Blockchain-based Teaching Evaluation System for Ensuring Data Integrity and Anonymity

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***Abstract*—The significance of student feedback within educational institutions cannot be overstated, as it serves as a pivotal tool for evaluating faculty performance and identifying potential gaps in course content. Blockchain technology has emerged as an increasingly promising solution for diverse digital applications, owing to its distinctive attributes and robust security features. This study endeavors to explore the use of blockchain technology for secure student feedback systems in education, specifically for analyzing faculty performance in a course. However, a noteworthy challenge that plagues existing feedback systems is their inability to ensure complete anonymity, leading to students' hesitancy in providing candid and honest feedback. Furthermore, these conventional systems often rely on databases for data storage, rendering them susceptible to tampering and data breaches. In response to these pressing concerns, the present paper proffers a comprehensive and innovative solution. The crux of the proposed approach revolves around the implementation of a blockchain-based student feedback system, artfully designed to guarantee both student anonymity and tamper-proof data storage, thereby facilitating the evaluation of teaching effectiveness. By leveraging the potential of an Ethereum-based blockchain, a secure and trusted platform is meticulously established, catering to the sensitive realm of student feedback in an impervious and confidential manner. Concomitantly, a user-friendly web application is deftly developed to complement the proposed system, meticulously documenting the implementation process, Smart Contract and project code. It is noteworthy that this cutting-edge feedback system provides an invaluable layer of security, fostering heightened user trust and engendering an environment conducive to genuine and authentic evaluations.**

***Keywords*—Blockchain; student feedback system; faculty performance evaluation; anonymity; smart contract, ethereum**

I. Introduction

In today's educational landscape, student feedback is a vital component for organizations seeking to analyze and address various issues. This invaluable information is utilized to make important decisions within the organization, assess faculty performance in specific courses, identify solutions for existing problems, as well as inform future improvements. As such, feedback is treated with utmost care and consideration. Feedback plays a crucial role in assessing student achievement, promoting skill development, enhancing understanding, and fostering student motivation and confidence [1]. There is an ever-growing need to measure the activities and performance of faculty members in colleges and universities. Evaluating faculty performance is one of the most critical tasks within an institution and it has become a top priority worldwide [2]. However, most organizations rely on databases to manage their feedback systems. Therefore, the system administrator holds the authority to remove, alter, and manipulate the given feedback [3]. Henceforth, it is evident that the feedback system within the database management system does not provide anonymity [4]. According to a report published in [5], A $2.2 million fine was imposed on an Australian hotel business for deleting negative reviews from their website. A blockchain system that is decentralized, immutable, and auditable is inherently suited to prevent fraudulent and manipulated reviews [6].

Blockchain ushers in a new era of innovation and represents a huge advancement in decentralized information technology [7]. It offers several benefits to the education evaluation process, including decentralization, classification, and secure storage of evaluation data. By leveraging blockchain's inherent security features, such as immutability and tamper-resistance, it can enhance the confidentiality of data and prevent unauthorized access or modification [8]. The faculty members who receive or view feedback may be negatively impacted by the organization and their students if negative feedback is disclosed. Furthermore, faculty members may attempt to uncover the identity of students who have given negative feedback through administrators or databases, which could lead to adverse effects on those students. Administrators with access to databases can also change feedback or reveal the identities of the students who submitted it, thereby this feedback system does not remain fully anonymous. Maintaining confidentiality and safeguarding anonymity are fundamental components of an effective feedback system. Utilizing blockchain technology and its numerous fascinating characteristics, including anonymity, validation, robustness, and potential integration, one can create a feedback system that preserves anonymity effectively [9].

Satoshi Nakamoto introduced the concept of blockchain technology in 2008 by publishing a paper on Bitcoin [10] [11]. Blockchain is a decentralized ledger system that utilizes a network of distributed nodes to create a highly trustworthy ledger system without relying on third-party verifiers. The distinctive structure of the blockchain is data protection, anonymity, transparency, and integrity [12]. Blockchain technology aims to achieve a decentralized consensus among network nodes, where data is distributed and no single node has complete control [13]. It is a decentralized database that stores records in blocks [14]. Every block includes a hash value, timestamp, and the transaction's details. A hash function is employed to transform a collection of data into a compact and fixed-sized data structure referred to as a hash value [15] [16].

We looked over some of the research papers on feedback systems based on blockchain and tried to investigate the gaps. We found some research papers related to feedback systems that showed an opportunity to alleviate the existing challenges in this field. The existing Ethereum blockchain-based feedback system doesn't use any encryption and decryption process while login/registration and storing passwords on the blockchain. But in this paper user password encryption and decryption during login, registering, and storing on the blockchain is done using bcrypt algorithm.

Therefore, we proposed a secure student feedback system for the evaluation of faculty performance using blockchain technology, designed to prioritize user anonymity and tamper-proof features. With this system, data remains unaltered and secure, preventing both administrators and faculty members from accessing the identities of students who submitted feedback. Consequently, this system delivers enhanced security and anonymity, empowering students to provide feedback with confidence.

The subsequent parts of the paper are organized in the following manner. A synopsis of the prior related literature is given in Section II. Section III presents the methodology and implementation of the proposed blockchain-based teaching evaluation system. Section IV describes the results and Section V delves into discussion. Lastly, the paper's conclusion is presented in Section VI.

II. Literature Review

The existence of blockchain predates its introduction by Satoshi Nakamoto with the advent of Bitcoin [17] [18]. Its influence has been profound and all-encompassing, witnessing widespread adoption across various industries and sectors, driven by its potential to enhance security, efficiency, and transparency. In recent times, blockchain technology has emerged as a frontrunner in the realm of innovation, garnering substantial attention from the global public and academic communities [19]. Blockchain technology attained remarkable prominence, establishing itself as a leading technological breakthrough on a global scale. Consequently, an array of comprehensive research endeavors have been undertaken to delve into the intricacies of this system, culminating in proposed advancements and revisions to existing studies. This surge in interest underscores the profound significance of blockchain technology as an enabler of progressive and transformative solutions across various domains.

In their seminal work, Zheng et al. provided invaluable insights into the architecture of blockchain technology, shedding light on the intricate algorithms that underpin consensus among its participants. The authors also dedicated attention to the technology's inherent limitations, offering innovative solutions to mitigate these challenges. Their rigorous analysis encompasses a comparative evaluation of diverse consensus algorithms, with the overarching goal of identifying the most fitting approach for a multitude of applications [20].

Rahman et al. introduced a pioneering blockchain-based feedback system, meticulously engineered to safeguard user anonymity. The primary objective of this system is to empower users to provide feedback without compromising their privacy. Notably, once feedback is submitted, it becomes immutable. Furthermore, the system meticulously safeguards the privilege of providing feedback for registered users. However, the cloak of anonymity raises the potential for intentional negative feedback to tarnish the reputation of recipients [21].

Chandratre et al. proposed an innovative blockchain-based course feedback system, harnessing the power of Ethereum blockchain for its development. This inventive system integrates a survey management component, enhancing longevity and traceability. The feedback process unfolds through well-defined phases: initiation commences with the administrator crafting a survey form, followed by students sharing their feedback, culminating in the secure storage of this feedback on the blockchain [22].

Salah et al. demonstrated an online review system rooted in blockchain technology, featuring the use of the Solidity programming language and the Remix Integrated Development Environment (IDE) for implementation and testing. The system not only rewards genuine reviewers with tokens and Ether-based compensation for their reviews but also securely archives verified reviews within the InterPlanetary File System (IPFS), thereby ensuring their integrity and reliability. In a forward-looking approach, the authors aspire to develop user-friendly decentralized applications to further facilitate the work of reviewers [23].

Karode et al. presented an innovative blockchain-based online review system aimed at enhancing transparency on business platforms by combatting the prevalence of fake or unreliable reviews. Leveraging the Ethereum blockchain, this system securely stores review data, effectively thwarting data manipulation. Additionally, it ensures the public traceability of actions, significantly elevating the transparency of the online review system through the integration of blockchain technology. However, it's important to note that the adoption of blockchain in this context may introduce challenges, including increased costs and potentially slower response times [24].

The research papers previously mentioned delve into the development of student feedback systems that prioritize anonymity and data integrity. However, our innovative approach takes a step further, encompassing a performance-based evaluation system that serves both as a feedback mechanism and a valuable resource for identifying effective solutions to similar challenges. Diverging from some existing feedback systems, where administrators assign students to specific courses eligible for feedback, our proposed system introduces a seamless and automated validation process. By offering students the opportunity for self-registration, they gain access to provide feedback exclusively for the courses in which they are enrolled. Moreover, we introduce a rating-based system for evaluating faculty performance, a salient feature that bears immense potential for driving organizational improvement.

III. Methodology

The principal aim of our system revolves around the seamless facilitation of anonymous feedback while upholding the inviolable integrity of data, thereby empowering students to

express candid opinions without hesitation. To achieve this pivotal objective, we judiciously harnessed the potential of blockchain technology, renowned for its remarkable capacity in safeguarding anonymity and preserving the unassailable authenticity of submitted feedback. Our system, thoughtfully designed, imposes stringent measures to guarantee that solely registered users possess the privilege to proffer feedback, assiduously safeguarding the covert identities of students, and diligently ascertaining that the feedback reaches its intended recipient for meticulous review. Fig. 1 below illustrates the system architecture of our proposed system.

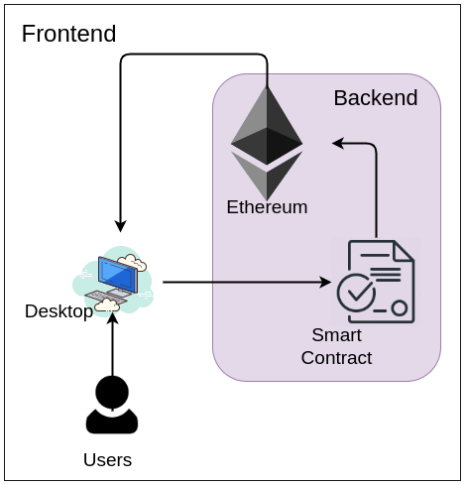

Fig. 1. System architecture.

As depicted in Fig. 1, our system has two distinct parts: front-end and back-end. The front-end is built using React.js and the back-end is developed using the Ethereum blockchain. Our system involves three key actors: the administrator, faculties, and students, each with a unique set of functionality that will be performed from their particular dashboard. To ensure anonymity, students provide feedback through customized forms accessible from the front-end of the system. This feedback is processed through smart contract and securely stored on the Ethereum blockchain. The administrator and faculties can easily access this feedback through their respective dashboards, which retrieve the data directly from the blockchain.

The student feedback system's diagram is clearly illustrated in Fig. 2 below, which depicts the various actors and their functionality and how the system is working. To initiate their engagement with the system, users are required to establish a connection to their Metamask wallet, followed by a secure login procedure employing a unique username and password. Once the username and password are validated, the system will identify the user's role, which may be administrator, faculty, or student. Depending on their role, users will be redirected to their corresponding dashboard, where they can perform specific functions tailored to their needs. The administrator can use the dashboard to manage user accounts, including registering new faculty and student accounts, creating new courses, and viewing all student feedback. Students, on the other hand, can use their dashboard to get enrolled in courses, and write and send feedback to specific faculty members and courses. Students are only able to submit feedback once in a course and cannot modify their responses afterward. Finally, faculties can access and view all feedback directed to them via their dashboard.

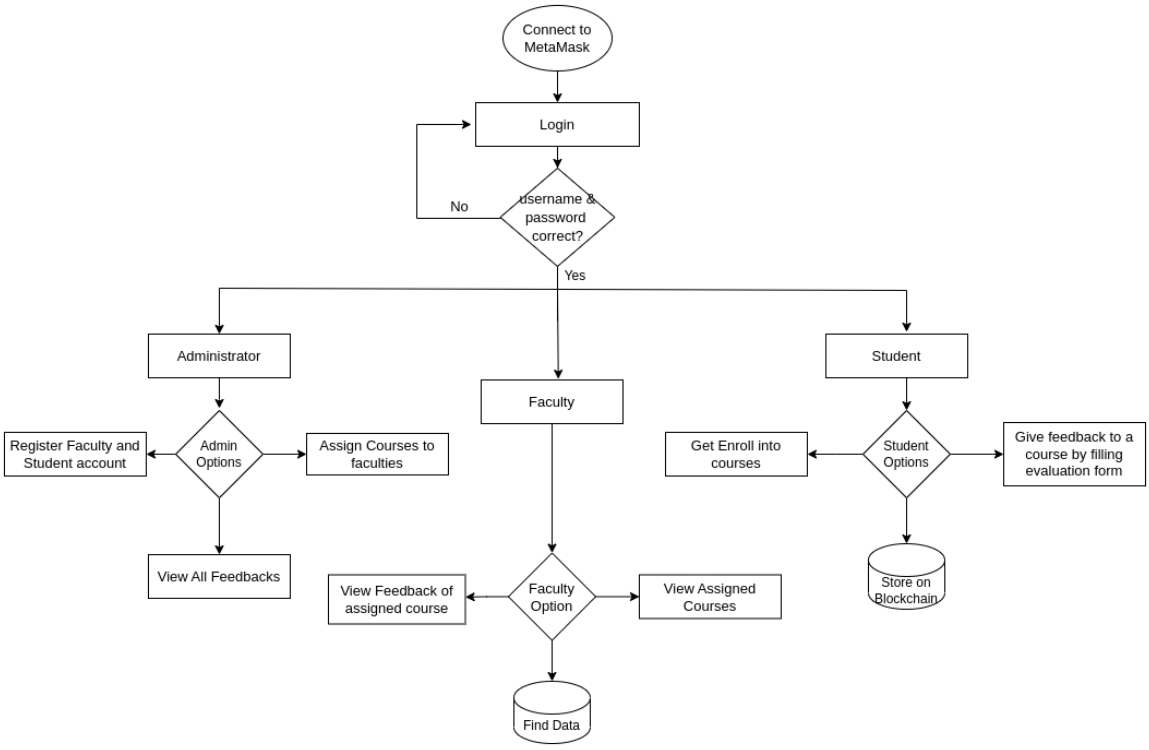

Fig. 2. Diagram of the proposed system.

A. Working Procedure

We have developed a student feedback web application using blockchain technology. The whole procedure is divided into five phases described below.

1) Registration phase: In this phase, the administrator registers new student and faculty accounts by accessing create account option from the dashboard. Once created, these accounts can be used by students and faculties to log in to the system. The user password will be encrypted and stored on the blockchain. Also, the administrator will register all courses offered by the institution. The students can enroll in these courses later, and validation is done during the registration of user accounts and courses.

2) Login phase: Our web application begins with a login page where users are required to connect their Metamask wallet and enter their usernames and passwords. The system verifies the password against the encrypted hash stored in the blockchain. If the password matches, users gain access to their accounts and are redirected to their respective dashboards based on their roles (administrator, faculty, or student).

3) Course enrollment phase: During this phase, students will self-register for courses by accessing the enrollment option on their dashboard. They can view the institution's course list and enroll in a specific course by clicking on it.

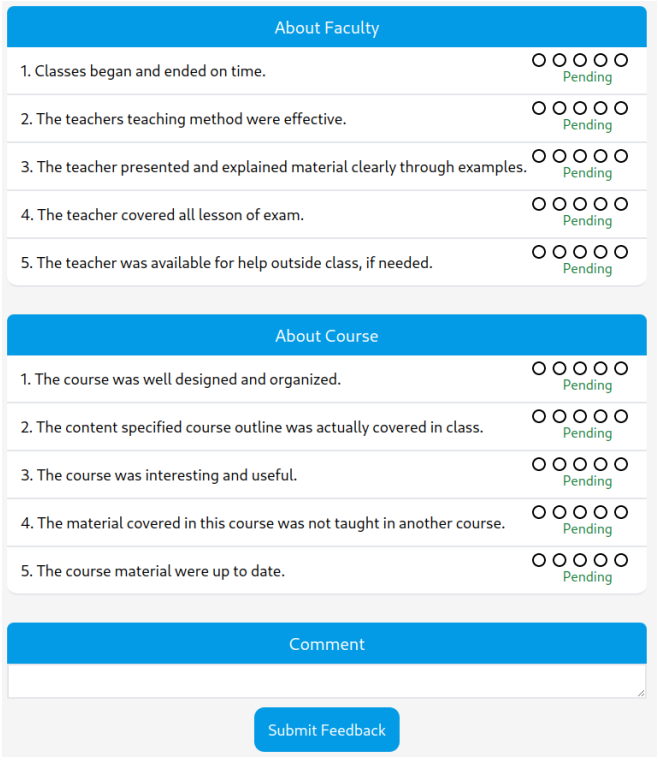

Fig. 3. Student feedback form.

4) Submit feedback phase: During this phase, students will provide feedback on courses and instructors by accessing the give feedback option on their dashboard. They select the course and faculty member for evaluation and fill out a feedback form with questions about the course and instructor. Our application's feedback evaluation form is illustrated in Fig. 3. The evaluation form consists of ten questions collected from the teaching evaluation system of Southeast University, Bangladesh. These questions help to evaluate the performance of the faculty. Each question carries a weight between 1 and 5 using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). We have calculated an average rating point out of 10 from the Likert scale responses submitted by students to assess the faculty's performance. Students are also encouraged to provide comments along with their chosen rating.

5) View feedback phase: In this phase, both the administrator and faculty members can access student feedback through their respective dashboards. Administrators have access to all course feedback, while faculty members can only view feedback for their assigned courses. Fig. 4 below shows the feedback page, displaying student ratings and comments. Moreover, we have created a formula to assess faculty performance in each course on a scale of 0 to 100 percent. The formula is the sum of total ratings divided by the number of feedback submissions, then multiplied by 10. Every faculty member will see a performance rating against a course here which is measured by the above formula.

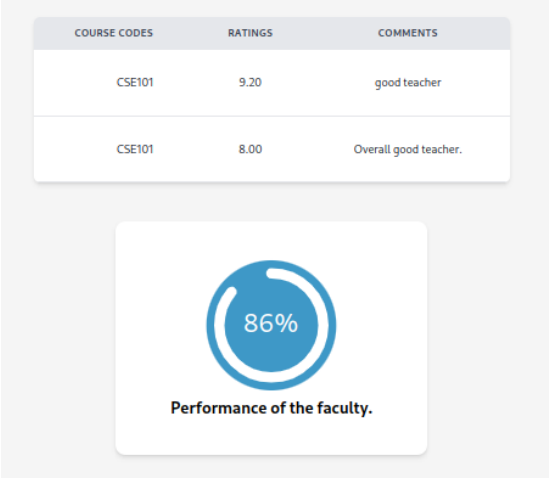

Fig. 4. View feedback page.

B. Implementation

This section focused on the implementation of the project code. We described the pseudocodes of functions and the tools used to build the project.

PSEUDO CODE 1: Function to create new user account

```
1: function createUserAccount(username, password, role):
2:     if the caller is the contract owner then
3:         Create → new user account property
4:         Store ← new user account information
5:     else
6:         return "Caller is not the contract owner"
7:     end if
8: end function
```

The "createUserAccount()" function serves as a pivotal feature, granting administrative personnel the authority to

create new student and faculty accounts within the system. This function receives username, password, and role as parameters and is triggered when the administrator creates a student and faculty account from the client side.

PSEUDO CODE 2: Function to submit feedback

```
1:function submitFeedback( userAddress, courseCode, rating, comment):
2:      if the user has already submitted feedback then
3:            return "Your feedback already exists"
4:      else
5:            Create → a new feedback object
6:            Store ← the feedback
7:            Update → feedback track
8:      end if
9: end function
```

submitFeedback() function allows the student to give feedback or do an evaluation against a course. The function validates that a student can submit feedback into a course for once.

PSEUDO CODE 3: Function to view feedback

```
1: function getFeedback( courseCode ):
2:      return a list of feedback for the specified course code.
3: end function
```

getFeedback() function returns all feedback stored into the blockchain. This function allows the administrator and faculties to view feedback given by the students.

C. Used Tools

We utilized a variety of tools to effectively achieve the project objectives and outlined the specific tools used in this project below:

1) Ethereum blockchain: Ethereum is a blockchain platform that has its own digital currency known as Ether (ETH)[25]. Vitalik Buterin created it in 2014 [26]. It supports the development and deployment of decentralized applications. It is not controlled by any central authority [27].

2) Solidity: It is a powerful, user-friendly, and object-oriented language used to write smart contracts that operate on the Ethereum Virtual Machine.

3) MetaMask: It links users to the Ethereum blockchain and allows them to use the Ethereum wallet through a browser extension or mobile app. This allows them to interact effortlessly with decentralized or web3 applications [28].

4) Remix: Remix is an open-source online Ethereum IDE. It is the smartest way to write contracts using the Remix IDE[29]. We can use it to write, compile and debug code. We wrote and deployed smart contracts from here.

5) ReactJS: It is a JavaScript library created specifically for constructing dynamic and interactive user interfaces using a component-based approach [30]. It is used to develop front-end of our web application.

IV. Results

We conducted a survey involving a limited number of students to explore their perceptions of the traditional teaching evaluation system. Our findings revealed that a significant portion of the students expressed apprehension about providing honest feedback due to concerns about their anonymity being compromised. They believe that the conventional database-driven feedback system falls short of providing complete anonymity. Subsequently, we introduced our Blockchain-based teaching evaluation system, which garnered significant interest among the student participants. A number of students chose to utilize our system and reported high levels of satisfaction, citing its ability to ensure absolute anonymity.

For the development and experimental validation of our proposed system, the Remix Integrated Development Environment (IDE) serves as the primary tool for composing and assessing the smart contract. Subsequently, to facilitate thorough testing procedures, the smart contract is deployed onto the Remix virtual network, effectively replicating a decentralized environment for examination. Within the context of our smart contract design, a singular entity, known as the "smart contract deployer," assumes the authoritative role of the system's administrator.

Once the smart contract passed the testing phase, we proceeded to deploy it on the Goerli test network. Metamask wallet wanted confirmation during deployment. Upon successful deployment of our smart contract, the contract was created and its address was returned to the Remix IDE. We collected this smart contract address and ABI(Application Binary Interface) from Remix IDE. This contract address and ABI were used to make communication between front-end and blockchain. Our newly deployed smart contract address is 0x6F04207829759752079DEE48136fd447c3F6198f. The source code of our feedback system is made accessible through the following link: https://github.com/uttamsaha/Web3-Student-Feedback-System

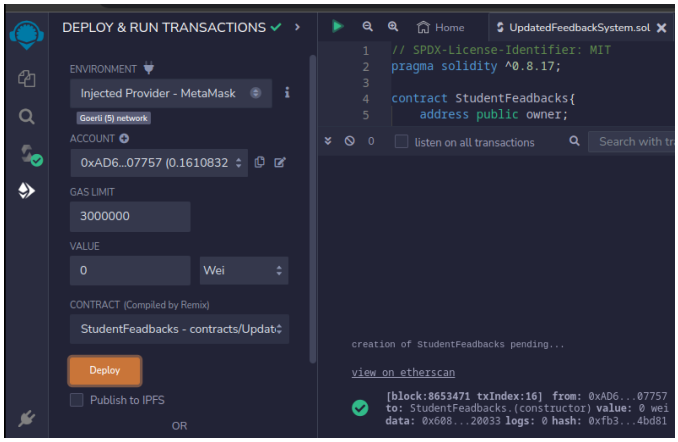

Fig. 5. Deploy smart contract to Goerlitestnet.

Fig. 5 shows that we deployed our smart contract on the Goerlitestnet network.

V. Discussioin

We have conducted a comprehensive comparison between our newly implemented teaching evaluation system and the existing blockchain-based system, presenting our key findings. The existing system in [22] allows students to give feedback only but the proposed system allows evaluating the

performance of a faculty in a course along with giving feedback. This existing system is quite manual for generating a permission list that maintains who can give feedback in a course, but it was maintained automatically in this work. Instead of knowing all usernames and passwords, the administrator or someone else cannot perform any action or view on student and faculty accounts because we developed and mapped the user information using their Metamask wallet address. This enhances the overall security measures. The traditional and existing system does not give such features

In our system, we implemented a robust encryption mechanism to safeguard user passwords during storage within the blockchain. Subsequently, when the user's login function is called, the stored password is decrypted securely. This encryption-decryption process serves as an integral aspect of our security infrastructure, augmenting the overall protection of user credentials and sensitive data. Furthermore, we devised a comprehensive performance evaluation approach for faculty members, quantifying their performance in courses through a percentage-based assessment. This helped the authority to know how a faculty is performing in the class. To uphold the integrity of the feedback process, we meticulously designed the system to ensure that each student is limited to providing feedback to a faculty member once and also ensured students can get enrolled in a course once.

VI. Conclusion

In today's digital age, feedback stands as a critical element for organizational enhancement and progress. Nonetheless, parallel to the imperative of obtaining valuable feedback is the need to safeguard the security and anonymity of the contributors. Preserving confidentiality emerges as a substantial challenge for any feedback system, as participants might harbor apprehensions about potential identity exposure. Consequently, feedback systems necessitate meticulously crafted designs that incorporate advanced security measures, effectively addressing these concerns and ensuring robust privacy and confidentiality. The challenges of ensuring confidentiality and security in feedback systems find a compelling resolution through the adoption of blockchain technology. Its inherent attributes, including decentralization, tamper-proofing, enhanced security, and anonymity, make it an ideal fit for addressing these concerns. Recognizing the potential of blockchain, our organization has harnessed its capabilities to construct a cutting-edge student feedback system that prioritizes both anonymity and security for its users. By leveraging blockchain, our system empowers users to freely and honestly express their feedback without the fear of their identity being exposed or facing repercussions. That is how our feedback system becomes more effective, reliable, trustworthy, and secure.

The feedback system does not permit modifications. Consequently, if a student inadvertently submits an incorrect evaluation, there is no opportunity to revise it. In our system, where user anonymity is maintained, someone may purposefully provide negative feedback with the intention of harming a candidate's reputation. As the system will rely on blockchain technology for maintenance, the transaction rate is expected to be relatively slow.

The knowledge we've gained through this experience can be applied to other feedback systems or adapted for different applications in the future. Companies that rely on rating mechanisms can seamlessly integrate our feedback system into their operational framework, leveraging its robust features to enhance their feedback collection and analysis processes. Also, this system can be used to develop a survey management and evaluation system using blockchain.

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