Educational Certification System Framework based on Blockchain Technology

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Abstract

Blockchain is a revolutionary technology that enables the creation of a decentralized environment, which serves as an immutable ledger. It provides a public infrastructure for building decentralized applications. Blockchain-based applications that are used in a wide variety of sectors ensure transparency and trust between all parties involved in the interaction. Therefore, blockchain technology is applied to the educational certification system to enhance the higher educational process. The proposed framework aids the educational credit records and academic certificates that can be transferred digitally to create a globally trusted among all stakeholders such as universities, companies, other educational institutions, and organizations. By applying blockchain technology, the first achievement of the proposed framework more trust, transparent and reliable services for credit transfer and *industry relationship*. Moreover, this provides distributed storage, security, and traceability, to efficiently monitor the student assessment data can be traced anytime anywhere and support the trusted higher education system between all institutions and universities linkage.

Keywords: blockchain technology, immutable ledger, stakeholders, certification system

1. Introduction

The blockchain is an emerging technology that provides significant benefits to disrupt traditional products and services due to its unique features including decentralization, security, reliability, and data integrity in nature. It has been applied in the fields of global finance, judiciary, commerce, health care, and education sectors. As we all know, only a small number of higher education systems have applied blockchain Blockchain technology is using technology. in educational institutions include the award of certifications. management of student records, credentials verification, intellectual property

management, automatic credit transfer, and student payments.

In the current challenge of the higher education system, universities store their educational data in one place in the form of central repositories. Issues of the centralized system are a single point of failure and security. Moreover, universities have to provide data to various outside stakeholders like companies and other educational institutions. Student credit transfer and share academic certificates need to trust between the university and outside stakeholders. To overcome this problem, an emerging technology called blockchain offers features like decentralized, transparent, and tamper-proof data storage. Overall, blockchain technology can be applied to record academic student evaluation data with a distributed ledger storage form. Theoretically, blockchain can solve the problems of information asymmetry and trust among strangers because of its decentralized distributed database which protects secure information. Each block contains the hash value of the previous transaction block and ensures the data traceability on the chain of the block. Therefore, blockchain is a strong technology that supports significant benefits for the higher education certification system. The main contributions of this paper are as follows: (i) develop the design scheme for Educational Certification system based blockchain technology (ii) prevents the fraud activities in educational recorded data that is stored in a distributed decentralized and immutable ledger to guarantee tamper-proof and data audit ability.

The rest of the paper is organized as follows. In Section 2, an overview of related work is discussed. Section 3 presents the traditional certification problems in the higher education system. This paper introduces the technical background theory in Section 4, followed by the proposed system based on blockchain architecture for the educational certification framework in Section 5. Finally, Section 6 is presented the conclusion of the paper.

2. Review Works

In this section, we will review the blockchain technology is applied to education in many innovative ways for various purposes. Therefore, some of these few studies of the education field are briefly summarized below.

Turkanovic M. et al.[7] (2018) proposed a global higher education credit platform, name EduCTX based on blockchain technology. The EduCTX system used the tokens to enable the transfer process. These tokens depend on the completed course for the student has gained the credits. Therefore, it led to creating a globally trusted, decentralized educational credit system for the higher education organization.

According to Palanivel k [11] (2019) proposed a blockchain architecture to e-Learning solutions in higher education systems. The proposed PETs architecture based on blockchain technology which uses the cryptography techniques and distributed consensus algorithms to offer security, reliability, immutability and global ecosystem to create a global trusted higher education system. Moreover, Wenshuang Z. et al. [12] (2018) presents a design scheme for the student ability evaluation system based on blockchain technology, which apply the clustering algorithm to analyze a student ability and an overall blockchain technologybased system architecture, which provides possibilities for creating an ecosystem of student capacity evaluation that highly support the trusted for the future.

Abhishek S. et al. [1] (2018) introduced a blockchain-based framework for a decentralized credit system to create a global trust platform in educational systems. This system leads to a globally efficient, simplified and ubiquitous environment over traditional centralized databases. It worked on a homogeneous network and provided easy access to credit transfer of a student from one university to another.

Authors in Reference [3] (2018) introduced the Ubiquitous learning (U-learning) system. This system provides a collaborative learning environment for students with any time/anywhere learning based on blockchain to support a high level of security. Thus, U-learning has an interactive multimedia system to encourage an efficient and effective communication learning system among educational stakeholders.

To the best of our knowledge, the proposed educational certification framework with blockchain is an appropriate technology for easy and efficient verification of the academic certification between the participating of the higher education system.

3. Traditional Certification Problems

Every university in Myanmar has its own educational record-keeping system to manage its grading and transcripts of the student. These records have been stored in a centralized database system. These traditional databases are not secure, which can be changed by internal officers and hacked by students intentionally. Moreover, the centralized system is not transparent to the employer. If an employer wants to evaluate the applicant's academic transcript, the university produces hard copy form. These printed transcripts are not integrity guarantees for their company. To verify the certificate data, employers need to trust the intermediaries involved in the certification process.

The next problem of the traditional certification system is further study in a foreign country. When a student applies a scholar in a foreign university, his/her transcript may need to be verified by their university. If the transcript of an apply student is not consistent with the grading system of the further studied university, the student may need the recommendation of the professor who is involved in the university process. A paperbased process evaluation is complicated and timeconsuming. Moreover, the traditional certification system leads to document fraud (alteration of legitimate credentials such as modification of name, fake logo, degree, serial number, etc.), institutional fraud (university admin creates the illegitimate document) and diploma mills (fictitious universities produce the fake certificate).

To solve these mentioned problems, the blockchainbased educational certification system is introduced. In this emerging blockchain technology, the student grading, transcripts, and certificates record on the decentralized distributed ledger, the stakeholders such as universities, companies, other educational institutions, and organizations can access this data globally on the internet. The distributed ledger storage system is immutable; the academic record cannot alter because these recorded data are stored on multiple nodes in the peer-to-peer (P2P) network at the same time. Moreover, the blockchain-based educational certification system saves time and money while the education records are reliable and accessible anytime/anywhere from the internet.

4. Background Theory

This section presents blockchain technology, the basic concept of blockchain and the features of blockchain technology followed by a type of blockchain.

4.1. Blockchain

Blockchain refers to the data storage which uses an innovative data structure and blockchain technology refers to the mechanism or methods, computer programs, architecture, and networks that maintain the blockchain [5] [9]. Blockchain is the revolutionary technology behind crypto currencies like Bitcoin, Litecoin and Ethereum. The design of blockchain technology based on digital currencies exchange can replace the need of third parties such as a bank, broker to ensure trust and security in the transactions. The global economy transforms into blockchain technology due to increase ability of transparency and trust. A blockchain is an unhackable technology because of a distributed ledger transaction. The contents of the transaction are verified and agreed upon by a network of the system. A blockchain network is a network of computer nodes over the internet who make the transactions are recorded into a series of blocks that give unique hash code of when what and who did. Then, the newly created block broadcast to other nodes in the blockchain network. Unhackable blocks of information are secured by complex cryptographic algorithms (e.g, SHA256) that are applied to ensure the security that is hard to hack and cannot be manipulated.

A more precise definition [2]: The blockchain is a distributed database that provides an unalterable, (semi-)public record of digital transactions. Each block aggregates a time stamped batch of transactions to be included in the ledger. A cryptographic signature identifies each block. These blocks are all back-linked; that is, they refer to the signature of the previous block in the chain, and that chain can be traced back to the very first block created. As such, the blockchain contains an un-editable record of all the transactions made.



Figure 1. Blockchain sturcture

Blocks are chained is cryptographically linked chain to the previous block, someone difficult to change a block of the blockchain thus providing immutable. When the new data are added to the blockchain, participants in the network approve the transaction is valid, making consensus about it validity. Therefore, blockchain ensures the tamper-proof, robust and reliable service between the various types of stakeholders. The benefits of blockchain, as a decentralized architecture applies from global finance to other fields including healthcare, education, digital asset management, voting system and crosses border trading.

4.2. Features of Blockchain

Blockchain is a new technology that is used in different sectors to improve the traditional business model. Many industries have already improved their businesses significantly by using the key features of blockchain technology [8]. The key features of blockchain are used to solve the traditional education certification problems that are discussed in the following:

• *Decentralized*: In blockchain technology, there is no centralized data storage or no single authority of the overall network. While everybody in the network has a copy of the blockchain database is stored in him/her, nobody can modify any block of the blockchain. If someone modifies the block, the hash code will change. The other users in the network compare their copy of blockchain with the modified one. If it does not match, this modified block will be discarded from the blockchain network.

• *Transparent:* Blockchain creates a highly transparent decentralized server that uses a distributed network or a peer-to-peer network. Any transaction between two users which allows all of the participants in the network can be visible. All participants can see who did what changes on the network. Therefore, blockchain can provide traceable storage all of the transactions. Moreover, Blockchain enables to approve the transaction consensus all participants in the network.

• *Immutable*: Data in the blockchain is tamper-proof, once the data is recorded in the blockchain it is immutable [6]. If someone tries to change data, all participants in the network can see this change of block. No one can be altered or changed. Blockchain prevents the dishonest ability and keeps integrity due to immutability.

• *Trust*: Blockchain has achieved the trust between the participants in the network that uses the peer-to-peer (P2P) protocol. Blockchain is no need to trust the third-party organizations to facilitate the transactions because blockchain technology uses the proof of work methods.

• *Smart contract*: When a smart contract runs on a blockchain, it runs exactly as programmed without any possibility of fraud or third-party interference and downtime [4]. A Blockchain-based a smart contract acts as the lawyer and also processes of proof of work or proof of authority. Therefore, a smart contract reduces the need for a trusted intermediary to make the trusted agreement between the processes or tasks. The proof of process is made by digitally enabled or on the digital platform.

4.3. Types of Blockchain

Blockchain systems can be categorized as three main types are (i) public blockchain (permission-less) (ii) private blockchain (permissioned) and (iii) consortium blockchain (permissioned).

(i) *Public blockchain*: This type open to the public and everyone can join the network without permissions. A public blockchain is a fully decentralized network because there is no control by a single organization. An example of a public blockchain is the Bitcoin blockchains.

(ii) *Private blockchain*: This enables only chosen users to join the network, as a distributed form but is controlled by a centralized network. In this private blockchain, read privilege is granted to a chosen user group and write privilege is controlled by the central point.

(iii) *Consortium blockchain*: Consortium enables a preselected group of users to take the responsibility of a distributed consensus process to validate transactions. This does not grant the write privilege to the central authority, but the consensus process is granted to the selected group of users in the distributed network.

5. Proposed System

In this section, the system overview of blockchain based education system and the design of proposed educational certification system framework are described.

5.1. System Overview

The proposed system uses a decentralized and distributed peer to peer (P2P) network where the student credit data is stored in the form of transaction blocks. The "transaction" is the record of the students' score and evaluate the students' ability in the blockchain structure will be distributed to every node in the network to ensure the operation process of the student ability evaluation result is open and transparent and cannot be modified with. The student ability evaluation record is stored to the blockchain as "transaction" to enable stakeholders such as students, employers, and other institutions. Therefore, the students' information is queried at any time and in any place.

In this system, four participating user groups will be involved in the blockchain network. These are host university groups, other educational institutions, employers/companies, and students. Host university group who grant authority of academic certificate, the authorized university has one or more stakeholders. These are instructors, registrar and authorize persons of the host university. The instructor defines the grading schemes for his/her courses. These grading schemes verified by authorized persons. These are the academic principles/rules that can be turned into a smart contract code that automatically calculates and updates the total course grade into the blockchain. This blockchain transaction grade is produced as the academic transcript to the students. If a student transfers the other university, the course grade record is useful for approved the applied university. If a student attends s class to another university, he/she has completed some pre-requisite course. The home university transfer credit to another university.

The next case is the student applies for the job, employers or other organizations/companies need to verify the certificate of the student. The home university shares the data as a distributed ledger which can be viewed by employers. For privacy reasons, the student grants the view authority with a transaction ID to the employer. Then, employers verify the academic record of students using this transaction ID. Figure 2 is the deployment view of the educational certification framework using blockchain technology.



Figure 2. Deployment view of educational certification system

5.2. Blockchain based Educational Certification Framework

In this section, the proposed framework design is described. There are four layers is provided in this framework.

Layer 1 is the front-end service layer. Three application services are provided in this layer.

(i) *Student Data Management application*: Instructors can define a grading scheme, assessment rules by using this application. Instructors can also view a student's transcript and certificate from this application. By using this application, the registrar and dean of the host university can approve the student assessment and grading score.

(ii) *Customer application*: Students can view the grading data, transcript and certificate from this application. Moreover, the student can grant viewing approval to the employers who request his/her transcript.

(iii)*Requester application*: The employers or other educational institutions request the student grading and certificate data from this application. When the request is granted, the requester can view the student data.

The stakeholders can directly interact at this layer and necessary information related to student evaluation results is accessed from these application interfaces.



Figure 3. Proposed Educational Certification System Framework

Layer 2 is the blockchain service layer. This layer is an important layer of the proposed framework. This layer is provided the blockchain services such as cryptographic service, distributed ledger, auditing services (proof of work) and smart contract service.

(i) *Cryptographic service*: The service calculates a unique hash code for the blockchain transaction by using the secure cryptographic algorithm. This service enhances the security and integrity of data between the linkages of the transaction.

(ii) *Distributed ledger service*: The blockchain will be distributed to the appropriate node of a dedicated network. These nodes are used for receiving encapsulated "transactions" from the application layer, and verifying the "transactions" for "proof of work" and "proof of authority". Blockchain is used to store all "transactions", that is student grading data. To enhance the reliability and traceability of the student educational process, the node of the system includes relevant education departments. All of their relevant departments can check the information released by the system at any time, and enhance the reliability and high trust of the student evaluation system.

(iii) Auditing services (Proof of Work): The main service of blockchain technology is proof of work that is relied on the unique hash-based consensus algorithm to validate the blockchain transaction. To confirm the transaction, this service extracts the appropriately authorized users who can operate the system. In a blockchain-based educational certification system, instructors, department head, registrar and dean of the university are actors who are an authorized person for creating and confirming the educational record.

(iv) *Smart Contract*: A smart contract refers to a set of institutional principles, legal rules, and conditions between two or more organizations that make the trust agreement without third party intermediate. In the proposed educational certification framework, smart contract rules are credit rules for course completion, award degree requirement rules and authorized rules to participate in the system. The below diagram is the smart contract rules for the educational certification system.

Table 1. Smart contracts in Educational Certification System

Smart contracts	Descriptions
Course	Exam, Assignment, Project, Tutorial, Presentation
Degree Program	Pre-requisite course requirement, Internship program, other competition
Authority	Access control policy

Layer 3 is the data storage service layer. This layer is stored the education records of student data in the distributed database form. These storage data may be structured or unstructured data.

Layer 4 is the infrastructure service layer. This layer provides the physical infrastructure for communication with the blockchain network. The relevant protocols are supported in this layer for the seamless transaction between the blockchain nodes.

The proposed system architecture covers the higher education system. This architecture may be required real-time data control to management the movement of data. In the future, we will consider the real-time data consistent algorithms are applied in the system to manage the data.

6. Conclusion

This paper introduces the blockchain-based educational certification framework to overcome traditional certification problems. The blockchain technology is appropriated on educational processes due to proof of work, smart contract and tamper-proof key features of blockchain. Moreover, this paper presents the proposed blockchain based educational certification system framework including proposed system design and related processes of academic certification record data stored on the blockchain network. In the future, the proposed system can be developed by applying not only for the academic certification process but also other related processes of education system such as online education process, the financial transaction of student payments records, tracking intellectual property and copyright records, etc..

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