AcadChain: A Blockchain Integrated Secure and Privacy Preserved Student Feedback System

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***Abstract*—Student feedback data is typically stored on centralized servers and can potentially be linked to individual identities, leading to concerns about repercussions or bias in evaluations. This lack of anonymity can inhibit students from providing honest and candid feedback. Because of this reason, a secure anonymous platform is needed as it provides the students with an uninhibited channel to offer their feedback. To overcome this, an architecture incorporating Blockchain into a Student Feedback System is proposed to address traditional systems' anonymity and transparency issues. This paper proposes an implementation of a robust student feedback system that fosters a dynamic exchange of feedback and enhances interpersonal relationships and collaboration between students and teachers. This constructive feedback loop facilitates the improvement of faculty performance and facilitates a greater understanding of students' educational requirements, ultimately leading to enhanced academic outcomes.**

***Index Terms*—Blockchain, Smart Contract, Role-based Access Control, Decentralised App(dApp), Anonymous Student Feedback System, Ethereum Network**

I. Introduction

In recent years, blockchain technology has emerged as a transformative force with the potential to revolutionize various industries. Often associated with cryptocurrencies like Bitcoin, blockchain is a decentralized and transparent digital ledger that enables secure and immutable transactions by creating, bundling, validating, and adding verified blocks. However, its applications extend far beyond financial systems. This paper explores the utilization of blockchain technology in the education sector, specifically focusing on the development of a student feedback decentralized application (dApp).

Student feedback is vital in education, offering insights into teaching methods, curriculum, and the student experience. It boosts engagement, tailors education, and fosters a great learning environment. However, a lack of anonymity, as recorded in UK higher education, leads to students withholding honest feedback due to fear of consequences or bias. This hampers feedback quality and system efficacy, affecting evaluations negatively, as concluded by Leckey et al. [1].

Furthermore, the lack of proper feedback from students hampers the acquisition of valuable student insights, impeding educators' ability to identify areas in need of improvement or adaptation. As a result, instructional effectiveness and the broader learning journey are hindered.

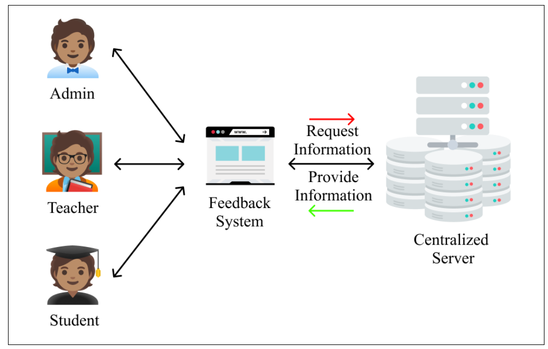

Fig. 1. Architecture of a Typical Student Feedback System

Ensuring anonymity is essential in fostering a secure and inclusive environment that encourages students to freely express their perspectives, facilitating the acquisition of precise and constructive feedback crucial for advancing educational practices. However, existing student feedback systems, which typically store all feedback on a centralized server, fail to provide adequate anonymity and a secure platform for feedback provision. This centralized architecture poses risks to student anonymity as well as other security threats like Single Point of Failure (SPOF). The architecture of a typical Student Feedback system is illustrated in Figure 1.

There is also the risk of the student feedback being altered from the server by adversaries. To address these limitations, blockchain technology emerges as a viable solution. Initially implemented primarily in the finance sector, blockchain demonstrates the potential for various other fields. Its inherent features, such as anonymity, a peer-to-peer network, and secure communication channels, make it an appropriate solution for ensuring complete anonymity for students providing feedback and providing an accessible platform for educators to access this feedback. This paper proposes a novel blockchain-leveraged feedback system providing a robust solution for the anonymity and access control of participants.

The subsequent sections of this paper are organized as follows: Section II presents a review of previous research in the field. Section III examines the distinctive characteristics of the proposed student feedback system. Section IV provides an architectural overview of the proposed student feedback system. Section V delves into the underlying algorithms of the AcadChain implementation. Section VI provides detailed insights into the implementation and validation of the AcadChain solution. Finally, Section VII concludes the paper, highlighting future prospects in this area of research.

II. Related Research

Satoshi Nakamoto, in [2] introduced blockchain as the architecture behind a financial system that sought to remove intermediary banking systems in the form of bitcoin. It has since seen implementation in various other sectors such as Supply Chain [3]–[5], Smart Agriculture [6]–[8], Smart Healthcare [9], [10] and many others including the education sector. The issue of privacy and anonymity in conventional student feedback systems, along with other forms of implementation in the education sector can be addressed through the implementation of blockchain technology.

The Student Feedback System proposed in [11] is a web-based platform developed for paperless and user-friendly feedback on faculty performance. Using HTML, JavaScript, PHP, and XAMPP MySQL, students log in with unique credentials, choose a subject, and rate faculty using radio buttons. Data is stored in the database, generating graphical records. An admin login enables result viewing and subject management. While anonymity isn't explicitly stated, individual logins suggest limited anonymity. However, the system's implementation overlooks concerns of anonymity and data integrity, a gap that is addressed by the proposed AcadChain solution.

The Augmented Lecture Feedback System (ALFs) proposed in [12] enhances classroom communication by enabling students to engage with lectures through mobile devices, while teachers control the system via motion-captured gestures and augmented reality (AR). ALFs process data from student devices and the teacher's AR feed, displaying student status and feedback to enhance engagement. An evaluation during a university lecture garnered positive student feedback on interaction and communication improvements, though willingness to use such a system again varied. However, the paper does not clearly state whether the recorded responses were provided anonymously, in contrast to the proposed feedback system which explicitly addresses this aspect.

The utilization of blockchain technology in the educational domain, as presented in the referenced study [13], aims to address several critical issues such as reducing instances of diploma fraud, expediting the process of validating diploma authenticity, minimizing costs associated with intermediary parties, and ensuring that graduates' competency levels align with their respective qualifications by thwarting the forgery of diplomas. This system enables universities to publish their certificates on the blockchain, enabling broad accessibility and dissemination across various institutions. However, unlike the proposed AcadChain implementation, the study does not provide an explicit delineation of the system architecture and it's implementation.

Zhao et al. (2019) proposed a blockchain-based student capability evaluation system in [14] where students generate virtual assets containing personal information, which are encapsulated into transactions. Teachers create transactions that include course results, academic achievements, practical experience, and the students' personal information. The school then presents these transactions to education regulation authorities for evaluation. The SimRank [15] algorithm is employed to ensure evaluation result credibility. However, unlike in the proposed AcadChain solution, the study does not discuss the integration of student feedback or mechanisms for collecting such feedback.

The feedback system proposed in [16] leverages blockchain technology to guarantee the confidentiality, integrity, and credibility of feedback. Users are required to authenticate themselves through their identity number, name, or contact number, which undergoes validation to ensure its legitimacy. Feedback is provided on a user-friendly interface and once submitted, it becomes immutable. The system ensures that feedback is directed to the intended recipient, thus maintaining accuracy. To safeguard the feedback, it is encrypted using the SHA-256 [17] hashing function, which prevents data reversal or decryption. Additionally, self-registration is prevented to mitigate the inclusion of fake users and their associated feedback. However, the study does not discuss Role-Based Access Control for entities using the interface, nor does it delve into the implementation aspect. Both of these concerns have been addressed in the proposed AcadChain solution.

III. Novel Contributions

A. Problems Addressed

The following issues in the existing student feedback systems are addressed in the proposed AcadChain solution:

- Eliminating centralized authorities to bolster the security of the Student Feedback system.
- Preserving the anonymity of students during the feedback provision process.
- Maintaining data integrity and security by eliminating adversaries in the network.

B. Novel Solutions Proposed

Following are the novel solutions proposed in our AcadChain implementation:

- The utilization of peer-to-peer (P2P) networks and consensus-based updates in the proposed feedback system eliminates the presence of centralized entities and the necessity of centralized databases for accessing student feedback.
- The execution of all transactions in a blockchain network is carried out using the public key associated with each user. Consequently, students are not required to utilize their personal credentials during the feedback process, thereby upholding their anonymity.
- Due to the immutable nature of blockchain technology, potential threats such as data security breaches and unauthorized modifications get eliminated.

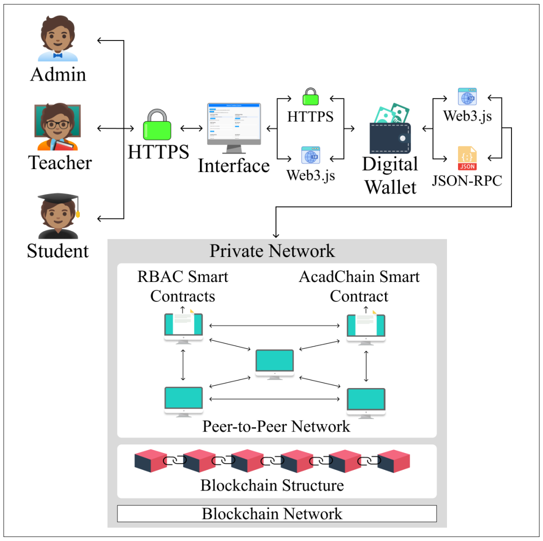

Fig. 2. Architectural overview of proposed AcadChain implementation

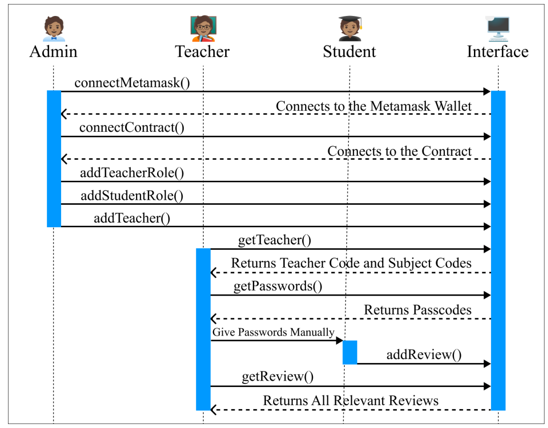

Fig. 3. Sequence Diagram of Proposed AcadChain implementation

IV. Architecture of the Proposed AcadChain Solution

An architectural overview of the proposed student feedback system is shown in Figure 2. The key components of the proposed solution encompass diverse participants who engage with the interface to assume specific roles, including providing feedback, reviewing feedback, adding teacher details, and generating authentication information for the students. The initial interaction commences with the Admin, who undertakes the responsibility of integrating the contract addresses of students and teachers into the blockchain. Additionally, the Admin records pertinent teacher information such as teacher codes, subject codes, and student counts for each respective class. Subsequently, Teachers utilize dApp to generate passwords for students enrolled in their specific subjects, personally disseminating them to students. These passwords enable students to provide feedback for the respective teacher and subject. Teachers, in turn, utilize the dApp to access and review the feedback provided by students. This safeguards student anonymity, as teachers can only access the feedback itself without ever knowing the real identity of the student providing it. The sequence of events is demonstrated in Figure 3.

Another major component in the proposed solution is the digital wallet. The wallet acts as a bridge between the student feedback user interface and the Ethereum network [18]. It enables secure management of Ethereum accounts, transaction signing, and interaction with smart contracts. It also facilitates the storage and control of digital assets. It seamlessly integrates with web applications, offering a convenient user experience for interacting with decentralized applications (dApps) directly in the browser. In the proposed Student Feedback dApp, the wallet is used for user authentication, account access, and secure execution of transactions with smart contracts.

The blockchain layer of the proposed feedback system comprises decentralized peer-to-peer (P2P) [19] nodes managed by various entities involved in the system. The proposed solution leverages the Ethereum platform as its underlying blockchain network. Ethereum implements the Proof-of-Stake (PoS) [20] consensus mechanism, selecting validators based on their ownership and commitment of a certain cryptocurrency's units, referred to as "staking", thus mitigating resource-intensive computational challenges in other consensus mechanisms like Proof of Work (PoW) [21] and reducing power consumption. The network architecture of the proposed system comprises nodes associated with various branches of the educational organization, as well as nodes affiliated with the Accreditation Council or agency. From this collective set of nodes, one is chosen to serve as the node verifier, in accordance with the aforementioned PoS mechanism. Within the Ethereum ecosystem, a unified computer called the Ethereum Virtual Machine (EVM) fosters consensus among network participants regarding the current state of the EVM. Every node in the network carefully monitors and records modifications to the EVM's state. Moreover, Ethereum enables the execution of smart contracts, and programmable code segments that automatically execute predefined actions upon meeting specific conditions. Keccak-256 [22] serves as the hashing protocol utilized by Ethereum for crucial tasks, including address generation, transaction hashing, block header hashing, and Merkle tree construction. The AcadChain solution operates on a private Ethereum Network, where only authorized entities function as network nodes. The proposed blockchain network encompasses two types of smart contracts: one to establish Role-Based Access Control (RBAC) and the other to facilitate the Student Feedback System.

The HTTPS protocol facilitates communication between the interface, server, wallet, and API/Web3.js integration. The proposed system utilizes Web3.js to establish a connection with Ethereum, manage transactions, and integrate blockchain functions with the interface for user interaction with the decentralized application (dApp). The interface communicates with the wallet through the Ethereum Provider API, a part of the Web3.js library. The wallet, alongside Web3.js, employs

JSON-RPC (JavaScript Object Notation Remote Procedure Call) for interactions with the backend, including transaction signing, account data retrieval, and smart contract operations. JSON-RPC ensures secure and standardized communication between the interface and the backend infrastructure of the dApp.

V. Algorithm For Proposed AcadChain solution

The steps required for feedback provision by students regarding a specific teacher and subject in which they had been previously enrolled are clearly outlined in Algorithm 1. Initially, the addition of student and teacher account addresses is necessitated to establish role-based access to the interface and enable submitting feedback for a particular teacher-subject association. The administrative privileges are verified within Algorithm 1 to ascertain the authorization of the user adding these addresses. Upon successful verification, the account address of the student is added, followed by the inclusion of the teacher's account address, along with relevant details such as their teacher code, the subjects taught, and the count of students enrolled in each subject. Subsequently, passwords for the respective subjects are generated by the teacher using the interface, which is then provided manually to the students. For giving feedback, the dApp is accessed by the student to submit their feedback.

Algorithm 1 is designed to validate the user's status as a student and, in doing so, the provided teacher code, subject code, and password are assessed for their validity. If the provided credentials are determined to be valid, the student's feedback is incorporated into the review map, thereby completing the feedback submission process.

The process through which teachers access and review feedback provided by students of a particular class using the dApp is delineated in Algorithm 2. Upon entering their respective teacher code and subject code, the authenticity of both inputs is duly verified. Once the teacher's identity is confirmed, Algorithm 2 proceeds to retrieve the array of feedback corresponding to the specified teacher and subject. If no feedback is found, a message conveying this status is displayed by the system.

VI. Experimental Setup and Result Validation

A. Experimental Setup

The AcadChain prototype is implemented on the Ethereum platform using a local Ganache blockchain. The local blockchain is configured to generate 10 test accounts, each having 100 test ETH, which allows for conducting transactions without incurring any actual monetary costs. This setup allows for testing the functionality of smart contracts using test ether in a simulated environment that accurately mimics the behavior of the mainnet. Figure 4 showcases the addresses of the test accounts and the roles assigned to each address. The compilation, testing, and deployment of the smart contracts are done using Truffle. Web3.js, JavaScript, HTML, and CSS are implemented to design the user interface.

Algorithm 1: Addition of Student Feedback in Proposed AcadChain Implementation.

Input : Student Address, Teacher Address, Teacher Details, and Student Feedback
Output : None

Phase 1: Add user details

Require: Current user is Admin
Procedure *ADD USER*
begin
  foreach *student* **do**
    $Contract_{StudentRole}.addStudent()$ `// Parent contract StudentRole called for adding address of student account`
  foreach *teacher* **do**
    $Contract_{TeacherRole}.addTeacher()$ `// Parent contract TeacherRole called for adding address of student account`
    $Contract_{StudentFeedbackSystem}$
    $.addTeacher(teacherCode, subjectCode[],$
    $studentCount[])$

Phase 2: Provide Student Feedback

Require: Current user is Student
Password Length > 0
Password has not been used before
Password should match one of the valid passwords
Procedure *PROVIDE FEEDBACK*
begin
  $usedPasswords[Password] = true$
  $reviewMap.push(Review(ratings, comments))$

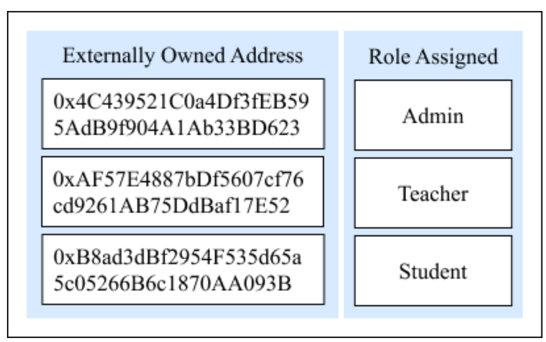

Fig. 4. Test Account Addresses and Assigned Roles in Implementation of AcadChain

A Role-Based Access Control (RBAC) mechanism is implemented using smart contracts to manage the involvement of various entities in the feedback system. The smart contract includes a Roles contract that enables the creation, addition, and renouncement of different roles for different Externally Owned Accounts (EOA). In the Student Feedback dApp prototype, the roles of Admin, Teacher, and Student are created

Algorithm 2: Retrieval of Student Feedback in Proposed AcadChain Implementation.

Input : Teacher Code, Subject Code
Output : Array of feedback submitted anonymously by students for that specific teacher and subject
Require: Current user is Teacher or Admin
Teacher Code and Subject Code should exist and be valid

Procedure *RETRIEVE FEEDBACK*
begin
  $feedback = getReviews(teacherCode, subjectCode)$
  if *feedback* == *NULL* **then**
    return "No feedback available for this teacher and subject"
  return $feedback$

and assigned. This ensures the entities update only the corresponding information on the blockchain like only the Admin can update or add information about the Teacher, Teacher contract address, and Student contract address. This prevents unauthorized entities, like students and potential adversaries, from introducing false or misleading information into the chain. Similarly, only the Admin and Teacher can generate passwords to be given to the students, get the teacher's details and get the feedback submitted by students and only the student can add new feedback. RBAC model developed in the proposed AcadChain solution is shown in Figure 5. Separate contracts are designed to handle the addition and management of different roles within the network. Each role contract includes functions to add a specific account as a bearer of that role or renounce the access. These functions are controlled by modifiers implemented in the smart contract.

B. Result and Validation

The creation and deployment of the contract for the Student Feedback System are illustrated in Figure 6, with the contract address designated as 0x938E85F81294c48ECe4Ce133b92508D7Fb957a1f. This transaction is initiated by the Admin's assigned address, as mentioned in Figure 4. To evaluate the proposed Student Feedback decentralized application (dApp), a sample feedback instance is furnished to a teacher, as illustrated in Figure 7. The feedback is submitted by a designated student, whose address is recorded in Figure 4. Upon the student's successful submission of the valid teacher code, subject code, and password, a transaction is initiated from the student account to the contract address via Metamask. Subsequently, the student's feedback is securely stored on the blockchain.

Due to the prior assignment of the teacher's role by the Admin, the teacher is granted the necessary privileges to access the feedback, conforming to the Role-Based Access Control (RBAC) protocol. Subsequently, the teacher utilizes the test account address as depicted in Figure 4 to access the interface

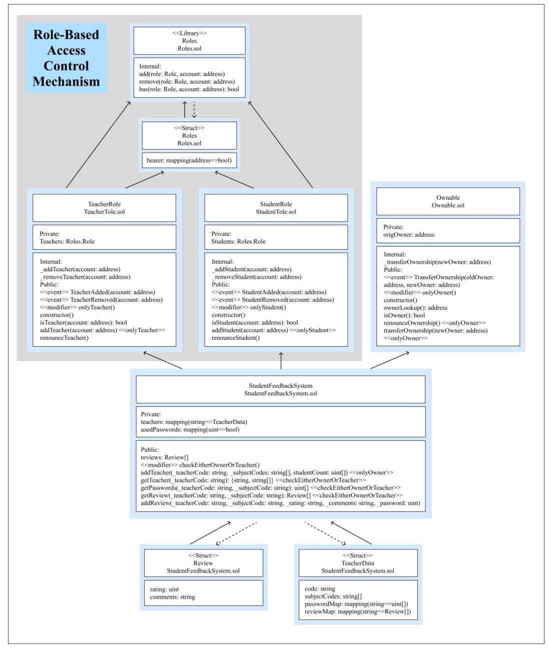

Fig. 5. Class Diagram of Proposed AcadChain solution

Fig. 6. Contract Creation and Deployment of Student Feedback System on Ganache Network

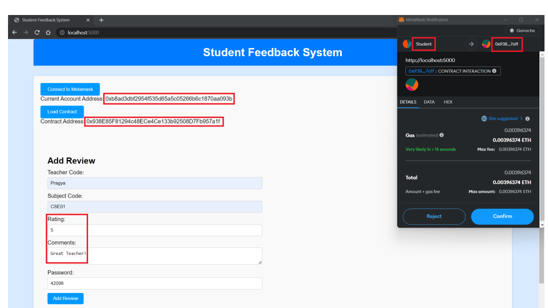

Fig. 7. Addition of Student Feedback Using dApp User Interface

and review the feedback provided by students. The teacher provides their teacher code along with the subject code for the subject whose feedback they want to access. The retrieval of the feedback by the teacher is captured in Figure 8. A Comparative analysis of the proposed AcadChain solution with some existing solutions are shown in Table I. The proposed AcadChain solution involves a decentralized architecture to ensure both the confidentiality of student feedback and the immutability of the provided feedback post-submission. Furthermore, the system employs a Role-Based Access Control mechanism to prevent any unauthorized feedback submissions.

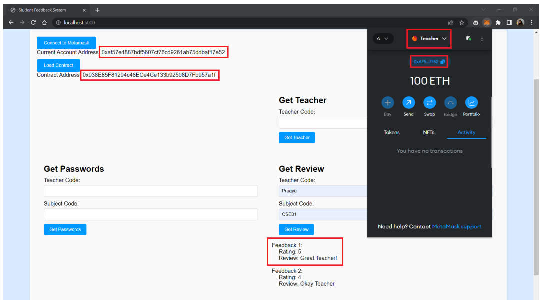

Fig. 8. Retrieval of Student Feedback Using dApp User Interface

TABLE I
COMPARISON OF PROPOSED ACADCHAIN WITH EXISTING SOLUTIONS

Parameters	**Kamble et.al.** [11]	**Zarraonandia et.al** [12]	**Rahardja et.al.** [13]	**Zhao et.al.** [14]	**Rahman et.al.** [16]	**Proposed Acad-Chain Solution**
Architecture	Centralised	Augmented Reality Based	Decentralised	Decentralised	Decentralised	Decentralised
Blockchain-Based	No	No	Yes	Yes	Yes	Yes
Openness	Private	Private	-	Private	-	Private
Feedback Supported	Yes	Yes	No	No	Yes	Yes
Anonymity Guaranteed	No	No	-	-	Yes	Yes
Immutability	No	No	Yes	Yes	Yes	Yes
Storage	Off-Chain	Off-Chain	-	On-Chain	On-Chain	On-Chain
RBAC	Yes	Yes	-	-	-	Yes

VII. CONCLUSION AND FUTURE RESEARCH

This paper demonstrates a novel solution for efficiently gathering and managing student's feedback using blockchain-based smart contracts. The main objective of using the Blockchain-based architecture is to provide anonymity to students providing feedback. In addition, the Proposed architecture enhances the transparency and trustworthiness of the student feedback process, ensuring that only genuine feedback reaches the teachers and administrators. An efficient Role-Based Access Control (RBAC) mechanism has been implemented which mitigates unintended updates to the feedback data and ensures data integrity. The immutable nature of blockchain technology prevents unauthorized alterations to student feedback ensuring security. In the future, we intend to enhance the scalability of the proposed system and perform a range of analyses on factors such as cost, time, and functionality. In addition, we aim to employ a more comprehensive roster of questions to facilitate targeted feedback and enhance the graphical user interface (GUI) for optimal user experience.

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