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ijirset@gmail.com

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Academic Record Storage Using Blockchain

Sushanth Reddy Palavalli¹, Prof. Nisha Chaube², Kashyap Bhalodiya³, Brijesh Yadav⁴

Professor, Department of Computer Science, MIT ADT University, Pune, Maharashtra, India²

Student, Dept. of Computer Science, MIT ADT University, Pune, Maharashtra, India^{1,3,4}

ABSTRACT: Advancements in digital technologies have made the storage, sharing, and verification of educational credentials extremely important for entities such as students, universities, institutions, and companies. Digital credentials play an important role in students' lives as a lifelong learning passport.

The educational field is experiencing numerous issues such as academic record forgery, record misuse, credential data tampering, time-consuming verification procedures, and issues related to ownership and control. Modern-day technology, Blockchain, is an appropriate alternative to resolve these issues and increase trust among entities. In this research, we intend to propose a Blockchain-based educational digital credential issuance, and verification model that addresses these issues in the education system using Ethereum Blockchain and smart contracts. The method we propose offers a way to demonstrate the correctness of specific credential attributes without revealing other attributes, thereby leading to ownership, minimal disclosure, and control. We offer an interface for storing massively encrypted academic records in a decentralized file system like Interplanetary File System (IPFS). Furthermore, Ethereum provides tamper-resistant chains to maintain the integrity of digital credentials.

KEYWORDS: Blockchain, Integrity, Metamask, Ethereum, Solidity, Decentralized Application, Security, Ipfs.

I. INTRODUCTION

In the rapidly evolving landscape of technology, the utilization of blockchain has emerged as a groundbreaking solution for storing academic records securely and efficiently. This research paper delves into the intricate mechanisms of how blockchain technology is leveraged for the storage of academic records, ensuring transparency and security. Solidity, Truffle, and Ganache, as integral components of blockchain development, play a crucial role in facilitating the process of storing academic records in a decentralized and tamper-proof manner. Through the implementation of these tools, the system guarantees the immutability of data, safeguarding the integrity of academic records stored on the blockchain. By exploring the nuances of academic record storage using blockchain, this paper aims to shed light on the innovative approaches and technologies that revolutionize the conventional methods of record-keeping in the academic domain.

The potential growth in smart cities is due to advancements in technologies such as Internet of Things, Machine Learning, Cloud Computing, Data Science, Virtual Reality, Big Data Analytics, Artificial Intelligence, Neural Networks, Deep Learning, and others. These cutting-edge technologies have influenced most daily activities because of their obvious advantages like quick response, ease of use, and extensive availability. However, online sharing and verification of educational documents cannot always guarantee security, privacy and integrity in secured networks. Recent developments in Blockchain introduce a decentralized way to achieve security, transparency and integrity for numerous application domains.

II. PROBLEM FORMULATION

While blockchain technology presents transformative potential for academic record management, its integration into educational systems is fraught with significant challenges. Traditional academic record storage methods are centralized, susceptible to tampering, fraud, and data loss, and often lack the transparency required for easy verification of credentials. These systems are generally inefficient, requiring extensive manual intervention and are burdened with bureaucratic processes that delay the dissemination and verification of records.

Our research aims to develop a robust blockchain-based system for academic record storage that can overcome these hurdles and revolutionize how educational credentials are managed and verified. The following are the main goals of our research:

Decentralized Record Management: Implement a decentralized system using blockchain technology to store

academic records securely. This will eliminate the risks associated with centralized data storage, such as server failures and unauthorized access, ensuring that records are immutable and permanently verifiable.

Enhanced Security and Transparency: Utilize the inherent security features of blockchain, such as cryptographic hash functions and smart contracts, to enhance the integrity and transparency of academic records. This will facilitate instant verification of credentials without the need for intermediary verification steps.

Streamlined Access and Verification: Develop a user-friendly interface that allows students and institutions to access and manage academic records effortlessly. By integrating advanced web technologies like React JS and Web3.js, the system will provide seamless interaction with the blockchain, enabling real-time updates and retrievals of academic records.

Adaptability and Scalability: Address the scalability challenges associated with blockchain technology in educational settings. Our system will be designed to handle a growing amount of data and users, ensuring that it can be adopted by institutions of varying sizes without performance degradation.

Interoperability and Compliance: Ensure that the system is interoperable with existing educational and technological frameworks, adhering to legal and regulatory requirements concerning data privacy and management.

Through the realization of these objectives, our research will not only advance the technology behind academic record management but also significantly contribute to the academic community by providing a system that ensures data integrity, security, and ease of access. This will empower educational institutions and learners, facilitating a more efficient and transparent academic environment.

III. METHODOLOGY

The methodology for developing a blockchain-based academic record storage system is designed to ensure rigorous testing, effective implementation, and real-world applicability. Our approach is structured into several distinct phases, each critical to the successful deployment of the system:

1. Requirements Gathering

Stakeholder Interviews: Conduct comprehensive interviews with educational administrators, IT staff, students, and regulatory bodies to gather detailed requirements.

Needs Assessment: Assess the specific needs for academic record storage, including security, accessibility, and compliance requirements.

Feasibility Study: Evaluate the technical and operational feasibility of implementing a blockchain-based solution within existing educational infrastructures.

2. System Design

System Architecture: Develop a scalable and secure architecture using Ethereum blockchain. This includes defining the blockchain structure, consensus mechanisms, and smart contract frameworks.

User Interface Design: Design intuitive and accessible user interfaces for both web and mobile platforms, focusing on ease of use for students and administrators using React JS.

Database Integration: Plan the integration with off-chain databases for non-blockchain data, ensuring seamless data synchronization and backup.

3. Development

Smart Contract Development: Write and deploy smart contracts using Solidity. These contracts will handle the logic for recording, retrieving, and verifying academic records.

Frontend Implementation: Build the frontend application using React JS integrated with Web3.js to interact with the blockchain.

Backend Setup: Develop a robust backend using Node.js, handling API requests, user management, and interfacing with the blockchain and the database.

4. Testing

Unit Testing: Test individual components, such as smart contracts and APIs, to ensure they function correctly in isolation.

Integration Testing: Test the integration of components to ensure the system operates as a cohesive unit.

Load Testing: Simulate different loads to test the scalability and performance of the system under peak usage scenarios.

Security Auditing: Conduct thorough security audits and vulnerability assessments to ensure the system is secure from potential threats.

5. Deployment

Testnet Deployment: Initially deploy the system on a testnet to simulate real-world operations and allow for safe testing of the system's functionalities.

Mainnet Launch: After successful testing and auditing, deploy the system on the Ethereum mainnet to go live.

Monitoring and Updates: Continuously monitor the system for performance and security. Regularly update the system to address any issues, enhance functionalities, and integrate new technologies.

6. Evaluation

User Feedback: Gather and analyze user feedback to assess the usability and functionality of the system.

Performance Metrics: Measure system performance metrics such as transaction speed, system throughput, and user engagement.

Comparative Analysis: Compare the blockchain system with traditional academic record management systems to highlight improvements and identify areas for further development.

7. Documentation and Training

Documentation: Prepare comprehensive user manuals and system documentation to support end-users and system administrators.

Training Programs: Develop training programs for stakeholders to ensure they are well-equipped to use and manage the new system effectively.

This methodology ensures a structured and systematic approach to the development of the blockchain-based academic record storage system, focusing on practicality, security, and user experience to meet the needs of modern educational environments.

IV. PROPOSED SYSTEM

Our proposed system encompasses a comprehensive approach to addressing the challenges associated with traditional academic record-keeping methods. Leveraging the Ethereum blockchain and an array of complementary technologies, including Web3, Solidity, Truffle, React JS, Node JS, Ganache, and Metamask, our solution offers unparalleled security, transparency, and efficiency in managing academic records.

Algorithm

The following algorithm outlines the process flow for a blockchain-based academic record storage system using Ethereum, Metamask, Solidity, React JS, Wagmi, and IPFS.

Start

Step 1: User Authentication

1.1 Users (students or institutions) access the system through a web interface built with React JS.

1.2 The Wagmi library connects the React application to the Ethereum blockchain via Metamask for user authentication.

1.3 Users select their role (student or institution) and log in using their Ethereum wallet addresses.

Step 2: Data Reception and Verification

2.1 Receive data submission requests from users.

*If a student:

*Submit new academic records or update existing ones.

*If an institution:

*Review submitted records for verification.

2.2 Data is temporarily stored in a secure session until transaction initiation.

Step 3: Preprocessing and Transaction Preparation

3.1 For new records, generate a unique hash of the record using Solidity functions.

3.2 Encode data (such as student ID, record details, and timestamp) for blockchain storage.

3.3 Upload supplementary documents to IPFS, receiving an IPFS hash back for immutable linking with the blockchain record.

Step 4: Smart Contract Interaction

4.1 Utilize smart contracts written in Solidity deployed on the Ethereum network (Sepolia testnet for testing, Ethereum mainnet for production).

4.2 Perform actions based on user interactions:

*For student submissions:

*Call smart contract functions to store the new or updated record along with the IPFS hash.

*For institution verifications:

*Call smart contract functions to update the record status as verified.

Step 5: Transaction Execution and Confirmation

5.1 Initiate blockchain transactions using Wagmi functions integrated with Metamask for digital signature and transaction management.

5.2 Monitor transaction status until it is confirmed on the blockchain, ensuring data integrity and immutability.

Step 6: Output Generation and Display

6.1 Retrieve updated record status and details from the blockchain and IPFS.

6.2 Generate output:

*If a student:

*Display the status of submitted records (pending, verified).

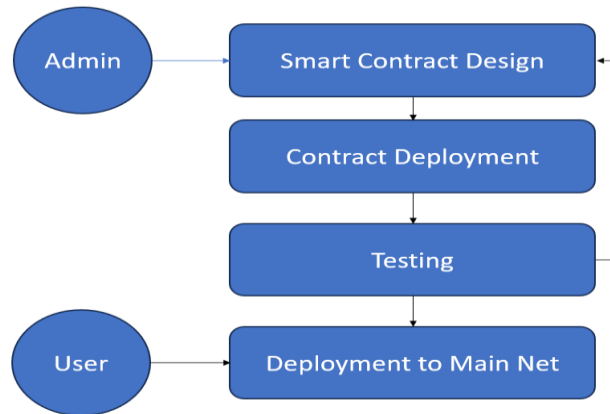
*If an institution:

*Display confirmation of record verification.

6.3 Output is displayed to the user through a graphical user interface built with React JS.

End

This algorithm ensures that every interaction with the system is secure, transparent, and immutable, leveraging blockchain and IPFS technologies to maintain the integrity and accessibility of academic records.



Flow Chart of Proposed System

This role typically involves configuring and setting up the system parameters, managing user permissions, and overseeing the overall system integrity.

Smart Contract Development: Using Solidity, smart contracts are written to handle various tasks such as record creation, modification, and verification. These contracts are the backbone of our system, enforcing the rules set forth for interacting with academic records.

Contract Deployment: Once developed, these contracts are deployed to the Ethereum blockchain, which involves various stages including testing on test networks like Ganache.

Testing: Before full deployment, the smart contracts undergo rigorous testing to ensure they operate correctly and securely under all expected conditions. This phase helps in identifying and mitigating potential vulnerabilities.

Deployment to Main Net: After successful testing, the smart contracts are deployed to the Ethereum main network, where they become immutable and publicly verifiable.

User Interaction: Users interact with the system via a web interface built with React JS and Web3.js. This interface connects to Ethereum through MetaMask, allowing users to access and verify their records securely.

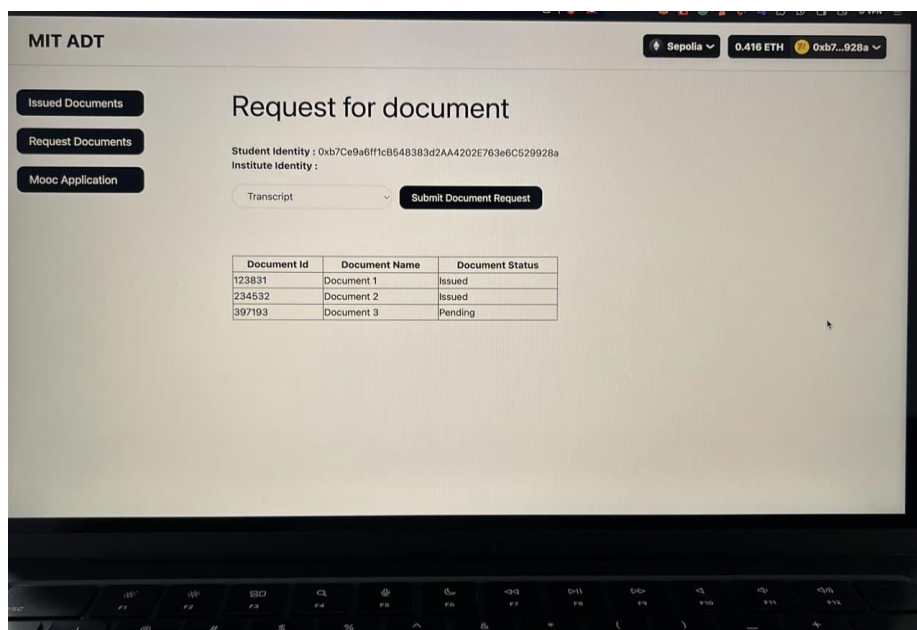


Figure I: Student Portal

The screenshot illustrates the Student Portal interface of the proposed blockchain-based academic record storage system, showcasing its functionality and user interaction. This portal is an integral part of our system, designed to provide students with an intuitive and secure platform for managing their academic documents.

Interface Overview:

Header Information: Displays the name of the institution, in this case, "MIT ADT", signaling the customizability of the portal for specific educational institutions.

Student Identity: Shows a unique Ethereum blockchain address that identifies the student within the system, ensuring secure and direct association of records with individual students.

Institute Identity: (Not shown) This field, when populated, would display the blockchain address of the institution, linking the student directly to their educational provider.

Functionality:

Issued Documents: A tab that students can click to view all their academic records that have been officially issued and stored on the blockchain. This ensures transparency and easy access to verified credentials.

Request Documents: Enables students to submit requests for new documents or updates to existing records. This action is facilitated through smart contracts on the Ethereum blockchain, which record and verify all transactions to ensure tamper-proof record keeping.

Mooc Application: An additional feature that could integrate with Massive Open Online Courses (MOOCs), allowing students to add certifications directly to their blockchain-based academic portfolio.

Key Features of the System:

1. **Decentralized Storage:** Academic records are stored on the Ethereum blockchain, making them immutable and resistant to tampering. This decentralized nature ensures that no single party can alter the information once it is recorded.
2. **Transparency and Auditability:** Every transaction (record entry) is transparent and can be audited by any party, enhancing trust among institutions, students, and other stakeholders.
3. **Security:** Utilizing blockchain's inherent security features, the system offers enhanced protection against common threats such as data breaches and unauthorized access.
4. **User-Friendly Access:** Through a React JS-based frontend, users can easily access their academic records. The integration of Web3.js with MetaMask ensures that users can interact with the blockchain seamlessly and securely.
5. **Scalability:** While scalability can be a challenge with blockchain applications, our system design incorporates efficiency measures such as optimizing transaction processes and using efficient querying mechanisms via Node JS.
6. **Automated Verification:** Smart contracts automate the process of verifying the authenticity of records, reducing the need for manual verification and minimizing human error.
7. This proposed system leverages cutting-edge technologies to address critical needs in the management and verification of academic records, providing a robust, secure, and user-friendly system. This architecture not only supports the current requirements but is also designed to accommodate future advancements and increased loads as more institutions adopt this technology.

V. CONCLUSION

In conclusion, our research project aims to address the critical challenges surrounding the management and verification of academic records using blockchain technology. By developing a secure, transparent, and decentralized system, we seek to enhance trust, efficiency, and reliability within the academic ecosystem. Through an exhaustive exploration of the background, objectives, methodology, and implementation of our project, we lay the groundwork for a successful and impactful contribution to the field of blockchain-based academic record storage. Our project to store academic data using blockchain technology offers unparalleled data security, making records impervious to tampering and fraud. This system provides a transparent and efficient way to verify academic credentials, creating trust among institutions

and students. Challenges include scalability and adoption in academic institutions.

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