International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 13 Issue: 04 | Apr 2026 www.irjet.net p-ISSN: 2395-0072

BLOCKCHAIN-ENHANCED SECURE EXAMINATION MANAGEMENT SYSTEM USING MFA

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Abstract - *Traditional examination management systems are highly vulnerable to issues such as question paper leakage, unauthorized access, and data tampering due to centralized storage and manual handling processes. To address these challenges, this paper proposes a Blockchain-Enhanced Secure Examination Management System using Multi-Factor Authentication (MFA).*

The system integrates blockchain technology to ensure immutability and transparency of records, while the InterPlanetary File System (IPFS) is used for decentralized and secure storage of encrypted question papers. Multi-Factor Authentication strengthens access control by allowing only authorized users to access sensitive data.

Experimental evaluation shows that the system demonstrates efficient performance with an average authentication time of 1.2–1.8 seconds, data retrieval latency of 1.5–3 seconds, and reliable transaction processing. The proposed approach significantly improves data integrity, security, and fault tolerance compared to traditional systems.

Overall, the system provides a scalable and robust solution for secure examination management and can be extended to other domains requiring tamper-proof data handling.

Key Words: **Blockchain, Examination Management System, Multi-Factor Authentication (MFA), Data Security, Decentralized Storage, IPFS, Data Integrity, Encryption, Tamper-Proof System, Secure Data Sharing**

1. INTRODUCTION

Examination management systems play a critical role in maintaining the integrity and credibility of academic institutions. However, traditional systems that rely on manual processes and centralized databases are highly vulnerable to security threats such as question paper leakage, unauthorized access, and data tampering. These issues not only compromise examination fairness but also reduce trust in the overall evaluation process.

With the increasing adoption of digital platforms, centralized systems continue to face challenges including single points of failure, lack of transparency, and susceptibility to cyber-attacks. Ensuring secure storage, controlled access, and traceability of examination data has therefore become a major concern.

To overcome these limitations, this paper proposes a Blockchain-Enhanced Secure Examination Management System integrated with Multi-Factor Authentication (MFA). Blockchain technology provides a decentralized and immutable ledger that ensures all transactions are tamper-proof and verifiable. The use of the InterPlanetary File System (IPFS) enables secure and distributed storage of encrypted examination data, eliminating dependence on centralized servers.

In addition, Multi-Factor Authentication strengthens system security by requiring multiple verification steps before granting access, thereby significantly reducing the risk of unauthorized entry. The integration of these technologies ensures confidentiality, integrity, and availability of sensitive examination data.

The proposed system aims to provide a secure, transparent, and scalable solution for managing examination processes. By combining decentralized storage, cryptographic security, and strong authentication mechanisms, the system addresses the critical challenges faced by traditional examination management approaches.

1.1 Problem Statement

Traditional examination systems are vulnerable to question paper leakage, unauthorized access, and data tampering due to manual processes and centralized storage. They lack strong security, transparency, and proper access control. Hence, there is a need for a secure and decentralized system that ensures data integrity, confidentiality, and controlled access to examination data.

1.2 Proposed System

The proposed Blockchain-Enhanced Secure Examination Management System using Multi-Factor Authentication (MFA) provides a secure and decentralized solution for managing examination data. In this system,

question papers are encrypted and stored in IPFS, while their hash values are stored on the blockchain to ensure data integrity and prevent tampering. The system uses MFA to restrict access only to authorized users. When a user requests a paper, it is retrieved from IPFS and verified using blockchain before decryption. Overall, the system enhances security, transparency, and reliability in examination management.

2. LITERATURE REVIEW

Kapse et al. [1] showed that integrating blockchain with IPFS improves secure transmission of examination data by removing centralized risks. Christidis and Devetsikiotis [2] highlighted blockchain's ability to provide decentralized and tamper-proof systems, while Zyskind et al. [3] focused on secure data storage and privacy using blockchain.

Additionally, studies emphasized the role of IPFS and encryption in protecting sensitive data, and Aloul et al. [4] demonstrated that Multi-Factor Authentication (MFA) enhances system security by preventing unauthorized access. However, most existing systems address only specific aspects like storage or authentication. The proposed system overcomes this by integrating blockchain, IPFS, encryption, and MFA to provide a complete and secure examination management solution.

3. METHODOLOGY

The proposed system begins with user authentication using MFA to ensure secure access. Teachers create and encrypt question papers, which are then stored in IPFS. The file's hash is stored on the blockchain to maintain integrity.

When accessed, the file is retrieved, verified using blockchain, and then decrypted. This approach ensures secure storage, controlled access, and tamper-proof verification.

The system utilizes a blockchain platform (such as Ethereum) to maintain secure and controlled access to data. Cryptographic hashing (SHA-256) is used to generate unique identifiers for stored files, ensuring data integrity. Smart contracts are implemented to validate user access and enforce authorization rules, enabling secure and automated transaction processing.

3.1 System Architecture

The system architecture represents the overall structure of the Blockchain-Enhanced Secure Examination Management System using MFA, designed using a layered approach. It consists of a frontend layer for user interaction, a backend layer for processing and security operations, and a decentralized layer that includes blockchain and IPFS.

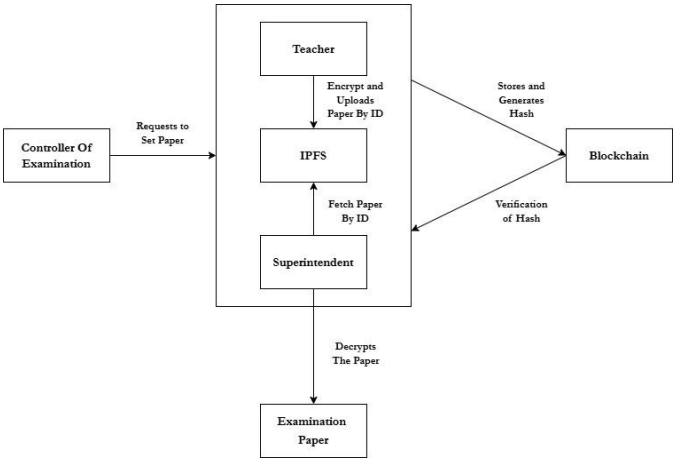

Fig. 1: System Architecture

The frontend provides interfaces for login, uploading, and retrieving question papers. The backend manages authentication using MFA, performs encryption and decryption, and controls communication between components. The decentralized layer stores encrypted files in IPFS and maintains hash values and transaction records on the blockchain, ensuring data integrity and tamper resistance.

The architecture ensures secure data flow between all components, preventing unauthorized access and data manipulation. It also improves system scalability and reliability by eliminating dependence on centralized storage. Additionally, it provides transparency through audit logs and enhances trust in the examination process.

3.2 Secure Examination Management Process

The system uses a secure workflow for managing examination data. A teacher first logs in using Multi-Factor Authentication (MFA) and uploads a question paper, which is encrypted before storage. The encrypted file is stored in IPFS, generating a unique Content Identifier (CID). A hash of the file is then stored on the blockchain to ensure data integrity.

When an authorized user requests access, the system retrieves the file using the CID and verifies it by comparing the hash with the blockchain record. If verified, the file is decrypted and displayed. This approach ensures confidentiality, integrity, and controlled access, reducing risks of data leakage and tampering.

3.3 Algorithm

The secure examination process follows a structured approach to ensure confidentiality, integrity, and controlled access. Initially, users are authenticated using Multi-Factor Authentication (MFA). Question papers are encrypted before storage and stored in IPFS, while their hash values are recorded on the blockchain. During

retrieval, the system verifies data integrity using blockchain before allowing access.

Algorithm: Secure Examination Management using Blockchain and MFA

1. User enters login credentials
2. System verifies user using Multi-Factor Authentication (MFA)
3. If authentication fails → deny access; else proceed
4. User uploads examination data
5. Data is encrypted
6. Encrypted data is stored in IPFS → generate CID
7. CID and metadata are stored on blockchain using smart contracts
8. On data request:
    - Verify user using MFA
    - Validate access permissions
9. Retrieve CID from blockchain
10. Fetch encrypted data from IPFS
11. Verify data integrity using blockchain hash
12. Decrypt data and display to user
13. Log all actions on blockchain for auditing

Output: Secure, tamper-proof examination management system

3.4 System Workflow

Workflow: The workflow of the proposed system begins when the user logs in using Multi-Factor Authentication (MFA). Once authenticated, the teacher creates and uploads the question paper, which is then encrypted to ensure confidentiality. The encrypted file is stored in IPFS, and a unique Content Identifier (CID) is generated. A hash of the file is created and stored on the blockchain to maintain data integrity.

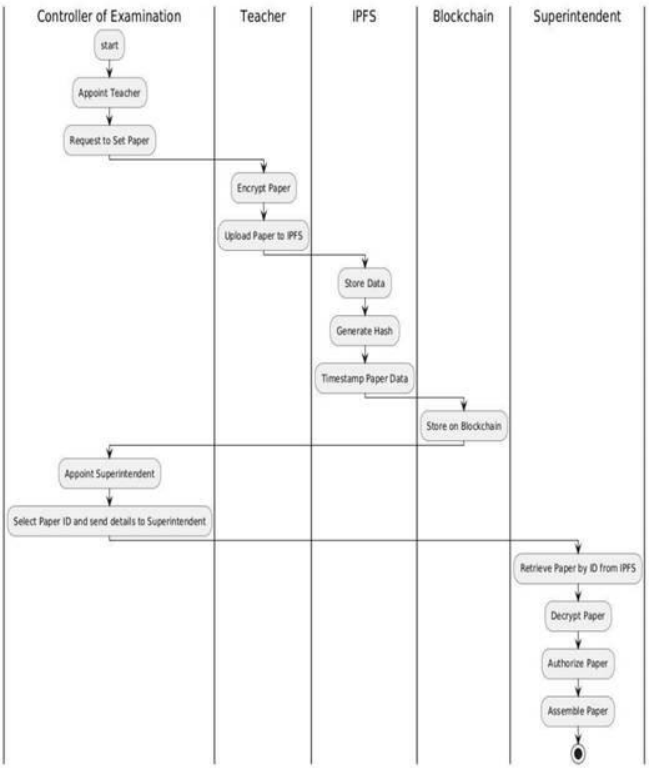

Fig. 2: Workflow

This presents the system workflow: User login → MFA authentication → Teacher uploads paper → Encrypt file → Store in IPFS → Store hash in blockchain → User requests access → Verify user → Retrieve file → Verify hash → Decrypt file → Display results → Record activity in blockchain.

4. IMPLEMENTATION AND RESULTS

The proposed system was implemented as a web-based application integrating blockchain, IPFS, and Multi-Factor Authentication (MFA). The frontend manages user interaction, while the backend handles encryption, authentication, and communication with decentralized storage and blockchain components.

The system was tested under different scenarios to evaluate performance in terms of authentication, data storage, retrieval, and overall system reliability.

4.1 Experimental Results

The performance of the system was evaluated using key parameters such as authentication time, data upload time, retrieval latency, and transaction processing time.

Table 1: Experimental Results

Parameter	Observed Result
Authentication Time (MFA)	1.2 – 1.8 seconds
IPFS Upload Time	2 – 4 seconds
Data Retrieval Time	1.5 – 3 seconds
Blockchain Transaction Time	3 – 5 seconds
System Success Rate	96%

The results indicate that the system performs efficiently with acceptable latency while maintaining strong security features.

4.2 Dataset Description

The system works with structured data related to users, question papers, authentication details, and blockchain records. Question papers are handled as digital files, which are encrypted before storage to ensure confidentiality. Each uploaded file is assigned a unique identifier (CID) in IPFS, while its corresponding hash value is stored on the blockchain.

User data such as roles (Admin, Teacher, Controller) and authentication details are stored in the database to enable secure access control. This structured data management ensures efficient handling, retrieval, and verification of examination information.

4.3 System Interface and Outputs

The proposed system provides a user-friendly interface for secure examination management, including login, request handling, and authentication verification. The interface is designed to ensure ease of use while maintaining high security standards. Figures below show the key interface screens of the system.

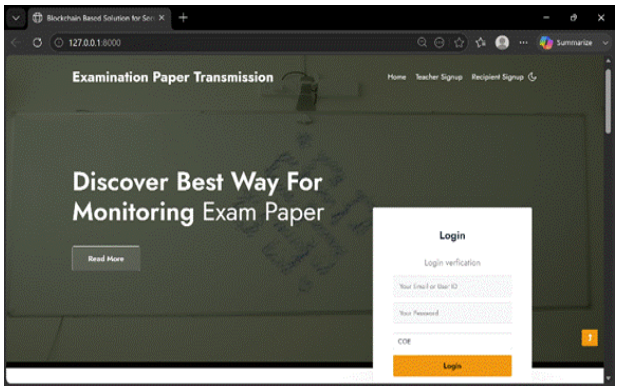

Fig. 3: Homepage Interface

The homepage displays the system title and a login panel for Email, Password, and Role, allowing only authorized users to access.

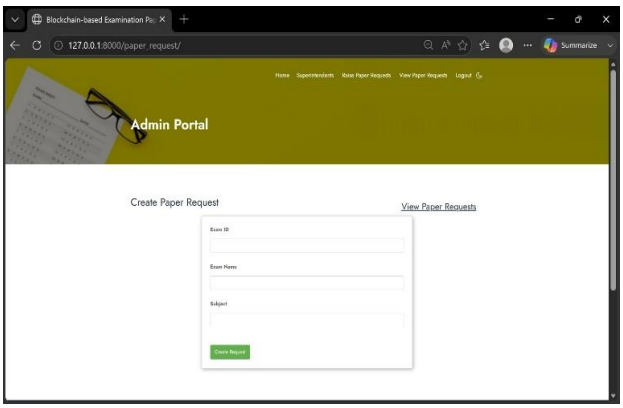

Fig. 4: Admin Portal – Paper Request Creation

The Admin Portal allows the Controller of Examination to create paper requests by entering Exam ID, Exam Name, and Subject, and to view existing requests for organized management.

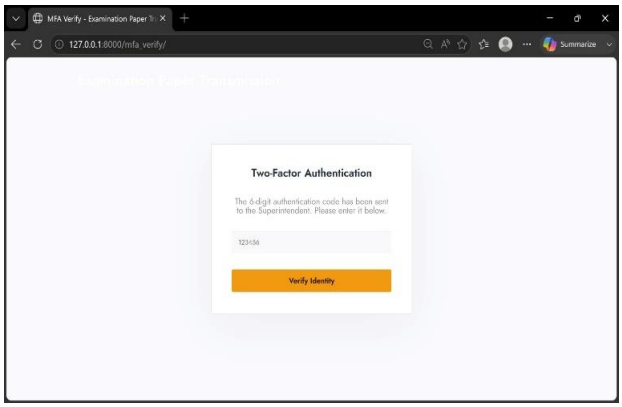

Fig. 5: MFA Verification Interface

This screen shows the MFA page where users enter a 6-digit OTP, adding extra security to protect access to exam data.

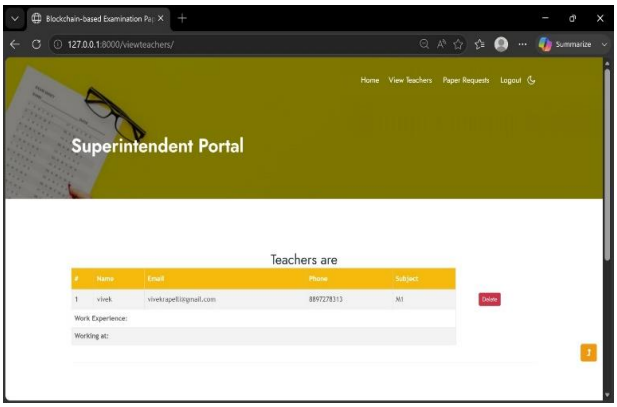

Fig. 6: Superintendent Portal – Teacher Management

Displays a table of teachers with details, allowing the superintendent to manage and delete records to keep only authorized staff.

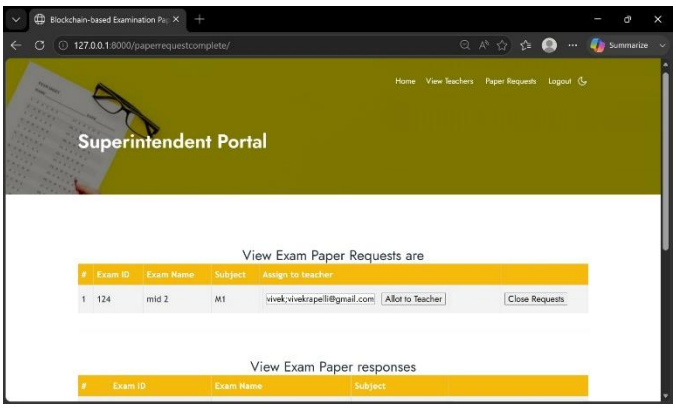

Fig. 7: Superintendent Portal – Exam Request Assignment

Displays exam paper requests with details, allowing the superintendent to assign them to a teacher using the "Allot to Teacher" option.

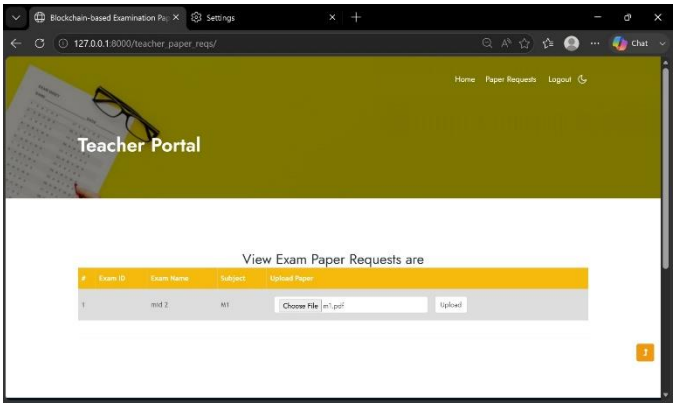

Fig. 8: Teacher Portal – Paper Upload

Assigned teachers upload question papers (PDF), which are stored on the InterPlanetary File System, with the hash recorded on Ethereum blockchain for security.

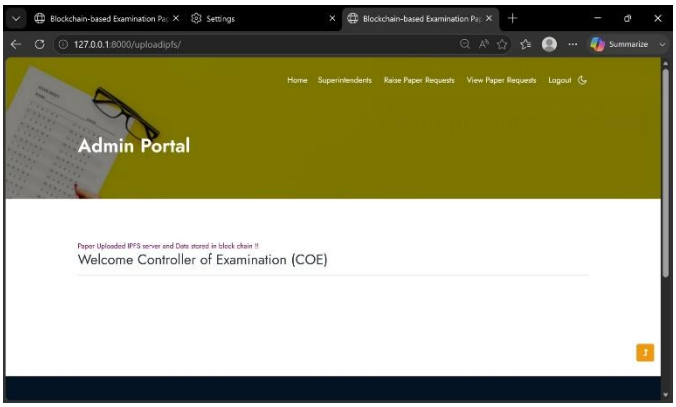

Fig. 9: Admin Portal – COE Dashboard

Confirms successful upload with storage on the InterPlanetary File System and Ethereum; the COE can track and manage requests from the dashboard.

4.4 Performance Analysis

The performance of the proposed system is analyzed based on security, efficiency, and reliability.

- Security:
  Blockchain ensures immutability of records, preventing unauthorized modification. MFA enhances access control by requiring multiple verification steps.
- Efficiency:
  The system demonstrates low processing time for authentication and data retrieval. IPFS enables fast distributed storage and retrieval without overloading a central server.
- Reliability:
  The decentralized architecture eliminates single points of failure, ensuring continuous availability of data even if some nodes fail.
- Scalability:
  The system supports multiple users and simultaneous requests without significant performance degradation.

Overall, the system performs better than traditional centralized examination systems in terms of security, transparency, and fault tolerance.

4.5 Comparison with Existing Systems

Feature	Traditional System	Proposed System
Data Storage	Centralized	Decentralized (IPFS)
Security	Low	High (Blockchain + Encryption)
Access Control	Password-based	Multi-Factor Authentication
Data Integrity	Vulnerable	Tamper-proof
Transparency	Limited	High (Audit Trail)
Failure Risk	High	Low

5. CONCLUSION

The proposed *Blockchain-Enhanced Secure Examination Management System using Multi-Factor Authentication (MFA)* successfully addresses the major challenges faced by traditional examination systems, such as question paper leakage, unauthorized access, and data tampering. By integrating blockchain technology, IPFS, and encryption, the system ensures secure storage and transmission of examination data. The use of blockchain provides a tamper-proof and transparent audit trail, while IPFS enables decentralized and reliable storage. Multi-Factor Authentication strengthens access control, ensuring

that only authorized users can access sensitive information.

The system also improves efficiency by reducing manual processes and minimizing human errors. Overall, the implementation demonstrates enhanced security, data integrity, and reliability, making it a practical and scalable solution for modern examination management. This approach can be further extended to other domains requiring secure data handling and verification.

Future work can focus on optimizing transaction latency and integrating AI-based anomaly detection for enhanced security.

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