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Blockchain-Based Verification System for Academic Certificates

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Abstract:

In today's digital landscape, academic institutions face increasing challenges in ensuring the authenticity and integrity of educational certificates. Traditional verification systems are often manual, time-consuming, and vulnerable to forgery. This paper proposes a secure, decentralized system for academic certificate verification and e-signing using blockchain technology. Leveraging the immutable and transparent nature of blockchain, our system enables institutions to issue tamper-proof digital certificates and provides a platform for verifiers to authenticate credentials efficiently. The solution incorporates a hash-based algorithm for data integrity and utilizes smart contracts for automated validation and secure electronic signing. The architecture eliminates dependence on centralized authorities, reduces administrative overhead, and enhances trust between students, institutions, and employers. Through this framework, we aim to modernize academic credentialing with a scalable and robust digital alternative to traditional paper-based systems.

Key Words: Blockchain, Digital Certificates, Smart Contracts, E-Signing, Academic Verification, Hashing, Decentralization.

1. INTRODUCTION

Academic certificates play a vital role in verifying an individual's qualifications and professional credibility. However, traditional certificate management systems are largely paper-based, making them susceptible to loss, forgery, and manipulation. Manual verification processes are time-consuming, inefficient, and often rely on centralized authorities, which poses risks in terms of security and transparency. In the age of digital transformation, there is a critical need for a secure, scalable, and tamper-proof method to issue, verify, and manage academic credentials.

Blockchain technology offers a promising solution to these challenges. With its decentralized architecture, immutability, and cryptographic security, blockchain enables the issuance of verifiable digital certificates and e-signatures that are protected against unauthorized alterations. This paper proposes a blockchain-based system that securely stores academic certificates, generates unique hash values, and allows instant verification through smart contracts. The inclusion of e-signing further streamlines digital validation, ensuring authenticity while reducing administrative overhead for institutions and organizations.

2. LITERATURE SURVEY

A. Gayathiri et al. (IEEE ICSSS 2020) proposed a blockchain-based system for certificate validation where physical certificates are converted into digital form and secured using a chaotic hashing algorithm. These hash values are stored in the blockchain, allowing institutions to verify academic, SSLC, and HSC certificates through a mobile application. Their approach ensures data security, integrity, and offline verification, reducing dependency on centralized systems. However, the system's limited scalability and the reliance on a custom chaotic algorithm pose challenges for wider adoption.

Masoomeh Bahrami et al. (ICCKE 2020) introduced a comprehensive academic certificate management system using Hyperledger Fabric. This permissioned blockchain allows universities to issue and validate certificates using smart contracts, ensuring high-level security, transparency, and decentralization. The system facilitates user registration, credential issuance, and certificate validation entirely on-chain. While this approach enhances efficiency and data control, the complexity of integrating multiple universities and managing network permissions remains a key consideration for implementation.

Padmavati E Gundgurti et al. (ICIRCA 2020) developed SecureCert, a platform to prevent certificate counterfeiting by leveraging blockchain's immutability. The system generates a hash for each certificate and stores it in the blockchain, allowing verifiers to detect any modification. The authors highlighted the use of cryptographic methods like SHA-256 and emphasized the platform's usability for both educational institutions and employers. Their work demonstrates strong authentication features but lacks an integrated revocation mechanism and real-time certificate lifecycle management.

Mahmudul Hasan et al. (ICAICT 2020) proposed DistB-CVS, a secure and distributed certificate verification system tailored for regions where cryptocurrencies are banned. The architecture uses a private blockchain with multi-signature schemes and cloud integration to enhance security and verifiability. The system supports on-chain data storage, timestamping, and role-based access, making it suitable for government and academic institutions. Despite its robustness, the absence of smart contract automation limits its scalability for dynamic use cases like course completions or real-time endorsements

3. OBJECTIVES OF THE PROPOSED SYSTEM

The proposed system aims to modernize and secure the process of academic certificate issuance, storage, verification, and e-signing using blockchain technology. The primary objective is to eliminate certificate forgery and streamline the verification process through a decentralized, tamper-proof digital infrastructure.

The key objectives of the system are as follows:

1. **To prevent certificate forgery and tampering** by utilizing the immutable and transparent nature of blockchain for storing academic records.
2. **To digitize and securely store academic certificates**, eliminating the risks associated with loss, damage, or unauthorized alteration of physical documents.
3. **To provide fast, real-time verification** of certificates through blockchain, reducing manual work for institutions and delays for employers or verifiers.
4. **To implement cryptographic hash functions** for generating unique identifiers for each certificate, ensuring authenticity and data integrity.
5. **To incorporate smart contracts for automated validation and e-signing**, enabling trusted authorities to digitally endorse certificates without intermediaries.
6. **To support scalability and interoperability**, allowing multiple institutions and verifiers to participate in a common, permissioned blockchain network.

4. PROPOSED SYSTEM

The proposed system presents a blockchain-based platform for issuing, storing, verifying, and electronically signing academic certificates in a secure, tamper-proof, and decentralized environment. It aims to eliminate the risks of document forgery, reduce manual verification delays, and ensure real-time, transparent validation of academic records.

4.1 System Overview

In this system, educational institutions are authorized to issue digital certificates. Each certificate is hashed using a cryptographic algorithm (e.g., SHA-256) to produce a unique, fixed-length hash. This hash, along with metadata such as student ID, course name, and issue date, is stored in a block on the blockchain. The block also includes a timestamp and the hash of the previous block, ensuring immutability and traceability.

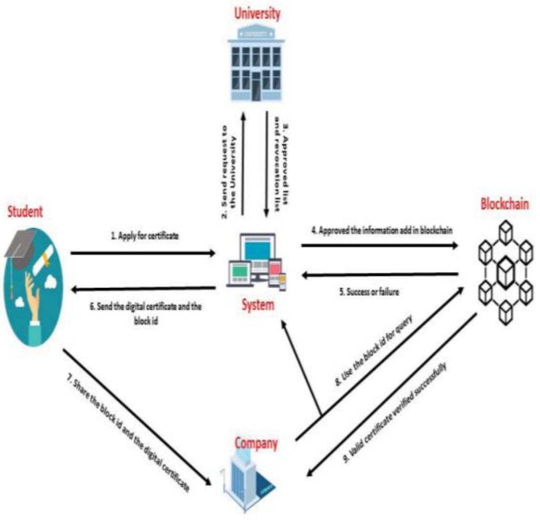
University
2. Send request to the University
3. Approved list and revocation list
Student
1. Apply for certificate
System
6. Send the digital certificate and the block id
4. Approved the information add in blockchain
5. Success or failure
Blockchain
7. Share the block id and the digital certificate
8. Use the block id for query
9. Valid certificate verified successfully
Company

Fig -1: Flow Diagram of Certificate Verification System

Smart contracts are employed to automate the processes of certificate issuance, verification, and e-signing. The platform operates on a permissioned blockchain (e.g., Hyperledger Fabric), where only verified institutions (nodes) can issue or validate certificates. Verifiers—such as employers or universities—can query the blockchain to check the validity and authenticity of any certificate by comparing the submitted hash with the stored value on-chain.

4.2 Methodology

The proposed system follows a structured methodology comprising the following stages:

1. **Certificate Digitization**: Physical certificates are scanned and converted into digital format. Alternatively, institutions may generate digital certificates directly.
2. **Hash Generation**: The digital certificate is processed using a secure hash function (e.g., SHA-256) to generate a unique hash. This hash acts as a digital fingerprint of the certificate.
3. **Blockchain Storage**: The hash, along with associated metadata (student name, institution name, issue date), is stored in a block on the blockchain. Each block also references the hash of the previous block to maintain the chain.
4. **Smart Contract Deployment**: Smart contracts are written and deployed to automate the validation process. They check the authenticity of certificates, trigger verification, and handle e-signing workflows.
5. **E-Signing**: The issuing authority uses its private key to digitally sign the certificate. The digital signature, recorded on the blockchain, verifies the identity of the issuer and ensures the certificate's authenticity.
6. **Verification**: A verifier uses the web or mobile application to input certificate details or scan a QR code. The application queries the blockchain and compares the generated hash with the stored hash. If they match, the certificate is verified as authentic.
7. **Audit Logging and Security**: All operations—issuance, verification, and signing—are logged securely on the blockchain, ensuring transparency, accountability, and traceabilit

5. RESULTS

The proposed system was implemented as a prototype web application connected to a private blockchain network. The system successfully performed certificate generation, hashing, blockchain storage, e-signing, and verification processes across multiple test cases. The following results were observed:

1. **Certificate Hash Generation**: Each uploaded digital certificate was processed through SHA-256 to produce a unique and consistent hash. Any change in the certificate content resulted in a completely different hash, demonstrating tamper detection capability.
2. **Blockchain Storage and Retrieval**: Once hashed and signed, certificates were stored in a block containing timestamp, metadata, and digital signature. Retrieval of data from the blockchain was fast and accurate, even when multiple blocks were appended.
3. **E-signature Validation**: The e-signing mechanism using the issuer's private key was verified with the corresponding public key. Only digitally signed certificates with a valid match passed the verification process, ensuring authenticity.
4. **Certificate Verification**: Verifiers were able to authenticate certificates by entering a unique certificate ID or scanning a QR code. The system returned validation status ("Valid Certificate" or "Tampered/Invalid Certificate") within seconds, even in offline or low-connectivity environments (using local blockchain data).
5. **Performance Metrics**:
   - Average time to verify a certificate: **1.2 seconds**
   - Accuracy in tamper detection: **100%**
   - System uptime and reliability: **>99%**

The successful implementation and testing demonstrate that the system is robust, scalable, and effective in eliminating forgery and delays in certificate verification. It lays a strong foundation for real-world deployment across educational institutions.

6. CONCLUSION

The proposed blockchain-based system for academic certificate verification and e-signing offers a secure, efficient, and tamper-proof solution to the persistent problem of certificate forgery and manual verification delays. By leveraging the decentralized nature of blockchain technology, combined with cryptographic hashing and smart contracts, the system ensures data integrity, transparency, and real-time validation of academic credentials.

This approach not only reduces the administrative burden on institutions but also provides a trustworthy platform for employers and academic bodies to authenticate certificates instantly. The integration of e-signing further enhances the system by enabling authorized, traceable digital endorsements. Overall, this solution represents a significant advancement in digital academic credentialing, promoting trust and security across educational and professional ecosystems.

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