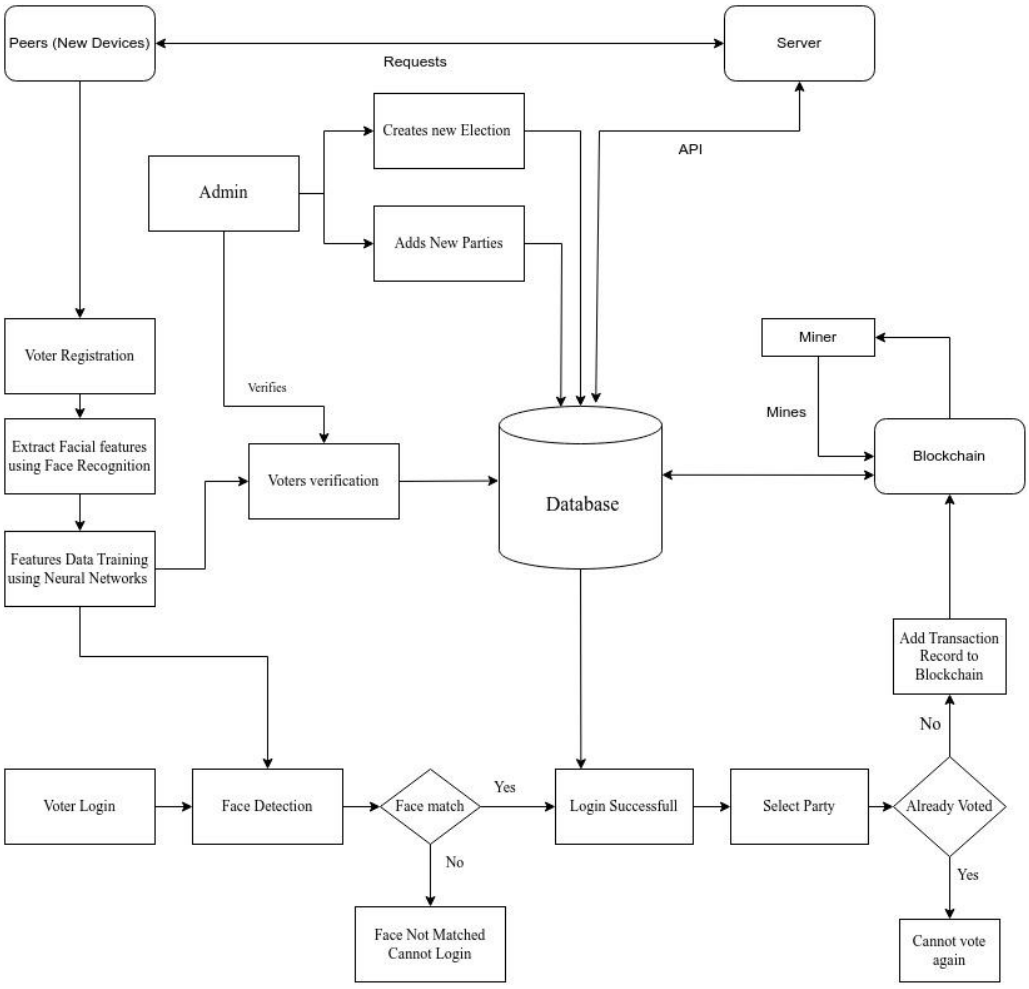

Fig 1: Flowchart of Election process

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5. Module Description

- Web application

The administrator can access the system by logging in with their credentials. If the credentials do not match, an error message will be displayed by the application. The administrator is able to add voters by entering their name, email, and Aadhar number. The administrator has the capability to create an election by specifying its name, unique ID, and date. Once added, they can view the details of the election. If an election with the same unique ID is already assigned, the application will not allow the administrator to add it again. After an election has concluded, the administrator can proceed to add a new election to the system. The admin can view the transaction information in the Blockchain where the previous and current hash are generated with the SHA-512 algorithm.

Voters can access the system by logging in with their credentials. If the credentials do not match, the application will display an error message. Additionally, if the voter has already voted in the current election, the application will not allow them to log in. Furthermore, if there is no ongoing election, access to the application will also be restricted. Once logged in, the voter can proceed to the voting page to select their preferred candidate to vote for. After making their selection, they can promptly log out of the application. The voters can view the voting status of the current election on the home page.

- Backend Process

SHA-512 is a cryptographic hash function belonging to the SHA-2 family, offering a high level of security and resistance against brute-force attacks. It generates a 512-bit (64-byte) hash value, providing robust data integrity verification. SHA-512 operates by processing input data in blocks through multiple rounds of hashing, resulting in a fixed-size output that uniquely represents the input. This algorithm is widely used in blockchain systems to ensure the immutability and integrity of transaction data, enhancing the overall security of the voting process.

Flask is a lightweight web framework for Python, ideal for developing web applications including blockchain-based voting systems. It provides simplicity and flexibility, allowing developers to create RESTful APIs and web interfaces efficiently. Flask integrates seamlessly with blockchain technologies, enabling the implementation of user interfaces for voter registration, ballot creation, and vote casting. Its modular design and extensive ecosystem of extensions make Flask a suitable choice for building scalable and secure online voting platforms within blockchain environments.

IV. RESULT

The testing of the blockchain-based e-Voting system yielded positive outcomes, demonstrating robust functionality, security, and usability. Key findings include successful implementation of smart contracts for secure vote recording, integration of cryptographic techniques ensuring data confidentiality, and efficient user interfaces facilitating voter engagement. Security assessments identified and addressed vulnerabilities, enhancing the system's resilience against potential threats. Usability testing revealed positive user experiences with intuitive interfaces. Performance testing confirmed scalability and responsiveness under varying loads. Overall, the results validate the readiness of the blockchain e-Voting system for real-world deployment, promising enhanced transparency and integrity in electoral processes.

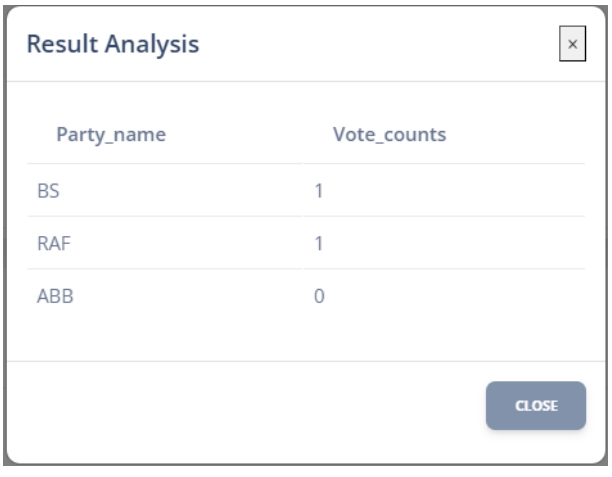

Fig 2: Result Analysis of a use-case Election

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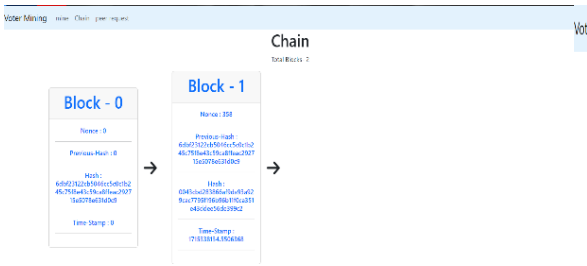

Fig 3: Adding of transactions to Blockchain

Fig 4: Transaction details after mining

During the process of adding transactions to the blockchain, each valid transaction undergoes verification by network nodes. Transactions are grouped into blocks, and miners compete to solve cryptographic puzzles to append new blocks to the chain. Once a block is validated and added to the blockchain, the transactions within it become permanently recorded and sequentially linked to previous blocks. This decentralized consensus mechanism ensures transparency and immutability of transaction history. After a block is successfully mined and added to the blockchain, transaction details become publicly accessible and immutable. Each transaction includes sender and receiver addresses, transaction amounts, timestamps, and cryptographic signatures. These details are recorded on the distributed ledger, providing a transparent audit trail of all transactions. The blockchain's decentralized nature ensures that once transactions are confirmed and recorded, they cannot be altered or removed, maintaining the integrity of the voting process.

Overall, the project successfully enhances security, transparency, and accessibility, revolutionizing democratic processes with decentralized, immutable technology.

V. CONCLUSION

In conclusion, the implementation of a blockchain-based e-voting system offers significant advantages in enhancing the integrity, transparency, and security of electoral processes. By leveraging blockchain technology, the system ensures immutability and tamper-resistance of voting records, thereby mitigating risks associated with fraud and manipulation. The decentralized nature of blockchain eliminates the need for a central authority, reducing the potential for single points of failure or bias in the electoral process.

Additionally, smart contracts can automate various stages of the voting process, such as voter eligibility verification and vote tallying, enhancing efficiency and reducing costs. Blockchain-based e-voting systems also facilitate increased voter participation by enabling remote and secure voting options, which can be crucial for absentee voters or those unable to physically visit polling stations. However, challenges such as scalability, privacy concerns, and user accessibility must be carefully addressed to ensure widespread adoption and trust in blockchain-based e-voting solutions. Overall, with proper design and implementation, blockchain technology holds immense promise in revolutionizing electoral systems by fostering transparency, inclusivity, and trust in democratic processes.

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