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A Secure Blockchain based Framework for Evaluation of Examination Answer Sheets

Mrunalini Nandanwar[1], Naresh Kireedula[2], Amit Sharma[3]

[1]Scientist E, Centre for Development of Advanced Computing (C-DAC), Mohali A-34, Phase – 8, Industrial Area, SAS Nagar Mohali, Punjab 160071, India
[2,3]Project Engineer, Centre for Development of Advanced Computing (C-DAC), Mohali A-34, Phase – 8, Industrial Area, SAS Nagar Mohali, Punjab 160071, India

Abstract
Examination system integrity is a top issue, especially in the context of where high numbers of sensitive academic information are processed and stored. In this study, a blockchain-based examination management system is proposed to improve the security, transparency, and accountability of assessment processes. Using Hyperledger Fabric, the system will store cryptographic hashes of examination documents, assessment marks, and results, making them immutable while enabling verification from concerned stakeholders.
The system architecture is designed based on a Flask-based backend for business logic, SQL Server database for structured data storage, and a responsive web interface developed with HTML, CSS, and JavaScript. Hyperledger Fabric is incorporated to capture tamper-proof audit trails and protect data references without storing sensitive data on the blockchain itself. Scalability is achieved in the design and supports both online and offline examination situations.
Application of the system proposed shows improved data integrity and audibility. Blockchain usage in storing document hashes and results of evaluation makes it highly difficult to provide unauthorized changes and offers a credible way of monitoring data provenance. The system was efficient and scalable and had minimal extra overhead but improved trust in examination processes. This study presents a new fusion of blockchain technology with traditional database-backed examination management systems. It presents a practical solution that can be implemented by educational institutions, public service commissions to secure examination data, ensure transparency, and establish trust among stakeholders. The approach makes a contribution to continued work in securing academic processes through new technologies while ensuring usability and performance.

Keywords: Blockchain, Hyperledger Fabric, Examination Security, Data Integrity, Evaluation Transparency, Exam Evaluation.

1. Introduction

Exams are the core of evaluation and recruitment processes in schools and public service commissions. These organizations have the responsibility of handling sensitive academic and recruitment information, such as question papers, answer scripts, and assessment outcomes. Guaranteeing the safety, integrity, and openness of these exams is essential for retaining public faith, inspiring meritocracy, and ensuring the

credibility of institutions involved in determining careers and administrative roles.

As examination processes become increasingly digitized, institutions are implementing software systems to automate processes like paper distribution, scanning of answer sheets, and publication of results. Although these systems provide efficiency and scalability, they also bring with them the risks of centralized data storage and scanty audit controls. Threats of unauthorized manipulation, cyber-attacks, and data loss due to inadvertence are looming risks [1][9] that compromise the integrity of examination results.

Public service commissions that recruit applicants for government positions and educational institutions that assess academic performance are both subject to the same kinds of challenges. The confidential nature of examination results requires effective security solutions beyond the standard use of encryption and access control. In addition, the absence of open and auditable processes has sparked growing demands and criticism for systems that will ensure fairness and accountability.

Blockchain technology has appeared as a revolutionary instrument that can tackle such difficulties.[3][7] By delivering a decentralized and tamper-evident ledger, blockchain makes it possible to ensure that once data related to examination is put into place, it cannot be changed without due consensus. Hyperledger Fabric, which is a permissioned blockchain platform, provides top-tier functionalities like role-based access control, modular transaction validation, and privacy features that correspond to the operational requirements of examination bodies. By leveraging cryptographic hashes, assessment documents and rating data can be safely referred to and validated without revealing confidential information.

This paper introduces a blockchain-integrated examination management system that will be beneficial for both educational institutions and public service commissions. The system uses Hyperledger Fabric to safely record hashes of examination files like scanned answer sheets, marks of evaluation, and result records while utilizing existing database infrastructures for handling data efficiently. The architecture incorporates a Flask-based backend, SQL Server for structured storage, and an interactive web interface developed using HTML, CSS, and JavaScript to enable user interactions.

2. Objective

The overarching aim of this study is to design a transparent and secure exam management system based on blockchain technology to overcome the issues of educational institutions and public service commissions.

The detailed objectives of this research are:

Improving Data Security: To secure examination records like question papers, scanned answer scripts, evaluation marks, and result data against tampering, unauthorized access, and unintentional corruption.

Enhancing Transparency and Trust: In order to make it possible to have a verifiable system in which stakeholders such as students, assessors, and administrative institutions can verify the integrity of examination data independently via unalterable audit trails.

Smooth Integration with Current Systems: With the aim of developing a solution that integrates with legacy database-backed systems, utilizing Flask as the backend, SQL Server for storing structured data, and an HTML, CSS, and JavaScript-based web interface for simplicity.

Using Blockchain for Auditability: To use Hyperledger Fabric's permissioned blockchain framework to store cryptographic hashes of examination files for safe and efficient verification without revealing sensitive content.

Scalability and Adaptability: To suggest an architecture that could scale and be adapted across different types of examination environments, such that both academic institutions and public service commissions can deploy the system with minimal disruption.

Through the attainment of these goals, the research hopes to add a solid framework that protects the examination process while fostering fairness and accountability across different institutional contexts.

3. Methodology

The methodology in this study is centered on developing and deploying a blockchain-based examination management system that enhances data integrity and transparency. The methodology integrates proven software technologies with the distributed ledger of blockchain to present a secure and auditable environment for examination data management. The methodology is structured into the system architecture, data flow, blockchain integration, and implementation tools.

3.1 System Architecture

The suggested system design is based on a layered structure in which classical database management exists alongside blockchain for crucial data verification.

The design has four main elements:

Backend: Flask framework is employed to create the server-side functionality. It processes requests from the user interface, communicates with the database, and sends messages to the blockchain network to log cryptographic hashes.

Data Storage: A SQL Server database is used to hold structured information like user data, examination timetables, and uploaded documents. Sensitive data stays in the database under tight access controls, whereas hashes of essential documents are transferred to the blockchain for validation.

Blockchain: Hyperledger Fabric is utilized to establish a permissioned blockchain network which stores hashes of documents pertaining to exam answer sheets [9]. Authorized nodes like evaluation bodies and administrative entities can only access and validate transactions, this layer ensures the answer sheets to be tamper-proof.

User Interface: A dynamic web interface implemented in HTML, CSS, and JavaScript enables users like administrators, evaluators, and scanners to upload, view, and validate document integrity.

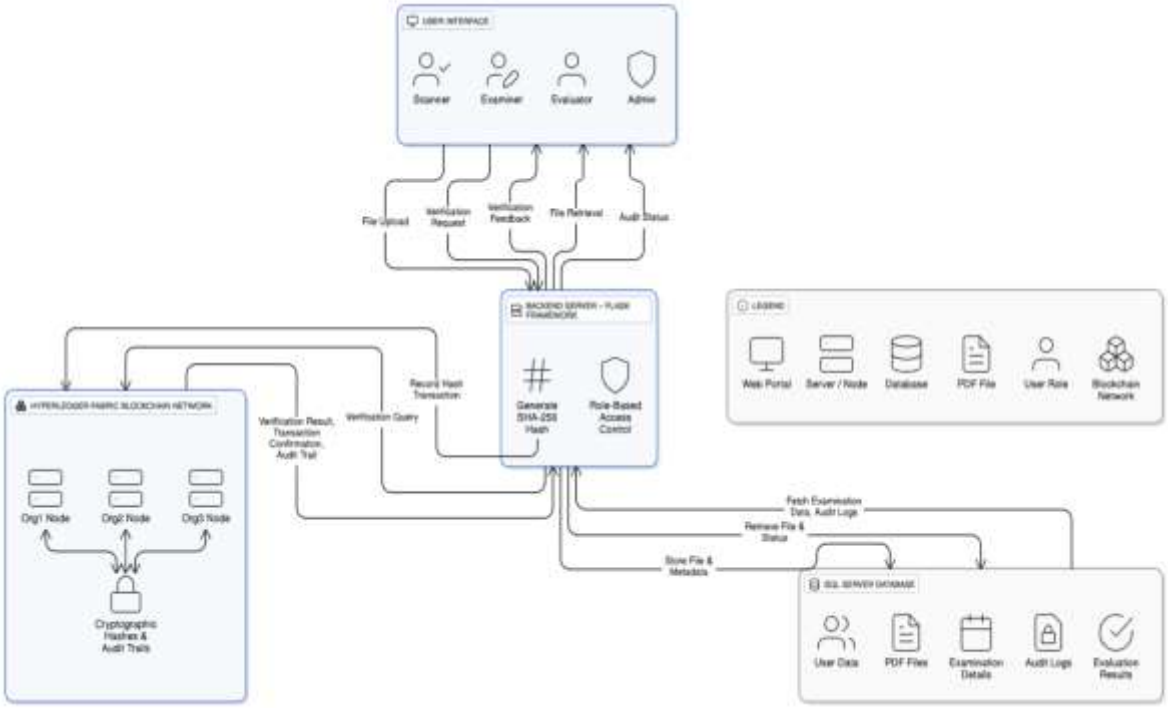

Figure 1: System Architecture of Blockchain-Integrated Examination Management System

3.2 Data Flow

The data flow starts when a scanner uploads an examination-related document, like a **scanned answer sheet**. The backend does the following:

File Upload and Storage: The file is uploaded via the web interface and stored within the SQL Server database and sending the same to the blockchain database with metadata like submission time, user ID, and examination code.

Hash Generation: A SHA-256 hash of the file is created to produce a unique fingerprint of its content without revealing the data itself.

Blockchain Transaction: The hash and accompanying metadata are transmitted to the Hyperledger Fabric network in the form of a transaction request. After validation, the transaction is added to the blockchain ledger, once the transaction is committed the document hash cannot be tampered without proper consensus from all the peers participated in this network.

Verification: At any point, stakeholders may ask for verification of the document's integrity. The system recompiles the hash from the stored file and checks it with the hash stored in the blockchain to verify its authenticity.

This flow ensures that the examination documents are verifiable without keeping the actual files on the blockchain and thus maintaining privacy and scalability.

3.3 Blockchain Integration

Hyperledger Fabric is selected based on its permissioned setup and enterprise characteristics appropriate for public institutions. The blockchain network involves several organizations, which represent trusted administrative organizations engaged in the examination process.

Main points of the integration are:

Membership Service Provider (MSP): It guarantees only approved parties can submit and verify

transactions

Chain-code Implementation (Smart Contract): Specialized smart contracts are created to validate transactions, ensuring only hashes adhering to specified rules are accepted.

Endorsement Policies: Specify which set of nodes needs to endorse a transaction before it gets committed to the ledger.

Privacy Concerns: Although hashes can be publicly verified, original documents are kept in the database, and access is restricted based on role-based permissions.

3.4 Implementation Tools

The following set of **tools and technologies** were utilized in the system development:

Flask: A minimalistic Python web framework to create RESTful APIs and securely handle file uploads.

SQL Server: A relational database management system for storing structured test data and user information.

Hyperledger Fabric: Permissioned blockchain platform with Chain-code (Smart Contract), MSP, and endorsement policies among tools for secure transaction management.

Web Technologies: HTML5, CSS3, and JavaScript were applied to build a friendly interface for handling document upload and verification procedures.

Cryptographic Libraries: OpenSSL or Python's hashlib library to calculate SHA-256 hashes of the files prior to uploading them to the blockchain [8].

The combination of these technologies ensures that the proposed system remains scalable, secure, and adaptable to real-world examination scenarios.

4. Results

The performance of the blockchain-integrated examination management system was measured on its capacity to improve data security, document integrity, and verification. The findings of the study are system performance, accuracy of verification, scalability, and user experience.

a. System Performance

The system was installed in a test setup with multiple nodes used to represent administrative entities. Uploading an examination document, computing a hash, and writing it onto the blockchain [4] took an average of 2–3 seconds. The light-weight Flask backend processed uploads of files and hash calculations with minimal lag.

Validation of transactions in the Hyperledger Fabric network, such as endorsement by required peers, was less than 5 seconds under normal conditions. The findings confirm that integration of blockchain does not affect the responsiveness of the examination management system.

b. Verification Accuracy

In order to evaluate the correctness of the verification process, multiple test cases were executed where documents were uploaded, verified, and tampered with. The system consistently identified any content changes in the document using the comparison of the recalculated hash value with the existing hash value in the blockchain.

For example, when a scanned answer sheet was intentionally modified by the introduction of additional characters, the hash recalculated from the modified file was not equal to the stored hash, and the system marked the file as compromised. This verifies that even small changes are identifiable, guaranteeing the

integrity check robustness.

c. Scalability

The system was also tested under concurrent uploads and verification requests to mimic the real- world examination scenario. The architecture handled simultaneous transactions effectively with no considerable reduction in performance [3].

Because only hashes not actual documents are deployed to the blockchain, network overhead is reduced. The underlying database contains the documents themselves, enabling the system to grow with available storage capacity. Hyperledger Fabric's modular architecture helps further accommodate growth by adding nodes when necessary to handle greater user bases.

d. User Experience

Test user feedback from administrators and evaluators informed us that the system interface is clean and easy to use. The upload of files is easy, and verification requests are handled without any delay.

Administrators welcomed the audit trails delivered by the blockchain, permitting them to scrutinize transaction history without having to access the actual content of documents. Examiners also used the system to their advantage in maintaining the integrity of answer scripts during assessments.

Users were assured of the system's capacity to prevent manipulation of data and unauthorized interference, leading to more trust in examination results.

e. Key Observations

The immutability and auditability of blockchain greatly increase the validity of the examination process without incurring significant performance overheads.

Cryptographic hashes are used to ensure confidentiality while permitting verification of documents.

Modular design enables easy integration with database systems that already exist, lessening the complexity and cost of implementation.

Real-time verification mechanisms enable stakeholders to verify examination data independently, alleviating historical concerns regarding fairness.

These findings confirm that the proposed system is not just technologically viable but also viable for use in educational institutions and public service commissions looking for secure and transparent examination processes

5. Discussion of Findings

Implications drawn from conducting the blockchain-integrated exam management system show a number of major improvements in securing exam processes for educational institutions and public service commissions. This discussion translates these findings against the backdrop of prevailing challenges and delves into their wider implications.

a. Strengthening Trust in Examination Systems

One of the most important aspects of examination management is trust—trust that question papers, answer scripts, and results are free from tampering. Blockchain's immutability ledger offers an immutable record that cannot be changed after it is verified by the network [5]. This aspect directly tackles fears of manipulation and tampering that have hounded examination systems in the past. In allowing stakeholders to check for themselves the integrity of documents without interference, the system encourages transparency and comforts candidates and administrators alike.

The verification process, which involved comparing stored hashes with hashes that were recalculated, was very accurate despite making minor changes. This detection level supports the credibility of the system and ensures that there is a mechanism to maintain fairness automatically, a factor that is particularly important in high-stakes tests organized by public institutions.

b. Maintaining Privacy while Ensuring Integrity

A common challenge when using distributed ledger technology in sensitive environments is balancing transparency with privacy. The system's architecture, which stores only cryptographic hashes on the blockchain while keeping full documents in a secure database, achieves this balance effectively. Hashes provide proof of existence and integrity without revealing the contents of files.

This method avoids illegal access to confidential examination information, thus solving confidentiality and misuse of data concerns [2][7]. Stakeholders are free to audit the system without exposing personal or examination information.

c. Smooth Integration with Current Infrastructures

A further advantage of the presented solution lies in its compatibility with traditional examination processes. Integrating blockchain with Flask, SQL Server, and web technologies, the system refrains from breaking habitual working patterns. Educational and recruitment authorities can implement the solution incrementally and utilize existing tools to increase data security measures gradually.

This helps avoid having institutions encounter steep learning curves or exorbitant costs related to full-scale infrastructure revolutions. The utilization of generic technologies for backend processing and data storage allows the system to be scalable and affordable.

d. Performance and Scalability Considerations

The performance testing verified that adding blockchain for hash storage and verification does not add considerable latency. The transactions are completed quickly, and the system remains responsive even when subjected to moderate loads. This is important because test environments tend to include concurrent interactions from many users in the course of document uploads and result verification.

Additionally, the architecture's design keeping hashes alone on the blockchain is minimizing the amount of data carried across the network, allowing institutions to expand their operations without needing large amounts of computational power.

e. Implications for Educational and Recruitment Bodies

The results indicate that institutions are able to implement this model to reduce long-standing problems of data integrity and auditability in examination exercises. Public service commissions, which carry out massive recruitment examinations, can gain from decreased administrative loads and increased candidate confidence. In the same way, academic institutions can make academic tests fairer and more credible.

The modular architecture of the system also leaves room for future extensions, for example, publication of results automatically, integration with digital identity systems, or distribution of examination materials securely.

f. Challenges and Future Directions

Despite the positive results, certain challenges remain. Blockchain adoption requires investment in technical infrastructure and training for administrative personnel [3]. Role-based access controls must be carefully managed to prevent misuse or unauthorized submissions. Moreover, ensuring the long-term sustainability of the blockchain network will require consistent governance and collaboration among participating organizations.

Subsequent research might investigate integration with sophisticated encryption methods, rollout over geographically dispersed nodes, and algorithms for real-time fraud detection. Pilots in various institutional contexts would also gain insights into usability, cost-effectiveness, and scalability [6].

6. Conclusion

Both public service commissions and educational institutions require the honesty and integrity of examination procedures. As examinations become more and more reliant on online platforms, risks of tampering, unauthorized access, and audits have come to fore-front [1]. This study proves that blockchain technology, specifically Hyperledger Fabric, presents an available and efficient solution for overcoming such threats without adding undue complexity and cost.

By merging blockchain with conventional examination management software, the framework proposed here guarantees that examination data like question papers, answer sheets, and evaluation marks are safely referred to with cryptographic hashes. The system offers verifiable audit trails without compromising the confidentiality of examination data, and the best balance between transparency and secrecy is achieved. The outcome is that the system operates with predictable reliability in practical operation loads, with negligible latency and high accuracy for data tampering detection [10].

Modular design, constructed with Flask, SQL Server, and web technologies, supports easy integration with current infrastructures, easing adoption in various institutional environments. Stakeholders such as administrators, evaluators, and candidates can enjoy increased trust, easier audit processes, and enhanced governance mechanisms.

While issues like investment in infrastructure and governance are still present, the work points to a scalable and flexible architecture that can be used by educational and recruitment agencies to protect examination integrity. There is potential for future research in further tightening privacy, deploying the architecture in distributed settings, and applying machine-learning methods for fraud detection.

In summary, the use of blockchain technology in examination management systems offers a promising method for developing secure, transparent, and reliable environments for exams. The study makes an added contribution in terms of a practical framework that can be applied by institutions to ensure confidence in academic and hiring processes, thereby guaranteeing fairness, accountability, and credibility in exams.

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