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Certichain – A University Certificate Verifier

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Abstract
The issue of certificate forgery is pervasive in universities, lacking a reliable and secure method for storing and verifying academic records. The current solutions are either time consuming involving manual labour or highly inaccurate by computing hashes on the original marksheets directly. In this paper, we employ a blockhain-based solution leveraging Hyperledger Fabric to address this problem. Our solution is both cost-effective and robust, tailored to the needs of educational institutions and examination authorities. Additionally, we incorporate Optical Character Recognition (OCR) technology to streamline the data entry process, allowing for quick and efficient upload of marks and certificate details directly from Portable Document Format (PDF) documents.
Our approach includes server-side encryption, safeguarding sensitive data from unauthorized access or malicious attacks. This ensures that student records remain secure, even in the event of a breach. Experimental results demonstrate that our system effectively reduces verification times while providing an immutable record of academic achievements, making it highly suitable for implementation by examination authorities and universities. This is a significant step forward in the field of educational research.

Keywords **: Blockchain, Hyperledger, Optical Character Recognition, Verification, Forgery, University**

INTRODUCTION

The verification of academic credentials, such as university marksheets and certificates, has long been a complex and time-consuming process, burdened by challenges of forgery, misrepresentation, and inefficiency (Abbas, 2019; Shende et al., 2024). In a digital era where the value of academic credentials is constantly scrutinized, educational institutions, employers, and students alike face an urgent need for a secure, transparent, and accessible system for storing and verifying academic records. Traditional systems rely heavily on centralized databases maintained by educational institutions, which are not only vulnerable to unauthorized access and manipulation but also lack interoperability, making cross-institution verification both slow and costly (Božić, 2023; Kadadi et al., 2014). Consequently, the academic sector has seen a growing demand for a solution that ensures authenticity, integrity, and ease of access.

Blockchain technology, known for its decentralized, immutable, and transparent nature, offers a promising alternative to conventional approaches for secure data storage and verification. By leveraging blockchain, academic records can be stored in a distributed ledger where every entry is cryptographically secured, making unauthorized alterations virtually impossible (Hofmann et al., 2017). Unlike traditional systems where a single point of failure could compromise data integrity, blockchain's decentralized architecture distributes data across numerous nodes, ensuring redundancy and enhancing security (Lu et al., 2024; Zarring et al., 2021). This technology not only deters forgery but also simplifies verification procedures, allowing educational institutions and third parties to authenticate academic credentials in real-time without the need for intermediaries.

In this paper, we introduce CertiChain, a blockchain-based system designed to securely store and verify university marksheets. CertiChain leverages the Hyperledger Fabric blockchain to create a tamper-proof record of academic achievements, where each marksheet is linked to a unique cryptographic hash stored on the blockchain. By using smart contracts, CertiChain automates the verification process, enabling authorized entities, such as employers or other educational institutions, to quickly verify marksheets without relying on

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manual intervention. Additionally, CertiChain enhances data privacy by implementing advanced encryption methods, ensuring that sensitive information remains secure while still enabling efficient verification.
Through CertiChain, we aim to address the critical issues of data authenticity, accessibility, and operational efficiency in academic credential management (Kabashi et al., 2024; Xu, 2024). This paper explores the architecture and implementation of CertiChain, evaluates its performance in terms of security and verification speed, and discusses its potential impact on the broader educational ecosystem. By integrating blockchain technology into the credentialing process, CertiChain offers a transformative approach to secure marksheet storage and verification, promising to reduce cases of academic fraud and to foster trust and transparency in academic achievements across institutions and borders.

The contributions of our work are as follows:

- Secure storage of university marksheets using Hyperledger Fabric
- Employing OC to quickly retrieve data from the physical documents for verification
- Efficient retrieval from the blockchain due to our unique naming convention that facilitates quick verification
- High accuracy (≈ 98%) of determining whether the given certificate is genuine or forged.

RELATED WORK

In recent years, blockchain technology has emerged as a promising solution for secure data storage, particularly in fields where data integrity and authenticity are paramount, such as academic credential verification (Sun et al., 2020; Sun et al., 2022). A variety of studies have explored the use of blockchain to address the challenges posed by traditional centralized databases in the educational sector, focusing on creating tamper-proof, distributed ledgers for storing academic records. Many of these works emphasize the advantage of blockchain's immutability and decentralization, which together offer a powerful framework for preventing unauthorized alterations of stored data (Rushyanathan, 2022). Some early implementations of blockchain-based educational record systems rely on public blockchains, such as Ethereum, to store cryptographic hashes of academic data, providing a lightweight approach that ensures data security without the overhead of storing large volumes of raw data on-chain (Nizamuddin et al., 2019; Wang et al., 2019).
Another significant area of research within blockchain-based credentialing systems revolves around the use of cryptographic techniques to enhance privacy and data security (Do & Ng, 2017; Martiri et al., 2018). Since academic records contain sensitive personal information, such as grades and identification numbers, maintaining confidentiality is crucial. Many existing solutions utilize asymmetric encryption methods, where a student's academic data is encrypted with a public key and can only be decrypted by authorized entities holding the private key (Atmaja et al., 2020). Other studies have explored the use of hybrid cryptographic solutions, combining both symmetric and asymmetric encryption to balance computational efficiency with security. These solutions often complement blockchain storage by ensuring that even if unauthorized users access the data, it remains encrypted and secure. Other solutions exisiting today make use of the cryptographic hash present in blockchain (Kumar et al., 2022; Shinde et al., 2022). However, these methods have a large amount of inaccuracy in the results.
Beyond blockchain, OCR has proven to be an essential tool for automating the verification of academic credentials, especially when verifying data in scanned documents, such as PDF marksheets (Chakrabarti et al., 2024; Curmi & Inguanez, 2020). OCR technology, which can extract text from image-based documents, plays a critical role in digital verification systems, converting physical documents into a machine-readable format. Numerous studies have examined the reliability and accuracy of OCR for extracting data from academic documents, noting that modern OCR tools, including those based on machine learning algorithms, have achieved impressive levels of precision (Rao, 2024; Sharma, 2023). However, despite these advancements, OCR still faces challenges in environments with varied document templates, non-standardized fonts, or degraded image quality, leading to potential inaccuracies in data extraction (Hamad & Kaya, 2016).
Combining OCR with blockchain-based verification has also been a focus of recent research (Azzam et al., 2023; Mthethwa et al., 2018). By integrating OCR, blockchain systems can simplify the verification process, enabling quick extraction and validation of academic data against records stored on the blockchain. This hybrid approach leverages OCR to scan marksheets and retrieve essential details, which are then compared to the blockchain's stored data for discrepancies. Such systems can detect forgery attempts by flagging mismatches between the OCR-extracted data and the secure blockchain record, providing an additional layer of defense against credential falsification. Some systems also incorporate Quick Response (QR) codes to assist with data retrieval, where the QR code links directly to the document's unique identifier on the blockchain, streamlining the verification process and enhancing user experience (Aini et al., 2020; Khanna et al., 2023).

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The use of QR codes in academic credentialing systems has gained traction as an efficient and user-friendly method for accessing blockchain-stored data (Geethanjali et al., 2022). A QR code embedded on a marksheet or certificate can hold metadata that links directly to a corresponding blockchain entry, facilitating easy retrieval of records during verification. Studies have shown that QR codes, when combined with a secure blockchain backend, not only simplify access but also help automate the verification process. For instance, when a verifier scans the QR code, it can trigger a query to retrieve the encrypted blockchain data associated with the document, bypassing the need for manual data entry. This method has been shown to reduce errors and speed up verification times, making it an effective solution for large-scale credential management systems (Naser et al., 2020; Patil et al., 2022).

Some blockchain-based credentialing systems also utilize smart contracts to automate data verification workflows. Smart contracts, which execute code automatically based on predefined conditions, have been explored as a way to streamline the authentication process, reducing the need for human intervention (Kumari & Dhandapani, 2018; Karataş, 2018; Shakila & Rama, 2023). When combined with OCR and QR technologies, smart contracts can independently validate extracted marks against the blockchain record, providing instant feedback on the authenticity of a document. Research in this area has highlighted the potential of smart contracts to reduce operational costs and minimize processing times, making credential verification more accessible and efficient for both institutions and verifiers. Other methods include the use of unique identity number (Chowdhary et al., 2021).

METHODOLOGY

Our proposed system, CertiChain, leverages blockchain technology to securely store and verify university marksheets, ensuring authenticity, immutability, and ease of access. CertiChain is designed to facilitate the seamless and secure submission of student records, safeguard against forgery, and provide a reliable platform for quick and efficient marksheet verification. The system comprises two main portals: an entry portal for university officials to upload student marks and a verification portal accessible to third parties for validating the authenticity of marksheets. A detailed workflow of our program can be seen in Figure 1. The key components of the CertiChain system are outlined below:

1. University Login and Marks Entry: A designated University Point of Contact (PoC) is provided with secure login credentials to access our CertiChain website. After logging in, the PoC is presented with a user-friendly form where they can enter a student's academic details and marks. The interface includes data validation to ensure accuracy, and once complete, the PoC submits the information, initiating the secure storage process.
2. Marksheet Generation and QR Code Embedding: Upon submission, a standardized marksheet in PDF format is generated, adhering to the template set by the examination board. This marksheet is equipped with a unique QR code that embeds essential metadata, including a unique identifier (UID) generated based on the student's roll number and a university-specific number. This QR code facilitates rapid and precise data retrieval during verification.

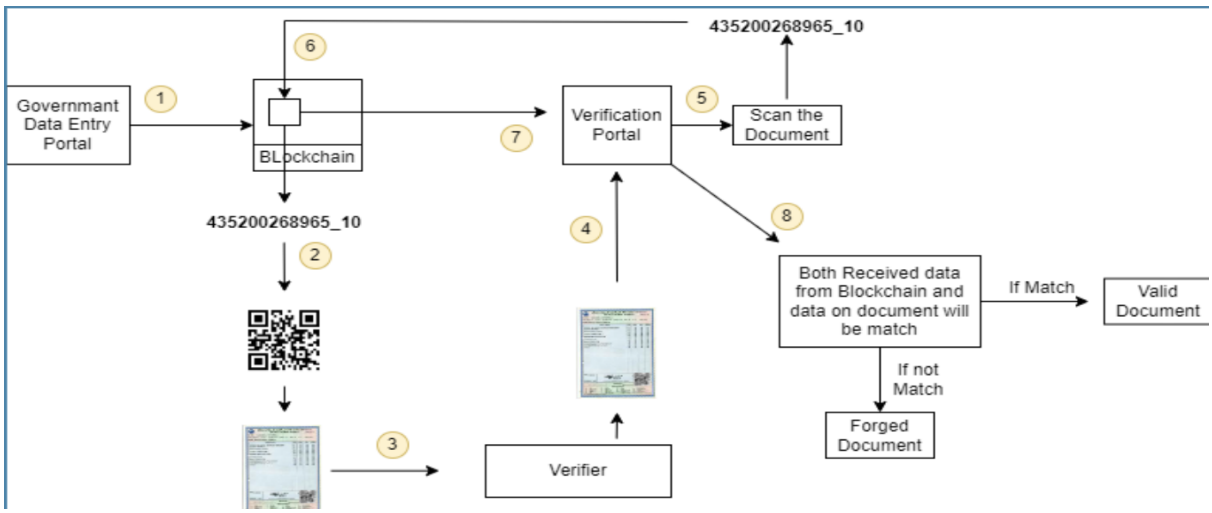

Figure 1: The working of our program

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3. Data Encryption and Blockchain Storage: To preserve data confidentiality, the student's academic records are encrypted before being sent to the blockchain. Using symmetric encryption methods, sensitive information like subject-wise marks is securely encoded, ensuring that only authorized users with appropriate decryption keys can access it. The encrypted data, formatted as JavaScript Object Notation (JSON), is then stored on the blockchain with a UID based on the student's roll number and university identifier, ensuring both uniqueness and easy retrieval.
4. Verification Portal and PDF Upload: The CertiChain verification portal is a publicly accessible interface where users, such as potential employers, other educational institutions, or students themselves, can verify the authenticity of a marksheet. Users are not required to log in, providing a convenient, open-access verification method that broadens the reach and usability of the system.
5. QR Code and OCR-Based Verification: During the verification process, the user uploads a PDF of the marksheet to be validated. CertiChain performs OCR on the PDF to extract the subject-wise marks. Simultaneously, the embedded QR code is scanned to retrieve the UID of the marksheet data stored on the blockchain.
6. Data Retrieval and Cross-Verification: Once the UID is obtained, CertiChain retrieves the encrypted marksheet data from the blockchain and decrypts it. Each subject's marks are then cross-verified with the data extracted from the uploaded PDF. If any discrepancies are detected between the stored data and the PDF contents, the system immediately flags the document as "Invalid".
7. Validation Outcome: If the verification process confirms that all extracted marks align with the blockchain data, the marksheet is deemed "Genuine". This outcome is displayed to the user, providing them with a reliable assurance of the document's authenticity. For more details, refer to figures 2 to 5.

Certificate/MarkSheet

Seat No	Centre No	Dist. & School No.	Month & Year Of Examination	Sr. No. Of Statement
A260	752	469	2023	A12058

Candidate's Full Name: Prashil Kadam
Candidate's Mother Name: Varsha

Subject Name	Max. Marks	Marks Or Grade Obtained	
		Marks Obtained	In Words
English	100	76	SEVENTY SIX
Hindi	100	82	EIGHTY TWO
Marathi	100	84	EIGHTY FOUR
Mathematics	100	95	NINETY FIVE
Science	100	73	SEVENTY THREE

Result	Percentage	Total Marks	Obtained Marks
Pass	82.00	500	410

Figure 2: Sample marksheet displaying the original marks as entered by the authority

Certificate/MarkSheet

Seat No	Centre No	Dist. & School No.	Month & Year Of Examination	Sr. No. Of Statement
A260	752	469	2023	A12058

Candidate's Full Name: Prashil Kadam
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Subject Name	Max. Marks	Marks Or Grade Obtained	
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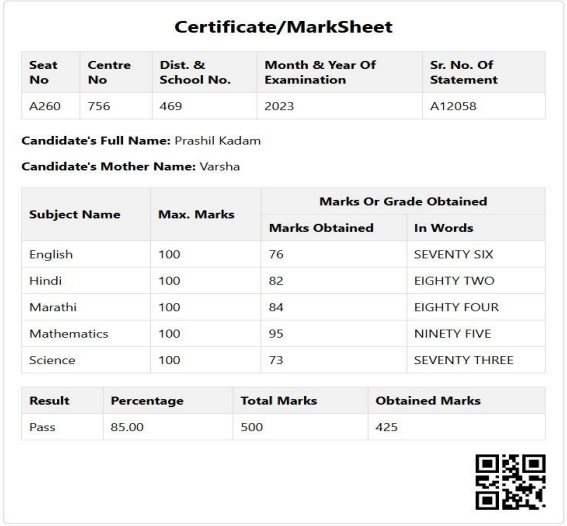
Mathematics	100	95	NINETY FIVE
Science	100	73	SEVENTY THREE

Result	Percentage	Total Marks	Obtained Marks
Pass	82.00	500	410

VALIDATED

Figure 3: Successfully validated as a genuine marksheet



Certificate/MarkSheet

Seat No	Centre No	Dist. & School No.	Month & Year Of Examination	Sr. No. Of Statement
A260	756	469	2023	A12058

Candidate's Full Name: Prashil Kadam
Candidate's Mother Name: Varsha

Subject Name	Max. Marks	Marks Or Grade Obtained	
		Marks Obtained	In Words
English	100	76	SEVENTY SIX
Hindi	100	82	EIGHTY TWO
Marathi	100	84	EIGHTY FOUR
Mathematics	100	95	NINETY FIVE
Science	100	73	SEVENTY THREE

Result	Percentage	Total Marks	Obtained Marks
Pass	85.00	500	425

Figure 4: Forged Certificate as the percentage and total marks have been modified

Certificate/MarkSheet

Seat No	Centre No	Dist. & School No.	Month & Year Of Examination	Sr. No. Of Statement
A260	752	469	2023	A12058

Candidate's Full Name: Prashil Kadam
Candidate's Mother Name: Varsha

Subject Name	Max. Marks	Marks Or Grade Obtained	
		Marks Obtained	In Words
English	100	76	SEVENTY SIX
Hindi	100	82	EIGHTY TWO
Marathi	100	84	EIGHTY FOUR
Mathematics	100	95	NINETY FIVE
Science	100	73	SEVENTY THREE

Result	Percentage	Total Marks	Obtained Marks
Pass	82.00	500	410

INVALID

Figure 5: Accurately detected as a forged marksheet

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By combining blockchain storage, encryption, and OCR-based verification, CertiChain ensures that student marksheets are protected against tampering and forgery, while offering a straightforward, efficient verification process. This system not only improves the security and transparency of academic records but also facilitates faster, more accessible verification for all stakeholders, ultimately fostering trust in educational qualifications and reducing administrative burdens on universities. The proof that our system is correctly storing the marks in the blockchain can be verified in Figure 6.

Overall, the integration of blockchain, OCR, and QR code technologies represents a transformative approach to academic credential verification, addressing key challenges of data security, authenticity, and efficiency. While blockchain ensures the integrity and immutability of stored records, OCR enables automated data extraction, and QR codes simplify access and retrieval. Despite these advancements, existing research highlights areas for improvement, such as enhancing OCR accuracy in varied document formats and reducing the computational overhead of blockchain operations. By building on these solutions, the proposed system aims to further advance the field, providing a robust and efficient framework for secure academic credential verification.

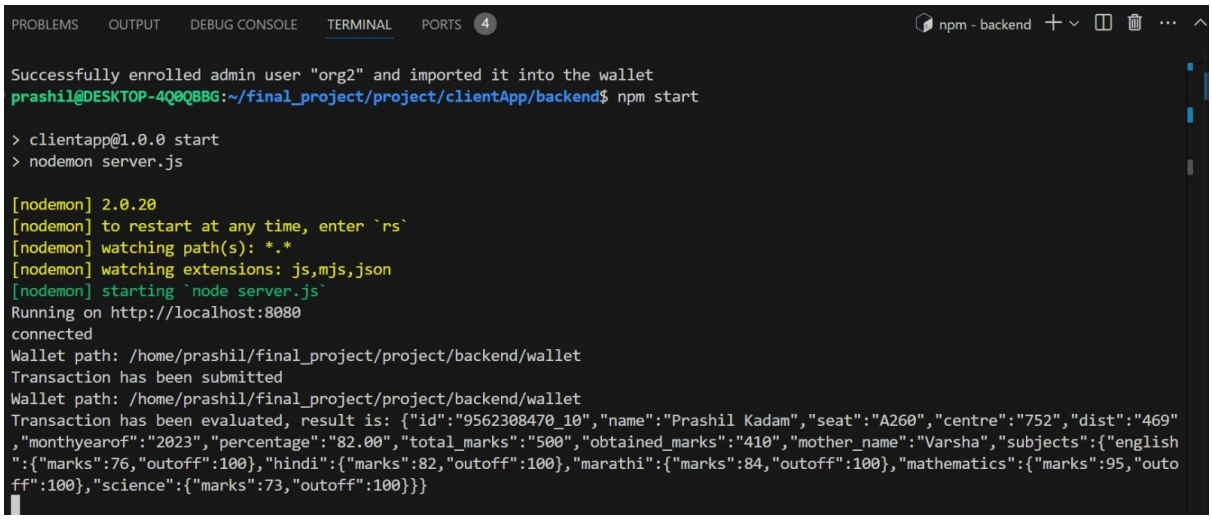

Figure 6: Terminal image of data entry in blockchain at the backend

PERFORMANCE METRICS

In our problem statement, the performance metrics would be of the following three kinds:

- Accuracy: Considering a training corpus of genuine and forged documents, the following formula is used:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

  Where TP refers to ‘true positive’, TN to ‘true negative’, FP to ‘false positive’ and FN to ‘false negative’.
- Time per Document- The average time taken to verify a single document for both the OCR system and manual verification. This directly compares the speed of the two methods.
- Throughput- The number of documents processed per unit of time (we have used number of documents per hour). This metric reflects the system's overall efficiency and scalability
- Processing Cost- The cost in Indian Rupee (INR) associated with each method. For the manual process, this includes labor costs. For the OCR system, this includes setup, hardware, and operational costs. The cost is calculated per each document.
- Storage Efficiency: Comparison of the storage space required in the blockchain for algorithm as compared to how much space would be occupied if IPFS had been employed.

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FINDINGS

In Table 1, we describe the confusion matrix of our verification system when trained on our synthetic test dataset. This clearly demonstrates the superior ability of our program to correctly identify forged marksheets. According to the above formula, our system performs with an accuracy of 100%.

	Actual True	Actual False
Predicted True	2	0
Predicted False	0	3

Table 1: Confusion Matrix depicting the number of samples correctly detected as 'Genuine' and as 'Forged', as well as the number of samples incorrectly detected

Table 2 highlights the speedup in verification time of our solution as compared to our approximated calculation for the time taken to manually verify whether a document is genuine. All of the results in the table are an estimate based on our observations.

Metric Used	CertiChain	Manual Verification
Time per Document(s)	10	120
Throughput	360	30
Processing Cost (INR)	0	500

Table 2: Speed comparison of our solution with the manual verification process

Table 3 shows how efficient our solution is at storing the data records as compared to storing the entire marksheet as a PDF on the InterPlanetary File System (IPFS). This is according to our estimated calculations. As can be clearly seen, our method in Hyperledger Fabric requires several orders of magnitude less storage (around 500 times less) compared to storing the entire PDF on IPFS. This makes our solution far more storage-efficient, especially when dealing with large numbers of documents.

Metric Used	CertiChain	Traditional IPFS Storage
Storage space (KB)	0.18	100

Table 3: Highlighting the storage space efficiency of our solution as compared to the usual storage by means of IPFS

DISCUSSION

Comparison with Existing solutions:

Our solution is vastly different from other blockhain-based document verification systems due to our decision to completely avoid the use of IPFS. This is in stark contrast to most other existing solutions (Malik et al., 2019; Shinde et al., 2022; Salau & Adeshina, 2021). Storing high quality documents on IPFS is costly due to the large size of data. Moreover, when we store the marksheets on IPFS there occurs a loss in quality of the images thus leading to a performance decrease in the accuracy of detection of the values on the marksehet. Other solutions rely on public blockchains such as Ethereum. However, this is extremely costly as every write to the blockchain will incur some gas that must be paid. This will render other solutions inflexible and unable to scale to the level required for our problem statement. By leveraging a private blockchain we have reduced costs of around hundreds of dollars a month, to completely zero charges. This is an incredible improvement.

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Benefits of Hyperledger:

As explained earlier, public blockchains like Ethereum incur some fee whenever we try to write some data to the blockchain. This is unavoidable and will accumulate over time as more and more documents have to be verified. However, our solution completely sidesteps this by making use of Hyperledeger, a private permissioned blockchain. The permissioned nature also adds another layer of security not possible in public blockchains.

Hyperledger Fabric's design is ideal for university document verification, as it operates on a private, permissioned network that securely limits access to authorized participants, reducing reliance on third-party storage. By storing only essential data (like cryptographic hashes) on-chain, while keeping full documents off-chain, it minimizes storage costs and improves access speed. Its efficient consensus mechanism and lightweight ordering service ensure quick transaction finality, reducing latency compared to public blockchains. Smart contracts (chaincode) automate verification workflows, further speeding up document access without manual intervention. Altogether, Hyperledger Fabric offers a fast, secure, and cost-effective solution tailored for institutional needs.

Efficiency of OCR:

By making use of OCR, there is a drastic improvement in the speed at which information is extracted from the marksheet and sent to the blockchain for verification. This also reduces manual input errors that would be common if the marks have to be re-entered by keyboard.

The limitations include varied fonts of marksheets and various formats. We are trying to overcome this obstacle by standardizing the format of all marksheets we will verify by first providing the official marksheets through our portal itself. This will reduce any errors in detecting the marks in an unfamiliar format of the marksheet.

Security:

By employing HyperText Transfer Protocol Secure (HTTPS) request calls, we are using the security built into the network layer of the internet. HTTPS secures data in transit by using Secure Sockets Layer (SSL)/ Transport Layer Security (TLS) protocols to encrypt the connection between a user's browser and the server, ensuring that sensitive information, such as passwords or personal details, cannot be easily intercepted by attackers. This encryption converts data into unreadable cipher text during transmission, which can only be decrypted by the intended recipient with the correct key. Additionally, HTTPS authenticates the server's identity, helping users confirm they are connecting to a legitimate site and reducing the risk of "man-in-the-middle" attacks. Thus, when the marks are being sent from the portal to the backend server, it is fully protected.

We took all precautions to ensure the sensitive data of private information of the students will not be exposed to any malicious attacks by outsiders. The immutable nature of blockchain provides an impermeable layer of protection of the data when it is stored. Hence, there is virtually no chance of any sort of data leak.

CONCLUSIONS

In this paper, we presented a blockchain-based solution for securely storing and verifying university marksheets, aimed at combating the prevalent issue of certificate forgery in academic settings. Our system, designed with Hyperledger Fabric, offers a highly cost-effective approach compared to traditional blockchain solutions that rely on public blockchains or third-party data storage services like IPFS. By using Hyperledger Fabric's private and permissioned blockchain architecture, we ensured that only authorized entities can access and verify academic records, significantly reducing operational costs and enhancing security. This focus on a controlled-access environment, combined with OCR integration for efficient data entry, enables seamless, rapid, and accurate credential verification, making our solution especially suitable for adoption by examination authorities and universities on a large scale.

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FUTURE WORK

Moving forward, there are several potential areas for further development to enhance the utility and robustness of our solution. One direction is to expand compatibility with additional blockchain frameworks, providing flexibility for institutions with different infrastructural requirements. Another avenue for improvement is the integration of advanced encryption protocols and zero-knowledge proofs to further enhance privacy for students and ensure that verification is both secure and privacy-preserving. Future work could also include extending the system's capabilities to manage other types of academic records, such as transcripts and diplomas, creating a comprehensive blockchain-based ecosystem for academic credential management. Through these enhancements, we aim to solidify our system's position as an innovative and efficient solution for secure academic verification, without the reliance on costly decentralized storage like IPFS.

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