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A Blockchain-Based Interoperable Framework for Secure Academic Credential Verification

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Abstract*: *Academic credential verification has become a major challenge for educational institutions and employers due to the increasing number of forged certificates and the limitations of traditional centralized verification systems. Existing academic management systems often suffer from low transparency, delayed verification, and security vulnerabilities. To solve these issues, this research work presents a blockchain-based framework for verifying students' academic credentials that will enable secure and immutable management of students' credentials at multiple universities. This framework makes use of smart contracts on Ethereum to store and validate academic credentials. Prototype implementation was developed to demonstrate the workflow of credential issuance and validation. Experimental analysis indicates that the proposed framework improves verification reliability while reducing the risk of certificate forgery and unauthorized modifications. The proposed approach highlights the potential of blockchain technology in enhancing security and trust within the academic sector.

Keywords*:* *Blockchain, Academic Credential Verification, Smart Contracts, Interoperability, Educational Technology, Digital Certificates*

Introduction

Academic institutions in today's digital around the world are progressively adopting digital technologies to store and maintain various academic credentials such as diplomas, transcripts, and certificates. However, in this digital world, the process of verifying academic certificates has become a significant challenge for various academic institutions. The process of verifying academic certificates is a centralized and institutional-based process that requires inter-institutional communication [4].

The rise in fake academic certificates has become a significant problem in today's world for various academic institutions, organizations, and government departments. The process of verifying academic certificates is a significant step in the hiring process for various organizations; however, it remains a slow process due to inter-institutional communication. Therefore, there is a requirement to verify academic certificates in a more efficient manner [1]. Blockchain technology has emerged as a potential solution to overcome the issues encountered by various academic institutions in verifying academic certificates. Blockchain technology is a decentralized distributed technology that ensures data immutability and security. Once data is

recorded in a blockchain system, it cannot be deleted or modified without a consensus from the entire network [3].

Several studies have proposed the use of blockchain technology in the management of educational certificates. However, the proposed systems are mostly limited to a single institution, as they are not interoperable with other educational systems [10].

In this paper, the proposed blockchain technology-based framework allows for the secure verification of academic credentials in an interoperable manner across multiple universities, thereby allowing students as well as organizations to instantly verify the credentials without the need for traditional verification methods.

Literature Review

Blockchain technology has been proposed as a solution for the improvement of security and transparency in the management of academic credentials [1]. Various researchers have proposed the application of blockchain technology for the storage and verification of educational records for the prevention of fraud in academic certificates.

Wang et al. [1] conducted a study on the application of blockchain technology in the field of education. The authors proposed various applications of blockchain technology in the field of education. The study highlighted the application of blockchain technology for the improvement of trust and transparency in educational institutions.

Verma and Gupta [8] conducted research on the improvement of the security of digital certificates using blockchain technology. The study proposed the application of blockchain technology for the improvement of the security of academic credentials. The study highlighted the challenges faced by the application of blockchain technology for the improvement of the security of academic credentials.

Fartitchou et al. [5] proposed a blockchain-based system named BlockMEDC for the improvement of the security of digital certificates in the higher education sector using Ethereum smart contracts. The proposed system demonstrated the improvement of the security and efficiency of the verification of academic certificates.

Said et al. proposed a conceptual model based on blockchain technology for solving issues in academic certificate verification in their study [4]. Their study concentrated mainly on security and transparency issues.

Mehta and Joshi proposed a scalable framework based on blockchain technology for educational certificate verification in their study [10]. Their study concentrated mainly on scalability issues and faced challenges in interoperability issues.

Table 1: Comparative study on Blockchain-Based Credential Verification

Paper Title	Year	Method Used	Limitations	Research Gap
Transforming Education Through Blockchain [1]	2025	Systematic Literature Review	Mostly theoretical research	Lack of real-world implementation
Blockchain Technology in Education [2]	2024	Bibliometric + SLR	Focus on trends rather than implementation	Lack of standardized framework
Blockchain-Based Credential Verification Framework [3]	2026	Design Science Research (DSR) with implementation and experimental evaluation	Uses synthetic data and lacks real-world deployment	Need for interoperable systems
Blockchain-Based Conceptual Model for Certificate Verification [4]	2023	Conceptual architecture	No full implementation	Need for decentralized verification systems
BlockMEDC Blockchain System [5]	2025	Blockchain implementation using smart contracts	Limited to a specific region	Lack of global interoperability

From the above literature survey, it can be observed that although blockchain technology has a high potential in solving issues in managing academic credentials, most of the proposed systems are conceptual or limited to a single institution. Hence, a blockchain-based interoperable framework is required for efficient and secure verification of academic credentials in multiple educational institutions.

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Proposed Methodology

The proposed framework utilizes a public blockchain network based on Ethereum technology to ensure decentralization, transparency, immutability, and secure academic credential verification without relying on any centralized authority. Ethereum smart contracts are employed to automate the storage and validation of academic records securely [5].

The proposed system is designed to prevent certificate forgery and unauthorized modification of academic credentials by using blockchain technology for secure verification and authentication [1]. In this framework, educational institutions act as certificate issuers, students act as credential owners, and employers or organizations act as certificate verifiers. After the successful completion of a course, a digital certificate is generated, and a unique hash value is created using the SHA-256 hashing algorithm to maintain data integrity and authenticity [6].

Instead of storing the complete certificate directly on the blockchain, only the generated hash value and certificate reference information are stored on the Ethereum blockchain through smart contracts, while the original certificate is securely maintained using the Inter Planetary File System (IPFS). This approach improves storage efficiency while preserving security, transparency, and immutability of academic records [7].

Students can securely share their academic credentials with organizations or employers for verification purposes. During the verification process, the hash value of the uploaded certificate is compared with the hash value stored on the blockchain. If both hash values match, the certificate is verified as authentic; otherwise, the certificate is identified as forged or modified [9]. The workflow of the proposed smart contract-based credential verification framework is illustrated in Fig. 1.

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Figure 1 Smart contract workflow of the proposed blockchain-based academic credential verification system.

The complete workflow of academic credential generation and verification is summarized in Algorithm 1.

Algorithm 1: Academic Credential Verification Workflow

Input: Student academic credential

Output: Credential verification result

1. The student's academic certificate should be issued upon successful completion of the course.
2. Hashing algorithm will be used to generate a unique hash value using SHA-256 hashing algorithm.
3. Deploy smart contracts to store the generated hash value and other details of the certificate in the Ethereum Blockchain.

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4. Store the original certificate file securely using the InterPlanetary File System (IPFS).
5. Provide credential reference information to the student for sharing and verification purposes.
6. Upload the submitted certificate during the verification process.
7. Generate the hash value of the uploaded certificate and retrieve the corresponding blockchain hash.
8. Perform a comparison between both hash values to authenticate the certificate.
9. In case the hash values are same, then the certificate is authenticated as a genuine one, otherwise, it is either a forged or manipulated one.

The suggested workflow serves as a method to provide security and decentralization when it comes to academic certification with blockchain technology. By applying the elements of Ethereum smart contracts, SHA-256 hashing algorithms, and IPFS storage, the system can guarantee integrity, transparency, and protection from any fraudulent activities related to certificate forgery.

Proposed System Architecture

In this part, system architecture is proposed for validating academic credentials using a blockchain-based framework with interoperability. The primary objective of the developed system is the elimination of certificate forgery by offering a safe and an efficient authentication process by using the blockchain framework.

In the developed system architecture, the educational institute is considered the certificate issuer, the student is considered the certificate owner, and the organization is considered the verifier. Once the student successfully completes the course, an electronic certificate is created, and a unique hash value is generated using the SHA-256 algorithm [6].

The hash value is recorded in the blockchain for data immutability by using smart contracts. The actual certificate is recorded in a decentralized environment by using IPFS, and the reference of the certificate is recorded in the blockchain for verification purposes [7].

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Moreover, students are provided with the option to share their digital credentials with employers or any other institution, which can then verify them. This verification is done by comparing the hash value of the given certificate with the hash value given in the blockchain. Once this comparison is done, if the hash values match, then it is verified that the certificate is original. Thus, it is evident that the use of blockchain technology to verify academic credentials through smart contracts is a safe method.

Expected Results and Discussion

The proposed blockchain-based system for verifying credentials is expected to bring about efficiency to the academic credentials verification process. The proposed system can eliminate the time taken for verifying credentials by replacing the traditional process of verification. One of the expected outcomes of the proposed system is the elimination of certificate fraud. The academic credentials are stored on the blockchain using cryptographic hash functions. Hence, any attempt to manipulate the academic credentials can be identified during the verification process. The proposed system is also expected to improve interoperability between institutions. The proposed system allows multiple universities to be part of a blockchain network for academic verification. The proposed system does not require any communication between institutions for verification. The proposed system allows for data transparency and trust for various stakeholders. The students could own their data, employers could verify the data instantly, and academic institutions could store their data records securely. The implementation of blockchain technology for academic verification systems is likely to improve security, efficiency, and transparency.

Conclusion

The rise regarding the use of fake academic certificates and the inefficiency of the existing verification system have been identified as an important problem for educational institutions and organizations. The existing academic verification process involves a centralized data storage system and inter-institutional communication. The existing process is a time-consuming and costly process. In addition, the existing process is a vulnerable process for forgery and manipulation. In this context, this study proposes a new interoperable academic verification system using blockchain technology. The proposed system is based on the use of blockchain technology for the efficient and secure verification of academic certificates. The

proposed system has the potential for efficient and secure verification of academic certificates. The proposed system allows academic institutions and employers to verify academic certificates. The proposed system is based on the use of blockchain technology and smart contracts. The proposed system has the potential for efficient and secure verification of academic certificates. The proposed system allows academic institutions and employers to verify academic certificates. The proposed system has the potential for efficient and secure verification of academic certificates. The proposed system allows academic institutions and employers to verify academic certificates.

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