Edu-Pro: Blockchain based Education System

Mahesh Shirole, Sejal Agrawal, Unnati Nandrekar,
Priyanshi Gupta, Yukta Sarode
Department of Computer Engineering and Information Technology, Veermata Jijabai Technological Institute, Mumbai, India

Abstract - Many academic institutions have begun to incorporate blockchain technology into their educational programs with the majority of them using it to assist degree management and summative evaluation for learning outcomes. This paper uses a blockchain network and smart contract to implement a new assessment system based on the 'learning is earning model.' It is observed that students often feel the burden of studies and lack the motivation to complete assignments. In addition, the traditional method for teacher evaluation is based on students' feedback, however it tends to be one-sided, lacking subjectivity and is hardly helpful for teachers' improvement. Teachers also often face difficulty in correcting and interpreting theory answers of multiple students which leads to students getting biased marks. Moreover, online testing comes with its own challenges such as test result data storage, non-repudiation and result tampering prevention. To address these shortcomings, our system provides appreciation and encouragement to students as well as teachers by rewarding them with digital currency proportional to their performance. With the help of students' unambiguous feedback, teacher evaluation will be conducted eliminating subjectivity. Further, subjective answer checking is facilitated by machine learning algorithms. This system aims to achieve increased productivity, fair evaluation, active participation and improvement in student grades.

1. INTRODUCTION

It is observed that students often feel the burden of studies and lack the motivation to complete assignments. In addition, the traditional method for teacher evaluation is based on students' feedback, however it tends to be one-sided, lacking subjectivity and is hardly helpful for teachers' improvement. Teachers also often face difficulty in correcting and interpreting theory answers of multiple students which leads to students getting biased marks. Moreover, online testing comes with its own challenges such as test result data storage, non-repudiation and result tampering prevention.

To address these shortcomings, our system provides appreciation and encouragement to students as well as teachers by rewarding them with digital currency proportional to their performance. With the help of students' unambiguous feedback, teacher evaluation will be conducted eliminating subjectivity. Further, subjective answer checking is facilitated by machine learning algorithms. This system aims to achieve increased productivity, fair evaluation, active participation and improvement in student grades.

The proposed solution has been implemented in two parts. To tackle the teacher evaluation problem the students give an anonymous rating and the teacher is given token proportionally. These ratings can be used by the teacher as a metric for performance and will help the teacher to make any improvements. Similarly students are awarded tokens for attempting quizzes and publishing research paper. This helps in active participation of students in academic activities.

The rest of the paper is organized as follows: Section II elaborates related work and termi- nologies. In Section III, we give a case-wise overview of the proposed methodology. Section IV discusses the design and implementation of this framework. Section V describes the future scope. The conclusion is presented in Section VI with references at the end.

2. RELATED WORK AND TERMINOLOGIES

Nowadays, some universities and institutes have applied blockchain technology into education, and most of them use it to support academic degree management and summative evaluation for learning outcomes.The paper [1] explores how a new assessment system can be constructed based on blockchain network and smart contract.

Online quizzes are often used today in E-learning because they allow quick updates for both the quiz creation technologies and the quiz contents. There are many challenges that need to be solved in the domain of online testing, especially test result data storage, non-repudiation and result tampering prevention. By using blockchain ,the changes are recorded in the ledger and tampering only a part of it will make the rest of the chain invalid and the full blockchain will have to be recomputed and modified, making this a time and resource consuming operation. Therefore paper [2] suggests using blockchain for tamper proof quiz implementation.

Trust and security are the major constraints for such online examination systems. By using blockchain, as suggested in paper [3] the original data is only seen by the candidate and the examination centre. By using the smart contracts, all the data is present in encrypted form.

Similarly, paper [4] proposes a blockchain-based e-learning assessment and certification system, which can be effectively employed in online education scenarios. It presents a new network structure on the basis of the combination of the public and private blockchains, which not only breaks the limitation of the single node role in the traditional single-blockchain systems with high flexibility, but also fully retains the security and credibility of the blockchain technology, which thus creates a fairer, healthier and more open online education environment.

By leveraging the advantages of the public blockchain, consortium blockchain, and private blockchain, the paper [5] proposes EduBloud, a heterogeneous blockchain system empowered education cloud. The system shows higher reliability, lower latency, higher data throughput, and better economic efficiency than homogeneous blockchain implementations.

On the same grounds, paper [6] introduces Kratos: an immutable and publicly verifiable data management system that enables Educational Data Mining (EDM) and Learning Analytics (LA), while maintaining data privacy and empowering students with a user interface for data governance and participation in school processes. The system aims to achieve data interoperability, which facilitates EDM and LA as incentives to educational stakeholders (policy makers, educators, developers of education technologies, etc.), while prioritizing student agency over their data.

In the paper [7] BookChain, a traceable and efficient blockchain-based inner campus book- sharing system is presented. BookChain stores the complete sharing data of an interested book permanently on the blockchain, such that every reader can trace the borrowing history, which reduces the potential for loss of the book. BookChain also introduces the use of smart contracts to automate the circulation of books with minimal human intervention, resulting in the improvement of efficiency.

Besides, paper [8] proposes a model which helps to setup a streamlined administration process in the educational institute to solve the variety of issues that are there in legacy educational organization/institutes administration process like tracking of records in cloud, fraud certification detection, keeping Identity digital under the control of authentic source and transferring over the internet securely, by eliminating need to verify them by third party sources.

A. Blockchain

Blockchain is a decentralized, distributed, immutable digital ledger technology which promotes maintaining records of transactions. It uses various cryptography principles for its working. It was introduced by Satoshi Nakamoto in 2008 as bitcoin cryptocurrency to solve the double spending problem in a peer-to-peer network [9]. Blockchain has been adopted for various use cases and new areas of research are being explored.

There are two types of blockchain : public (permissionless) and private (permissioned) blockchain. In a public blockchain there are no restrictions, anyone can participate and become a node and do transactions. This kind of blockchain is transparent as each and every transaction is made public to all the participating nodes. On the other hand private blockchains are permissioned to gain or provide access. This facilitates the trade-off between privacy and transparency among the peers on the blockchain and is suitable for enterprise use cases.

B. Ethereum

Ethereum is a global, decentralised software platform based on blockchain technology. It comes with the support for smart contracts, which are the backbone of decentralised apps. There is a single, canonical computer in Ethereum (known as the Ethereum Virtual Machine, or EVM) whose state everyone on the network agrees on. Every Ethereum node saves a copy of this computer's current state. The participant can also broadcast a request for this computer to conduct any computation they choose. Other network members check, confirm, and carry out the computation whenever such a request is broadcast. This computation leads to a state change in the EVM, which is committed and propagated throughout the entire network. Cryptographic procedures ensure that transactions are immutable after they've been validated as authentic and published to the blockchain. All transactions are signed and executed with suitable permissions.

B.1. *Ether*

Ethereum's native coin is Ether (ETH). Ether aids to create a market for computing which allow participants to have an economic incentive to validate and execute transaction requests as well as offer compute resources to the network. The participants wishing to broadcast a transaction request must also offer a bounty to the network in the form of ether. This reward will go to the person who completes the tasks of verifying, executing, committing and broadcasting the transaction to the network.The amount of ether paid is proportional to the time it takes to complete the computation. These bounties also keep hostile participants from clogging the network by restricting the execution of infinite computation or other resource-intensive programs, as they have to pay for computation time.

B.2. *Smart Contract*

Pragmatically participants don't create new code every time they wish to request a computation on the EVM. Users issue requests to execute these code snippets with various parameters, and application developers upload reusable codes into EVM state. The programs that are uploaded to the network and executed by it are referred to as smart contracts. For a price given to the network, any developer can construct a smart contract and make it public to the network, using the blockchain as its data layer and then invoke the smart contract to execute its code. Developers can create and deploy arbitrarily complex user-facing programs and services such as marketplaces, financial instruments and games using smart contracts.

B.3. *EVM*

The Ethereum Virtual Machine is a global virtual computer whose state is stored and agreed upon by all Ethereum network participants. Any participant can request the arbitrary code that needs to be executed on the EVM. Code execution modifies the EVM's state.

C. Web3

Web3 makes use of blockchains, cryptocurrencies, and non-fungible tokens to return power to users in the form of ownership. Web3 apps are built on blockchains, decentralised networks of numerous peer-to-peer nodes (servers), or a hybrid of the two. Dapps are a term for these kind of decentralized apps. Web3 is permission-less, meaning that everyone can engage in it and no one is excluded. Web3 has native payments, which means it spends and sends money online using bitcoin. Web3 is a trust-less system that relies on incentives and economic mechanisms rather than trusted third parties.

3. PROPOSED METHODOLOGY

The system incorporates the following features:

A.Evaluation System:

From the perspective of teachers, the instruction is sophisticated and artistic so that it is difficult to evaluate. The traditional method based on students' feedback tends to be one-sided, lacking subjectivity and is hardly helpful for teachers' improvement. A new assessment system can be constructed based on blockchain networks and smart contracts. First, teachers need to submit pre-planned instructional activities as a smart contract to the schools. During the teaching process, all teaching activities will be recorded in the blockchain network. The smart contract will verify the consistency of the teaching design and practice, which is going to be an important instruction evaluation indicator. What's more, a smart contract between teachers and schools, as well as the one between teachers and students can be verified and supplemented with each other. Teachers who meet the standards will get digital currency as a reward. It serves as both an appreciation and encouragement for teachers' teaching skills.

B. Online Quiz:

Online quizzes are often used today in E-learning because they allow quick updates for both the quiz creation technologies and the quiz contents. There are many challenges that need to be solved in the domain of online testing, especially test result data storage, non-repudiation and result tampering prevention. Even from the first implementations of such systems, it was important to use the latest technologies in order to offer the participants the best possible experience when browsing the course or taking an online test. Components of an online test are the user interface, the data storage and the business logic. In an online quiz implemented using blockchain, it is very difficult to make changes to the database alone in order to change a specific result. The changes are recorded in the blockchain and tampering only a part of it will make the rest of the chain invalid and the full blockchain will have to be recomputed and modified, making this a time and resource consuming operation.

C. Subjective Answer Evaluation:

Teachers often face difficulty in correcting and interpreting theory answers of multiple students which leads to students getting biased marks. This discourages students and hampers their motivation to study. In order to help teachers evaluate theory questions accurately and automate the answer correcting process, our system will implement a machine learning model for correcting students' responses. The teacher will add a model answer sheet while setting the question paper. This model answer sheet will be compared with the students' responses using similarity measures. The answers which have a high similarity score will be awarded a greater score. Thus, it will set a specific criteria with which the answers could be corrected.

D. Token Redemption:

Students and teachers will get a certain number of digital currency according to smart contracts as rewards. This kind of cryptocurrency can be stored in the wallet, and used in on-campus shops. Students can also use the currency for buying course materials from seniors.

4. IMPLEMENTATION AND EVALUATION OF THE PROPOSED BLOCKCHAIN BASED FRAMEWORK

A. System architecture:

The system consists of three layers as shown in the figure S1 namely user interface, business layer and blockchain platform. User interface and business layer are implemented as a part of the decentralized application. The user interface will be different for different users. There are three types of users:Student, Professor and Admin. Each user has different action controls to handle the system. The business layer is essentially an application server. The requests from user interface are directed to the application server using HTTPS protocol.It carries out the tasks of user management, public key management, reward management, recording lecture feedback and quiz implementation. It connects to the blockchain platform using the web3 library. The Blockchain platform consists of a blockchain driver and a data cache. Multiple blockchain nodes store the smart contracts which are accessed for different services.

B. Quiz Management

As shown in Figure S2, the teacher uploads the question and answer set for the quiz on the quiz user interface. This quiz is answered by students. The quiz is validated and scored by the smart contract and the grades are released by the teacher to allow the students to view their grades.

The teacher logs into the system by selecting the appropriate Metamask account and entering the valid user credentials (email ID and password). A dashboard is displayed with a list of classes created by the teacher. The teacher clicks on the class for which a quiz or a feedback needs to be posted. The selected Metamask account address is passed as props to the class component. After performing a search in the Firebase database, the address is classified as a teacher address or a student address. The 'Add Quiz' is displayed conditionally only for the teacher accounts. The teacher clicks on this button and a form gets displayed with the following fields:

1) A drop-down menu to select the type of announcement as Quiz or Feedback.
2) The title of the quiz or feedback.
3) The google form link of the quiz or feedback.

4) Additional field for number of subjective questions in case of a quiz along with the link of spreadsheet for the model answers.

5) The form response sheet link to fetch the responses of the students.

After filling the above fields, the teacher clicks on the 'Post' button to post the quiz or the feedback. Once the button is clicked, the corresponding quiz or feedback details are inserted into the Firebase database and appended to the Announcement array.

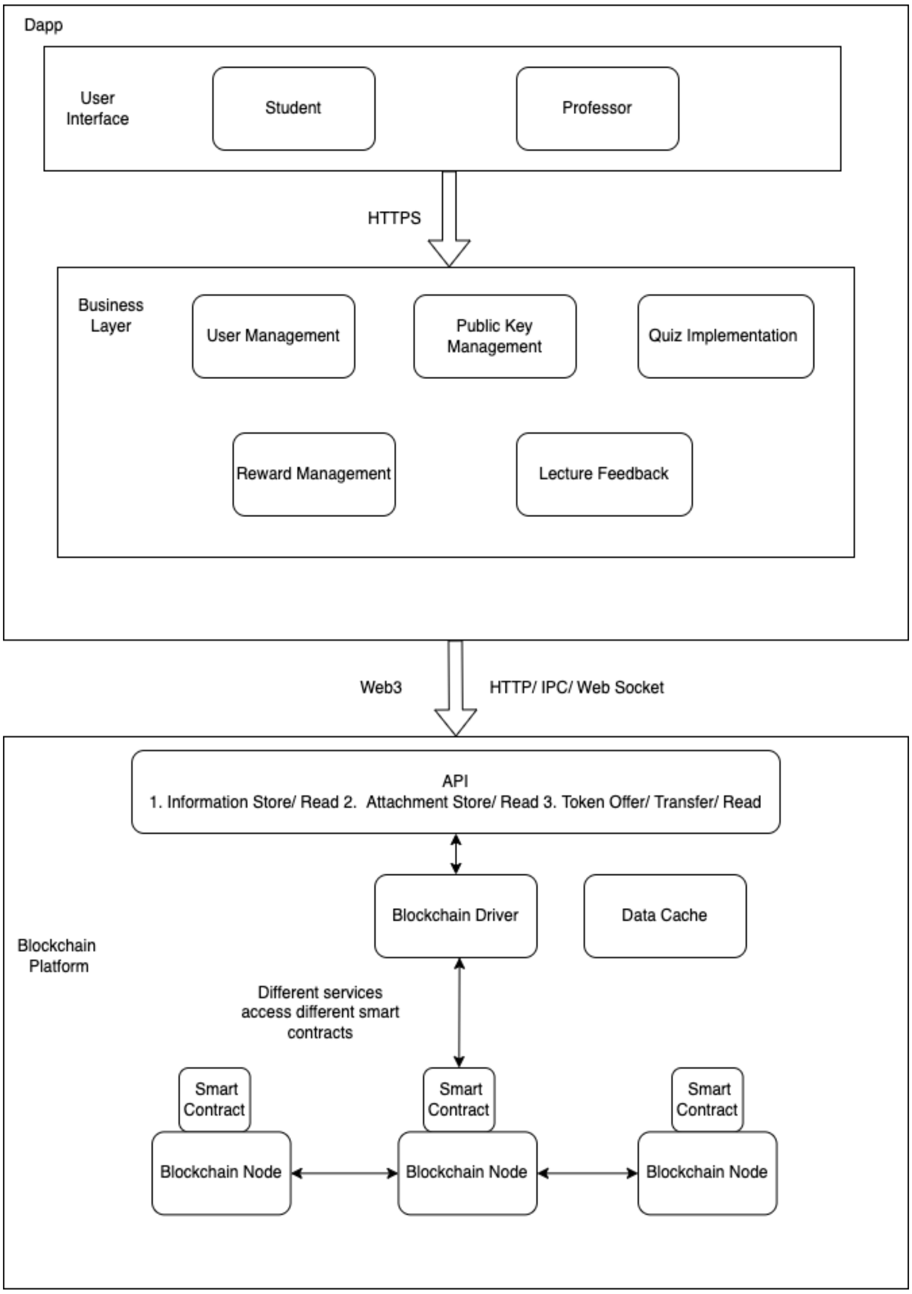

Fig. S1. System Architecture

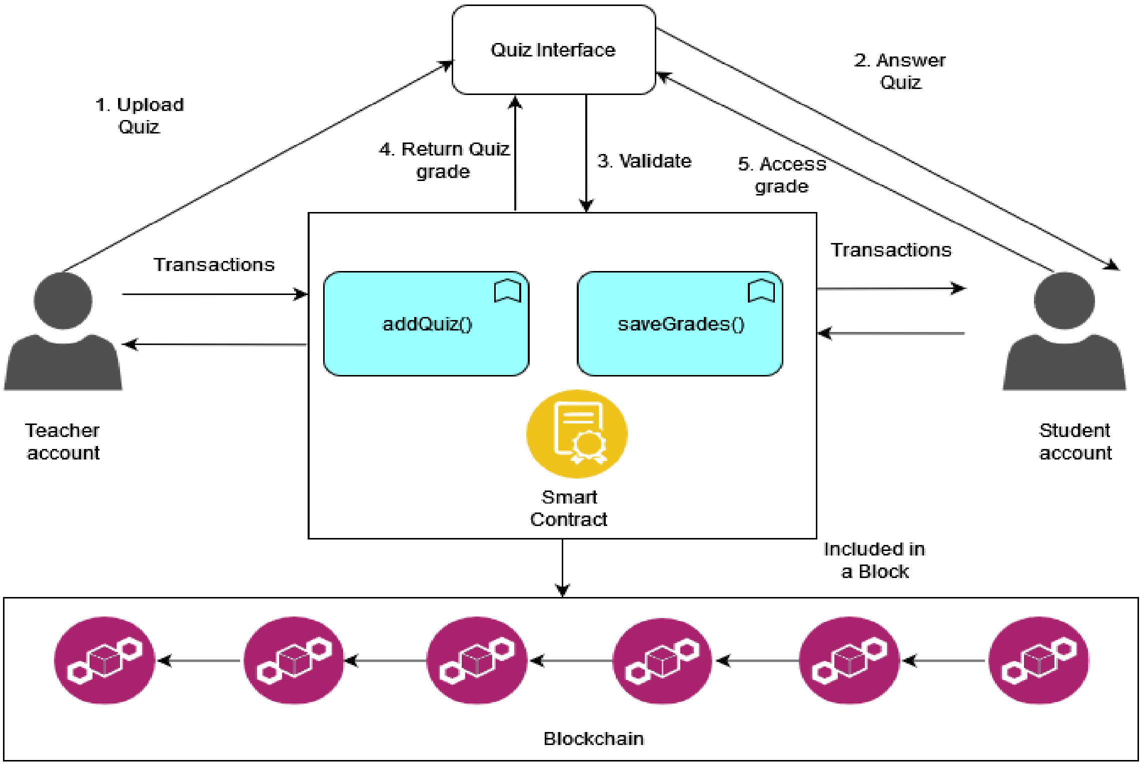

Fig. S2. Quiz implementation

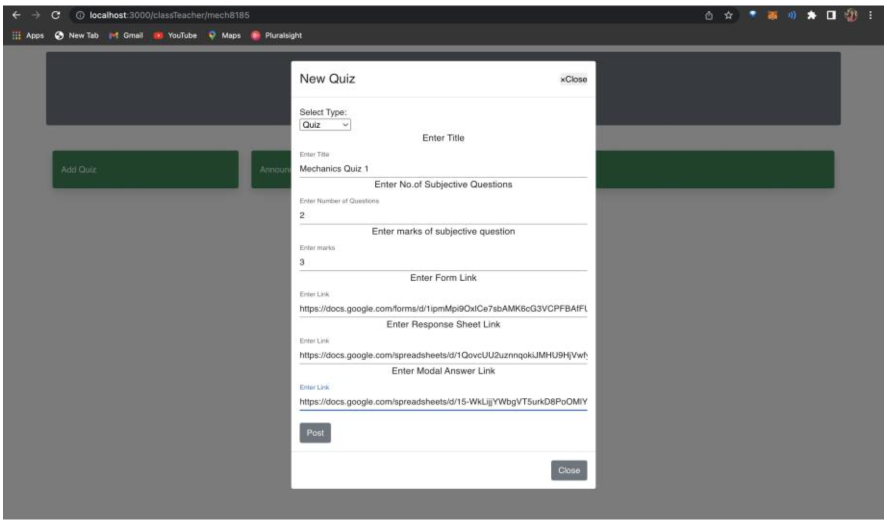

Fig. S3. Quiz form

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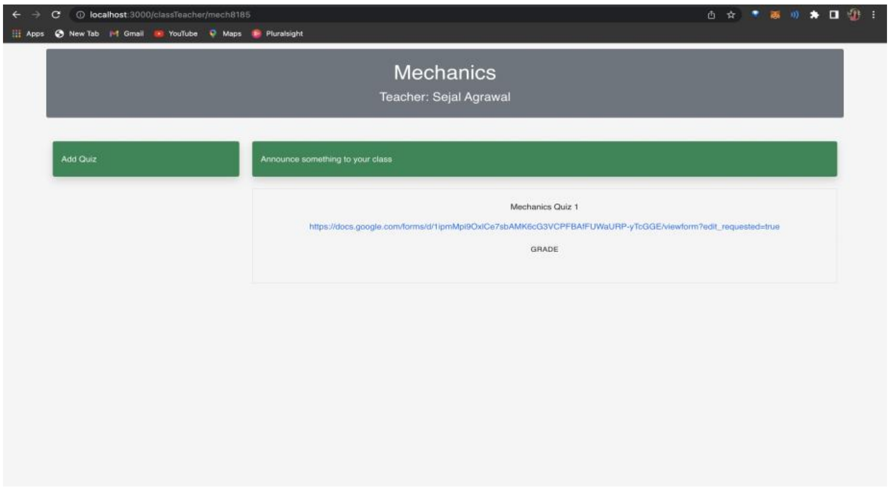

Fig. S4. Class stream with quiz announcement

Consequently, the quiz or feedback is displayed as an announcement to both teachers and students, with an additional 'Grade' button for the teachers to obtain the corresponding grades. It calls the fetchscore function. Inside this function another function is called *fetchsubjectscore()* runs which calculates the score of the subjective quiz answers. To calculate the subjective scores we have used the hugging face library's *BERT mode* for checking the similarity between students' answers and teacher's model answers. Based on the similarity score the marks are decided. The *BERT model* runs in the form of a python script in a node server. As shown in Fig S5 , to switch from a react environment to node environment axios calls have been implemented. When the node end point is hit with the axios post request, the node server gets the request and uses spawn to run the python script and gets the similarity score from the script. The node server sends the response back to the react in the form plain text.

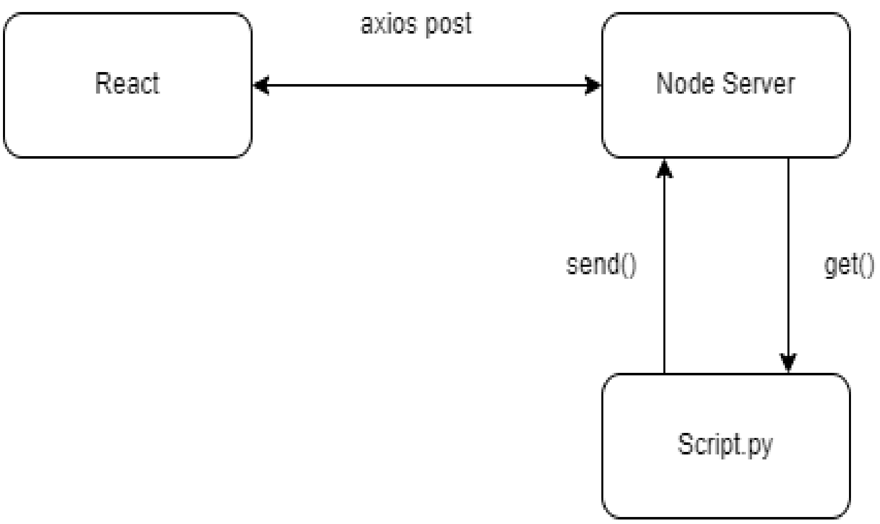

Fig. S5. Class stream with quiz announcement

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c. Reward Management

The smart contract for reward management generates rewards for teacher when the teacher publishes a research paper and for following lecture plan by checking the same from students feedback for the respective teacher. Students are rewarded for publishing research paper and answering quizzes. This is shown diagrammatically in Figure S5.

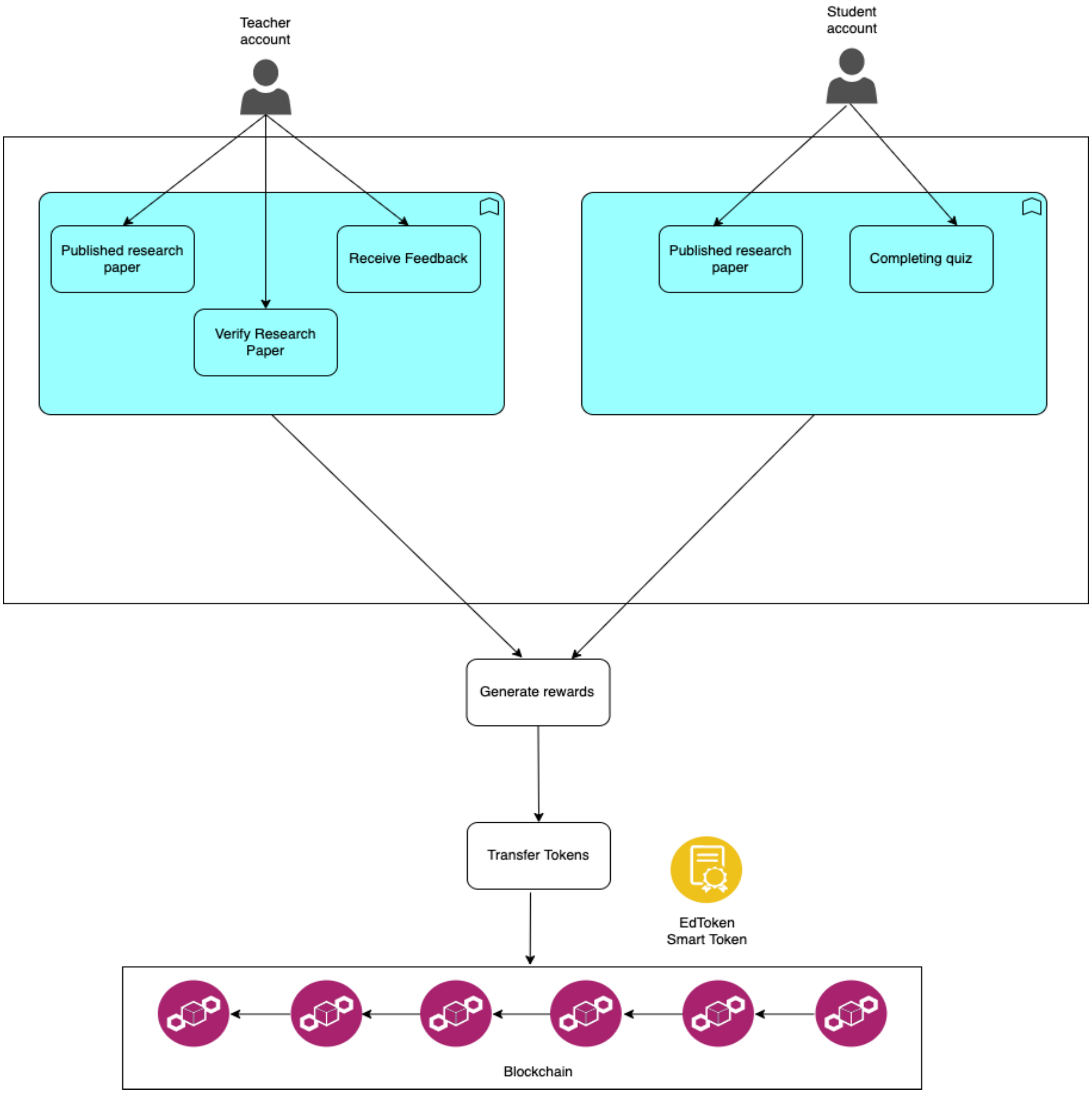

Fig. S6. Smart Contract flow for Reward Management

D. Token distribution

The teacher and the student receive tokens for the following tasks:

Teacher:

1) Feedback given by students:

The teacher can add feedback for a lecture by following the method specified above in the Quiz and feedback section. In the Announcement component present on the client side, the marks for each question are calculated and averaged in the fetchRatings() function. Based on the students responses, the tokens to be given for the feedback form is derived. The component further passes this token calculation to EdToken and StudentRegister contracts.

The EdToken contract assigns the tokens to the teacher by calling the transfer function. This function takes three parameters as input namely, from address, to address and the value which is the number of tokens to be transferred from first to second address.

The StudentRegister contract saves the token assigned and the feedback marks on the blockchain.

For feedback received from each student, StudentRegister contract also stores the attendance on the blockchain.

2) Evaluating the students' research papers:

In order to gain tokens by verifying students research papers, the teacher can enable the Research paper verifier option on the dashboard. After enabling, the teacher is added as a verifier in the database and students can request the teacher for verification of the paper. The teacher can view the requests on the dashboard. When the teacher clicks on the accept request button, tokens are transferred to all the authors of the paper as well as to the teacher.

Student:

1) Quiz marks:

The marks of the student for each quiz are stored in a Google sheet. This sheet is published by the teacher on the dashboard. The Announcement component contains a method called fetchStudentScore(). This function internally uses the Google sheet reader API to read the marks of each student. These marks are further passed to the StudentRegister contract where they are permanently stored on the database. The marks are stored by calling the inputMarks() function of the contract. This function calculates the tokens to be given to the student.

Finally, the transfer() function present in the EdToken contract is called to assign the tokens to the student.

For subjective answers, similarity measure is determined to calculate marks. These marks are used to distribute tokens as described in the BERT model section above.

2) Successful verification of the student's research paper:

A student can gain tokens by submitting their published research papers. The student is given an option where the student adds details about the research paper. These details include the students' name and college ID's of authors who have contributed in the publishing, the name of the verifier teacher to evaluate, title and link of the paper and the Digital object identifier(DOI) number of the research paper. After submitting this request, the student can see the pending request on their dashboard.

The same request is seen on the teacher's dashboard where they can verify the research paper. After successful verification, the students who contributed each receive 5 tokens and the verifier teacher receives 1 token.

5. FUTURE WORK

Our system can be extended to handle certificate management. A decentralized system for sharing certificates will allow students to easily share their certificates with higher universities as well as allow employers to verify the necessary skills of the candidate while hiring.

Additionally, we could implement a crowdfunding model to collect funds in the form of digital currency. The funds thus collected can be used for providing scholarships to eligible students as well as for infrastructure development in the college.

Furthermore, a book sharing model can be implemented wherein the students can buy books from seniors. The details of the book such as current price, edition year can be stored on the blockchain. These details, once added cannot be tampered with. Students can compare different books from all the seniors simultaneously and choose the most suitable.

6. CONCLUSION

Thus our system facilitates learning and encourages both students as well as teachers to improve and perform better during lectures. By rewarding students on their performance in quizzes and research papers participating we successfully implemented learning is an earning model. Our system also solved the crucial problem of grading subjective and objective quiz answers. Similarly to provide appreciation for teachers work tokens have been based on the feedback of the students and for validating research papers.

7. REFERENCES

The supplementary materials document may contain a reference list. The reference list should follow our citation style and should be checked carefully, since staff will not be performing any copyediting. You may add citations manually or use BibTeX. See [10].

Citations that are relevant to the primary manuscript and the supplementary document may be included in both places.

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