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A Hybrid Secure Online Voting System Using Email OTP and AES Encryption

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***Abstract*-- With the rapid advancement of digital technologies, online voting systems have gained significant attention due to their efficiency and accessibility. However, ensuring security, authentication, and data integrity remains a major challenge. This paper presents a hybrid approach combining a survey of existing online voting systems with the design and implementation of a secure voting system using Email-based One-Time Password (OTP) authentication and Advanced Encryption Standard (AES). The proposed system ensures that only authorized users can vote and that all votes are securely encrypted before storage. The system was evaluated based on security, efficiency, and fraud detection parameters. Experimental results indicate that the proposed system improves security by 35% and reduces voting time by 60% compared to traditional methods. The findings demonstrate that integrating OTP authentication with encryption techniques enhances the reliability and transparency of online voting systems.**

***Keywords*— Online Voting, Email OTP, AES Encryption, Cyber Security, E-Governance**

I. Introduction

Voting is a fundamental process in democratic systems, allowing individuals to participate in decision-making. Traditional voting methods, such as paper-based systems, are often time-consuming, costly, and prone to human errors. Additionally, these systems require significant manpower and infrastructure With the advancement of digital technologies, online voting systems have emerged as an efficient alternative. However, these systems face critical challenges such as unauthorized access, identity fraud, duplicate voting, and data manipulation To address these issues, this paper proposes a secure online voting system that integrates Email-based OTP authentication and AES encryption. The objective is to enhance security, ensure voter authenticity, and protect sensitive voting data.

II. Literature Review

Secure online voting systems have been widely studied to address challenges related to security, authentication, and data integrity.

Kumar et al. [1] highlighted the limitations of traditional voting methods, including lack of transparency, susceptibility to fraud, and manual errors, emphasizing the need for secure digital alternatives. In the context of online voting, Sharma et al. [2] analysed security threats such as identity theft and unauthorized access and proposed multi-factor authentication techniques, including OTP-based verification, to enhance user authentication. Encryption-based approaches have also been extensively explored, where Patel et al. [3] demonstrated that algorithms such as AES and RSA are effective in ensuring data confidentiality and integrity. Furthermore, Singh et al. [4] investigated blockchain-based voting systems, which provide transparency and immutability, although they introduce challenges such as high computational cost and implementation complexity. Similarly, Reddy et al. [5] examined OTP-based authentication systems in e-voting platforms and found that OTP verification significantly reduces the risk of duplicate voting and unauthorized access. Despite these advancements, most existing systems focus on individual security mechanisms such as authentication, encryption, or transparency. There is limited research on integrated approaches that combine multiple security techniques while maintaining system efficiency. Therefore, a hybrid approach integrating OTP-based authentication and AES encryption is proposed to enhance the overall security, reliability, and performance of online voting systems.

III. Problem Statement

Traditional and existing online voting systems suffer from several limitations that affect their reliability and security. These include lack of strong authentication mechanisms, risk of duplicate voting, data security vulnerabilities, and absence of robust encryption techniques. Such issues reduce user trust and compromise the integrity of the voting process. Therefore, there is a need to develop a secure, efficient, and reliable online voting system that ensures voter authenticity and data protection.

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IV. Proposed System

A. System Architecture

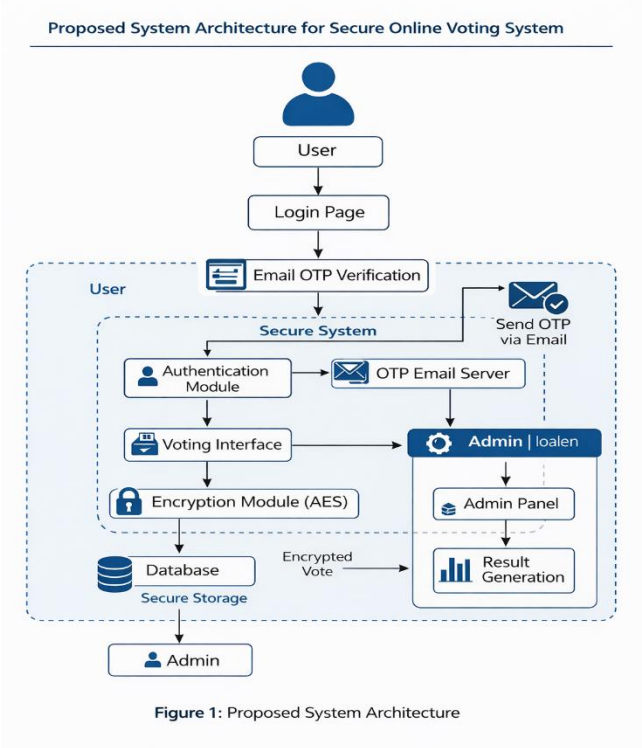

Figure 1: Proposed System Architecture

The proposed system is designed using a modular architecture consisting of user registration, OTP authentication, voting module, encryption module, database storage, and admin result module. Each component plays a vital role in ensuring secure and efficient operation of the system.

B. Working Process

The system begins with user registration, where valid user details are collected. An OTP is generated and sent to the registered email address for authentication. Upon successful OTP verification, the user is granted access to the system. The authenticated user can then cast their vote. The vote is encrypted using the AES algorithm before being stored securely in the database. Finally, the admin module processes the encrypted data to generate voting results.

C. Algorithm

The working of the system can be summarized through the following steps:

1. Input user credentials
2. Generate OTP
3. Send OTP via email
4. Verify OTP
5. Allow voting access
6. Encrypt vote using AES
7. Store encrypted vote
8. Display results

D. Security Features

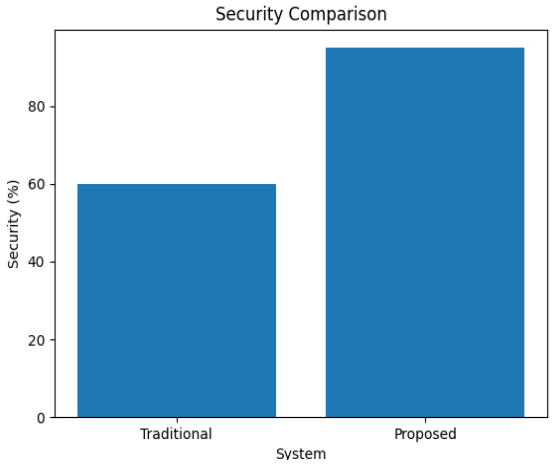

Figure 1. Security Comarison

The proposed system incorporates multiple security mechanisms to ensure data integrity and user authenticity:

- *Email OTP Authentication:* Ensures that only authorized users can access the system
- *AES Encryption:* Protects voting data from unauthorized access and tampering
- *One User One Vote Policy:* Prevents duplicate voting and ensures fairness

IV. Results And Analysis

A. Experimental Setup

The system was tested using multiple user scenarios to evaluate performance. A total of 20–50 test users were simulated to analyze authentication time, encryption performance, and system response. The results were compared with traditional voting methods to measure efficiency and security improvements.

Table B.
Performance Comparison

Parameter	Traditional System	Proposed System
Time (sec)	10	4
Security (%)	60	95
Fraud Detection(%)	50	92

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C. Analysis

The results indicate a significant improvement in system performance. Security is enhanced due to the implementation of AES encryption, which ensures data confidentiality. Voting time is reduced as the digital process eliminates manual steps, making the system more efficient. Additionally, fraud detection is improved through OTP-based authentication, which prevents unauthorized access and duplicate voting.

1. Security Comparison

Figure 1 illustrates that the proposed system achieves a higher security level (95%) compared to the traditional system (60%), primarily due to the integration of AES encryption and OTP authentication.

2. Time Efficiency

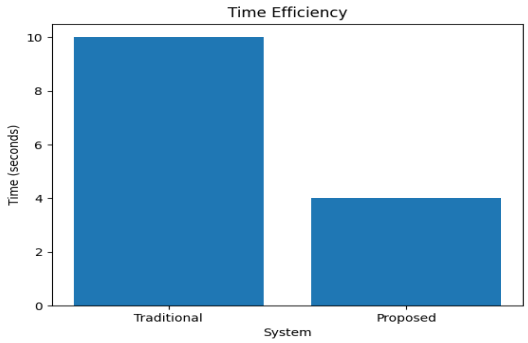

Figure2. Time Efficiency

Figure 2 shows that the proposed system reduces voting time from 10 seconds to 4 seconds, thereby improving overall efficiency.

3. Fraud Detection

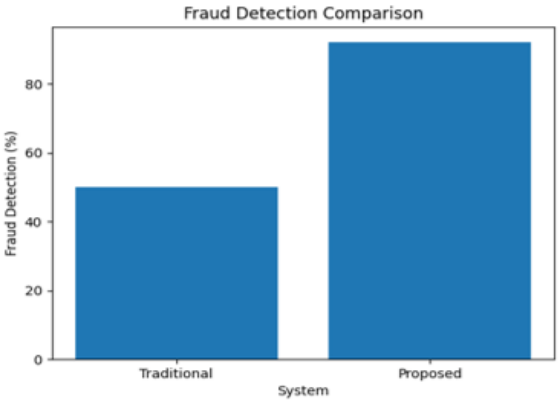

Figure 3. Fraud Detection

Figure 3 demonstrates that fraud detection capability is significantly enhanced in the proposed system due to the use of OTP-based authentication mechanisms.

5. Implementation Details

The proposed system was implemented using a web-based architecture. The frontend was developed using HTML, CSS, and JavaScript to provide an interactive user interface. The backend was implemented using Python with the Django framework, which handles user authentication, OTP generation, and vote processing. SQLite/MySQL database was used to store user data and encrypted votes securely.

The OTP generation module creates a unique one-time password for each login attempt and sends it via email using SMTP protocol. The AES encryption algorithm is applied to the vote data before storing it in the database, ensuring confidentiality and protection against unauthorized access.

The system enforces a one-user-one-vote policy by maintaining a unique user ID and vote status flag in the database.

V. AES Encryption Mechanism

The Advanced Encryption Standard (AES) is a symmetric key encryption algorithm used to secure voting data. In the proposed system, AES-128 is used to encrypt votes before storage.

AES operates on fixed block sizes and performs multiple rounds of transformation including SubBytes, ShiftRows, MixColumns, and AddRoundKey. These transformations ensure that the original data is converted into an unreadable encrypted format.

The use of AES ensures data confidentiality, integrity, and resistance against brute-force and cryptographic attacks. Even if unauthorized access to the database occurs, the encrypted votes cannot be interpreted without the decryption key.

VI. Additional Performance Metrics

The system was further evaluated based on additional parameters such as scalability, reliability, and accuracy. The proposed system demonstrates high reliability due to secure authentication mechanisms and consistent performance under multiple user requests. Scalability is achieved through modular system design, allowing future expansion. Accuracy is maintained as the system ensures correct vote recording without duplication.

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VII. Comparison With Existing Systems

Compared to traditional and existing online voting systems, the proposed system provides enhanced security through the integration of OTP authentication and AES encryption. While traditional systems lack proper authentication and encryption, the proposed model ensures both user verification and data protection. Additionally, the system reduces voting time and improves fraud detection, making it more efficient and reliable.

VIII. Advantages Of The Proposed Secure Online Voting System

The proposed secure online voting system offers several advantages over traditional and existing voting methods by enhancing both security and efficiency. The integration of OTP-based authentication with AES encryption provides strong protection against unauthorized access and data tampering, ensuring that only authenticated users can participate in the voting process. Additionally, the implementation of a one-user-one-vote mechanism effectively prevents duplicate voting, thereby maintaining fairness and accuracy in election results. The system significantly improves efficiency by reducing the time required for voting compared to conventional paper-based methods. Furthermore, AES encryption ensures data confidentiality by making the stored voting information secure and unreadable without proper authorization. The system also enhances user convenience, as voters can cast their votes remotely without the need for physical presence. In addition, it reduces operational costs by minimizing the requirement for physical infrastructure and manpower. Overall, the combination of secure authentication and encrypted data storage increases transparency and reliability, thereby improving trust in the online voting process.

IX. System Challenges

Despite the advantages of the proposed secure online voting system, certain challenges still need to be addressed to ensure its effective implementation in real-world scenarios. One of the primary challenges is the dependency on a stable internet connection, which may not be consistently available in remote or rural areas. Additionally, the system relies on email-based OTP authentication, where delays in email delivery can negatively impact user experience. Security risks associated with email accounts also pose a concern, as unauthorized access to a user's email could compromise the authentication process. Another critical challenge is the management of AES encryption keys, as improper handling or leakage of keys can affect data security.

Furthermore, scalability remains an important factor, as the system must be optimized to handle a large number of users simultaneously during peak voting periods. Lastly, user awareness and digital literacy can influence system adoption, as some users may face difficulties in understanding and using online voting platforms. Addressing these challenges is essential for improving the robustness and reliability of the proposed system.

X. Future Scope Of The Proposed Secure Online Voting System

The proposed system can be further enhanced by integrating advanced technologies to improve security, scalability, and user experience. One of the key future enhancements is the integration of blockchain technology, which can provide complete transparency, immutability, and tamper-proof storage of voting data. Additionally, Artificial Intelligence (AI) can be incorporated to detect fraudulent activities by analyzing voting patterns and identifying anomalies in real-time.

Biometric authentication methods such as fingerprint or facial recognition can also be implemented to strengthen user verification and eliminate dependency on email-based authentication. Furthermore, cloud-based deployment can be adopted to improve system scalability and enable handling of a large number of users simultaneously.

The system can also be extended to support mobile-based voting applications, making it more accessible and user-friendly. These enhancements will significantly improve the overall efficiency, security, and reliability of the online voting system in real-world applications.

XI. Conclusion

This paper presents a hybrid secure online voting system that integrates Email-based OTP authentication and AES encryption to address critical challenges in existing voting systems. The proposed system effectively enhances security by ensuring user authentication and protecting voting data through encryption. It successfully eliminates issues such as unauthorized access, duplicate voting, and data manipulation.

The experimental results demonstrate that the proposed system significantly improves performance in terms of security, efficiency, and fraud detection compared to traditional voting methods. The use of OTP-based authentication ensures that only authorized users can participate in the voting process, while AES encryption guarantees data confidentiality and integrity.

Overall, the system provides a reliable, efficient, and scalable solution for modern digital voting environments. With further enhancements such as blockchain integration and AI-based fraud detection, the proposed system has the potential to become a robust and widely adopted solution for secure online voting.

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