

# Management of Online Education Based on Blockchains

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**Abstract**—With the rapid development of network technology, online education becomes indispensable to the whole education system, which has been paid an increasing attention to by various education institutions, but the management of online learning process, certificates or other data is still far from perfection. To solve these problems, the paper proposes to use the blockchain technology in online education, which is conducive to the management of educational resources, student data, certification of students' achievements and students' employment. By means of public blockchains and private blockchains, the learning users, education institutions, education regulators and the talent markets can make direct communication with each other as different nodes on the blockchain, which can promote the healthy development of online education.

**Keywords-management; online education; blockchain**

## I. INTRODUCION

With the rapid development of network technology, online education becomes indispensable to the whole education system, which has been paid an increasing attention to by various education institutions. As the online education can take place anytime and anywhere on the condition that computers or mobile devices are available to make an online educational scenario, it has become more popular when the world is now affected by the rampant COVID-19. Many schools have offered online courses to the students, so they can continue their learning at home, reducing the possibility to be infected. In addition, “It (online education) has become an effective way to share high-quality educational resources among the public and encourage self-learning”<sup>[1]</sup>. For example, the MOOCs (Massive Open Online Courses) are now very popular among the students. As the various course materials will be easily converted into visualized ones suitable for mobile devices, it can be safely foretold that “the future of online education will incorporate advances in artificial intelligence to the point that a course will be able to dynamically adjust teaching methods to best suit each individual student”<sup>[2]</sup>.

However, there still exist challenges for online education. For example, “In an online test-taking environment, it is much harder to verify students are not cheating, simply because it is not possible to truly know if something or someone else is assisting them during the exam”<sup>[3]</sup>. The verification of students' online learning process, certificates or academic achievements is still far from perfection, and the infringement of copyrights and fraud in certificates or qualifications cannot

be completely prevented. In addition, it is hard to keep the safety of students' archives, staff information and other relevant education data. Faced with these challenges, education institutions have tried hard to find ways out. Very disruptive, the blockchain technology can help a lot in the storage, security and sharing of online education data. In nature, the blockchain is a new internet technology based on distributed ledgers to store, verify, transmit and exchange data without the intervention of third parties. Each ledger maintains the security, accuracy and authenticity of the information by satisfying a consensus mechanism. When a new block is produced by a node, it will be broadcast to the whole chain and certified by all the nodes.

Though the blockchain technology has been successfully employed in business transaction, such as Bitcoin, Ethereum, and Zerocash, its use in online education is still in infancy. Therefore, there are no mature application cases of blockchain technology in the management of online education, and there is no direct theoretical support either. This paper aims to make a preliminary study of blockchain technology in the management of online education, proposing some design schemes of blocks. The remainder of the paper is organized as follows. In section 2, we summarize the features and advantages of blockchain-based online education, especially their distribution, decentralization, security and authenticity, etc. In section 3, we mainly probe into the network structure designs and block architectures about the management of online education. Finally, we conclude our work with a summary of the paper and the prospect of blockchain technology in online education.

## II. FEATURES AND ADVANTAGES OF BLOCKCHAIN-BASED ONLINE EDUCATION

Different from the traditional online education, the blockchain-based education can ensure the equality between learners, educators, education institutions and the other parties. By means of timestamp and encryption algorithm, it can also ensure the authenticity of online learning and prevent the cheating and tampering with the relevant data. Therefore, we can say that the blockchain-based online education can ensure an ideal effect and direct communication between the nodes on the blockchain. Though the blockchain technology has not been widely used in education, its debut in the management of online education is enlightening and far-reaching, as the blockchain-based online education has its special features and advantages.

#### *A. Features of Blockchain-based Online Education*

The blockchain is based on distributed databases, which are linked together to form a network of different blocks. These blocks are chained chronologically. The blockchain technology is mainly characterized by the decentralization, transparency, anonymity, traceability and immutability of network data, so it provides a new paradigm for the execution and management of online education, and makes the online education have such special features as follows:

- All the data supplied by education institutions, educators, learners and other parties will be recorded with timestamps. These timestamps preserve a chronological order between these data, showing their logical relationship and the exact time when they are generated. These data with timestamps can faithfully record the online activities of all parties involved, ensuring the authenticity of learning process, relevant certificates or the qualifications of learners.
- The blockchain of online education is made up of distributed structure. This type of structure adopts decentralized protocols to ensure a complete record and storage of data, so all the information exchange between the nodes will be broadcast to the whole blockchain. “In this structure, the trust between distributed nodes is built through mathematical methods rather than the centralized organizations”<sup>[4]</sup>. The information of a node cannot be easily tampered with, as it is already distributed to all the other nodes on the chain and all the nodes will sync their ledgers. “Only when 51% nodes are controlled, can the data on the blockchain be modified or deleted. If the information of a node is changed, it will be found out by all the other nodes on the blockchain. In view of this, the information of each node is supervised by all the other nodes on the blockchain”<sup>[5]</sup>.
- The data on the blockchain adopt asymmetric cryptographic algorithm. The asymmetric cryptographic algorithm is a kind of encryption method, which helps a node generate pairs of keys, public keys and private keys. The public keys are broadcast to all the other nodes on the blockchain. If we use a public key to encrypt a document, we have to use the corresponding private key to decrypt it. Therefore, when Node A sends a document to Node B, it should encrypt the document by using the public key sent by Node B, and then Node B can decrypt the document by the corresponding private key. If Node B wants to send a document to Node A, it should do a similar thing. In addition, Node A can create a digital signature on a document by using its own private key and send it to Node B, and then Node B can verify the signature on the document by using the corresponding public key sent by Node A. The data exchange of blockchain-based online education is dealt with in such ways.
- The data exchange online complies with smart contracts. The concept of smart contract was first put forward by Nick Szabo in 1995. A smart contract is an agreement of commitment, which is formulated in digital form. These digital smart contracts have to be written into the readable codes of computer so as to be automatically executed by computers when the pre-set requirements are met. Actually, a smart contract is a kind of computer protocol, which is transmitted, verified and executed in an informationized way. In addition, a smart contract is conducted without the intervention of a third party, and the transaction is traceable and irreversible. With these smart contracts, all parties of online education maintain an equal status and unmediated communication.
- All the activities of online education comply with consensus mechanisms. As a chronologically data-stored structure, the blockchain supports different consensus mechanisms, which constitute an important component of the blockchain technology. A consensus mechanism is an algorithm used to reach a consensus of the chronological online data in a certain period of time, making all the nodes keep consistent with each other. Each node, to maximize its benefits, usually abides by the pre-set regulations to ensure the authenticity of records, which are broadcast to whole blockchain. Based on consensus mechanisms, the blockchain technology utilizes a mathematical algorithm to build trust among the network nodes without the intervention of third parties. In addition, consensus mechanisms maintain the smooth operation and fairness of the blockchain, unify the blockchain version, reward the users who supply helpful resources, and punish the malicious users.
- The user nodes on the blockchain have their own particularity. Though the nodes on the blockchain are all equal, they have different roles, as education has its own specialties. The role of education institutions is mainly to carry out the teaching plans, management of teaching process and evaluation of teaching effect. The role of learners is mainly to choose online courses and finish the learning tasks or assignments. Therefore, “Due to the particularity of the educational process, the user nodes in the network need to be separated into at least two different roles, which are educators and learners, respectively”<sup>[1]</sup>.

#### *B. Advantages of Blockchain-based Online Education*

The distributed, decentralized, secure and authentic features of blockchain are realized by the distributed data storage and collective maintenance across the network. All information exchanges are stored in blocks with hash keys linking with the previous blocks and the following. Tampering with any information of a node would result in a different hash value, which will be detected by all the other nodes by keeping the same validation algorithm. Each node keeps a complete storage of online data, and each node is independent. Besides, all the nodes keep consistent with each other by following a consensus mechanism. With these features, the blockchain-based online education is superior to the traditional one, which is mainly expressed by the following advantages:

- All the data are immutable. The information of online education is datafied and distributedly stored in various ledgers with timestamps to form blocks, which are chronologically chained. Accordingly, these data are immutable. “If any fraud happened in a node, it would always be detected, so nobody dare make false accounts at the very beginning”<sup>[6]</sup>.
- All the data are secure. By means of timestamps, asymmetric cryptographic algorithm, distributed ledgers, smart contracts and consensus mechanisms, the information exchange of online education enjoys a great safety. Thus, it ensures the authenticity of the learners’ learning process, certificates and qualifications.

- All the data are traceable. In blockchain technology, “Traceability means that all transactions on the blockchain are arranged in chronological order, and a block is connected with two adjacent blocks by the cryptographic hash function. Therefore, every transaction is trackable by examining the block information linked by hash keys”<sup>[4]</sup>. The timestamps, smart contracts, consensus mechanisms and asymmetric encryption algorithm for digital signatures ensure a correct chronological order of the data, getting them linked by hash keys. All data are endowed with hash value respectively, so by pressing a hash key, we can find the detailed information linked to it.

- All the data are anonymous. Due to the encryption algorithm for digital signatures, the data are transmitted by means of pairs of public keys and private keys, without disclosing the node identities. The nodes on the blockchain, educators or learners, are completely invisible in the process of information exchange. Therefore, the blockchain-based online education can also ensure the fairness of education.

### III. MANAGEMENT OF BLOCKCHAIN-BASED ONLINE EDUCATION

Against the background of education informatization, most paper data, such as the students’ archives, students’ achievement management, staff information, teaching materials, have been transformed into digital ones stored in various hard disks or networks. With the informatization of educational

facilities, system and environment, the traditional online education cannot ensure the safety of massive online data. Therefore, the management of online education, especially the management of relevant data, is an important work for educational institutions. The blockchain-based online education is an effective way to store and share these online data, and ensure their security. So far, the blockchain technology has been used by some educational institutions. For example, the Sony Global Education has adopted the blockchain technology to safeguard its copyrights. On the blockchain, the educational resources are distributedly stored for public sharing. The learners’ data, such as education experience, work experience, online learning activities and course assignments, can all be safely shared. The sharing of these data also benefits the educational institutions in optimizing the curriculum design, credit system, and teaching evaluation.

There are three basic concepts in the blockchain-based online education, account, wallet and transaction:

- Account. The account is a series of binary digit representing an entity on a blockchain. That is to say that the immutable series of binary digit is the address of the entity. To open an account on a blockchain does not demand the personal information of its user, so the privacy of users cannot leak out<sup>[7]</sup>. The address of an account is got by using the private key of asymmetric cryptographic algorithm, which is shown by Fig. 1:

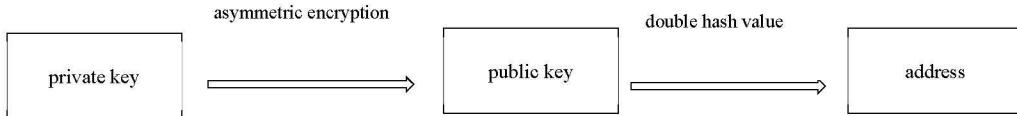


Fig. 1: The address production of an account

As is shown by Figure 1, by asymmetric cryptographic algorithm, a private key can produce its corresponding public key, which is then encrypted to produce a different hash value. The hash value is the address of an account. The production of an address is a unidirectional and irreversible process.

- Wallet. On the blockchain, a wallet can hold many

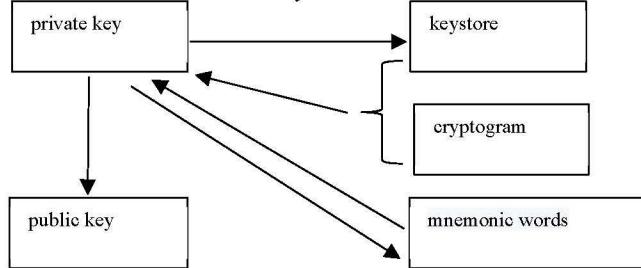
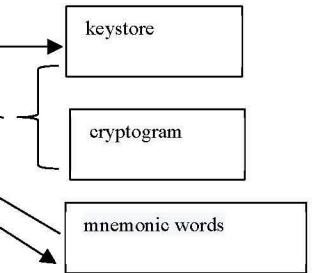


Fig. 2: The working process of a wallet

A private key is a random string. A public key is produced from its corresponding private key by means of encryption algorithm. The mnemonic words refer to a dozen of common English words which are translated from the private key through special algorithm. When an account is set, the mnemonic words will be produced, which should be saved for later use. The keystore is also a string, which in nature is a kind

of accounts. Actually, in a wallet are the users’ pairs of keys, private keys and public keys. The wallet is a kind of management tool of keys. The private key is used to produce signatures on transaction data, and the public key is used to produce the address of an account<sup>[7]</sup>. The working process of a wallet goes as Fig. 2:



of encrypted private key. Using the keystore and cryptogram, we can get the private key.

- Transaction. On the blockchain, any two nodes can make transaction with each other if they both have wallets and sufficient balance. Direct transaction between the nodes constitutes a salient advantage of blockchain technology. The transaction process can be shown by Fig. 3:

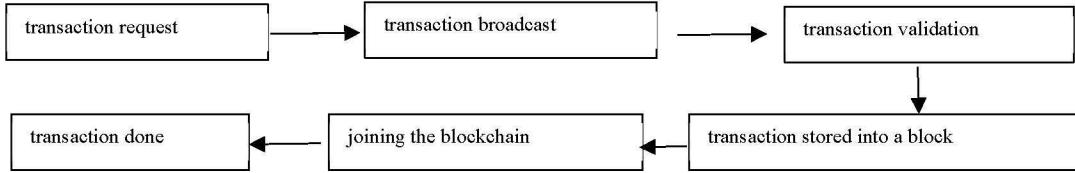


Fig. 3: The transaction process

A node requests a transaction via the wallet. The transaction will then be broadcast to all the other nodes on the blockchain network. Every node will validate the transaction according to a specific consensus mechanism. After that, the validated transaction will be timestamped and stored in a block with a hash value. Then, the block will join the blockchain when the other nodes validate the correctness of the block. By then, the transaction is done and become a valide component of the blockchain, which cannot be changed in any way.

When the account and transaction tools get ready, a node on the blockchain can do business with the others. By now, in the education field the blockchain technology has been used to ensure the authencity of the students' academic performance

and certificates. "After the blockchain technology entered the education field, the bitcoin became popular in schools. Some universities have set up bitcoin ATMs and some university stores have begun to accept the payment by bitcoin. Actually, it is necessary to let the students know about the digital currencies as soon as possible, as they may get involved in this field after graduation, with the increasing application of digital currencies and blockchain technology"[8]. The application of blockchain technology in online education is conducive to the management of educational resources, student data, certification of students' achievements and students' employment. To do this, we combine the public and private blockchains together, including learning users, education institutions, education regulators and the talent markets, and design a blockchain network as Fig. 4:

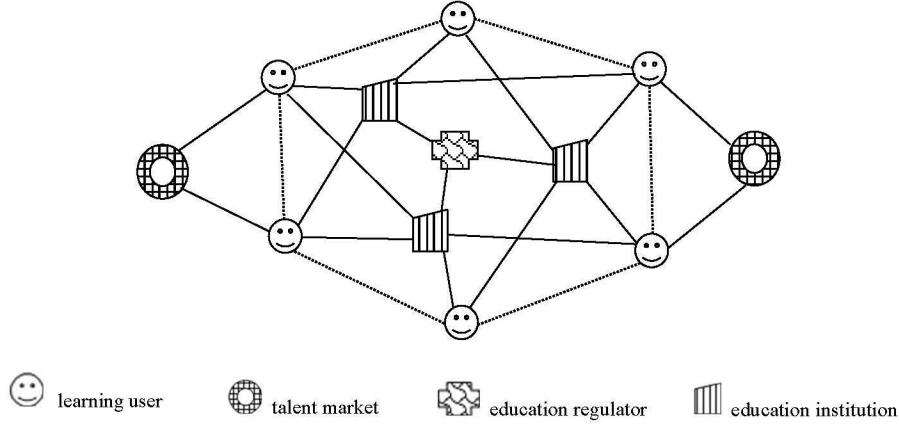


Fig. 4: The management blockchain network of educational resources

#### A. The Learning Users

The learning user refers to anyone who wants to learn online through the blockchain network. They should first apply for an account and join the network as nodes of the blockchain. Then, they can use the wallets and other transaction tools to make data exchange with the other learning users, education institutions, education regulators, talent markets, etc. In terms of learning resources, they have strong subjectivity, as they can independently choose the online courses they like or need. In terms of learning mode, they can communicate with the educators, and the other learners as well. By means of information exchange with the other nodes on the blockchain, all the data about the learners' learning process, academic performance, certificates and qualifications will be preserved in the blockchain and shared by all the nodes.

After finishing the study of online courses, learners can submit to education institutions certification applications, which may contain all the course requirements, such as

homework, test answers, report videos, or course papers. Then, the education institutions will check whether these learning records and other relevant materials are true. When these records and materials are validated and considered to meet the requirements of the courses, digital certificates will be issued and signed by the education institutions with timestamps and hash value. With private keys, learners will encrypt (or sign) again the hash value of the valid digital certificates which they receive. The original valid digital certificates with learners' signatures constitute a new block of digital certificates. The digital certificates with double digital signatures will be preserved permanently in the public blockchain. The learners can use these certificates and relevant data to show their learning experiences or to apply for a job on the blockchain network.

#### B. The Education Institutions

There are many online educational resources offered by various education institutions, such as the MOOCs of China's universities, National Digital Library of China, Memrise-

Unlock your language learning superpowers, TED: Ideas worth spreading, etc. However, there are no acknowledged course standards for these resources, and no effective certification either, so it is hard for the learners to make a choice. The blockchain technology can help solve these problems. In addition, to use the blockchain technology in online education can reduce the operation cost and set up a certification and assessment system, which is conducive to the development of online education.

In terms of teaching management, education institutions can use the blockchain network to deal with all the things with teachers, learners and teaching activities, such as online consultation, enrollment, paying tuition, course-choosing, learners' archives, course assignments and tests, and faithfully preserve them in the blockchain permanently. In addition, "Integrated technologies might even be utilized to combat issues such as plagiarism and academic conduct"[2]. The education institutions can incorporate the blockchain technology into the overall academic management, so as to ensure the openness and transparency of the students' archives. With the advantages of blockchain technology, the education institutions can also set up talent banks, and store the information about their faculties, scientific research, academic activities and open classes in the distributed ledgers on the blockchain. For example, the Zhongnan University of Finance and Economics of China and the 21 Vianet Group have co-developed an Integrated School Blockchain based on the platform of Windows Azure, which can help the colleges and universities record the students' academic achievements at school.

An education institution will have a unique pair of public and private keys by the key generator when joining the blockchain network. After the public key of the education institution is generated, it will be broadcast to the blockchain for further verification. The education institution encrypts the hash value of the digital certificates or other documents by using the private keys, completing the digital signatures. The signed certificates or documents together with the confirmed original information constitute new blocks. These new blocks with double digital signatures will be broadcast to the whole blockchain. All the nodes on the blockchain will reach a consensus, and then these new blocks will be added to the public blockchain.

### C. The Education Regulators

There are education regulators of different levels, national, provincial or local. These regulators usually consist of education administrators, experts in curriculum and discipline, experts in educational technology, instructors and researchers. They may have different responsibilities. Some regulators mainly supervise the vocational education, some mainly supervise the elementary education, some mainly supervise the secondary education, and some mainly supervise the higher education. All of them can join the blockchain network as different nodes, and supervise the teaching contents and relevant activities. In virtue of the blockchain network, they can perform their duties anytime and anywhere. They can supervise such things as the credibility or legality of the certificates of courses, online learning experiences, academic diplomas, vocational skills, vocational qualifications, honors and awards,

etc.

### D. The Talent Markets

In modern society, the talent markets play an important role. They are conducive to the reasonable allocation of the different types of talents, which promotes the talent flow. They are conducive to the talents' independent choice of their preferred vocations without any restraint or constraint. Dealing with the supply and demand of talents, they are conducive to scientific understanding of the social change. In addition, the improvement of talent markets is conducive to the improvement of socialized service system. Traditionally, the talent markets should collect the paper data about the talents' personnel archives and take care of them. And sometimes they should transfer these personnel archives to other talent markets or employing institutions. On most occasions, there is no direct communication between the talents, the employers and the certification of the talents' qualifications.

With the blockchain technology, the issuance and storage of digital certificates or other data are implemented in the private, public and consortium blockchains, which ensures the openness, credibility, transparency of these data and the certification process, as well as the direct and unmediated verification of digital certificates for employers or other third-parties from the talent markets. The agents of talent markets can join the blockchain as nodes with the invitation from the learners or education institutions. According to the public data on the blockchain about the learners, the agents can easily find the exact talents they need, and make a direct communication with them. Thus, the supply of talents and the demand of employers can reach an exact connection, which promotes the development of students, the cooperation between schools and enterprises and the integration of vocational education with industry.

## IV. CONCLUSIONS

In this paper, we point out the problems of traditional online education and the advantages to use the blockchain technology in online education. To better and more effectively manage the online education, we propose a blockchain-based network, which not only solves the problems of traditional online education, but also shows its great potentiality in the future educational informatization.

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## REFERENCES

- [1] Guo, Junqi et al., Blockchain-enabled Digital Rights Management for Multimedia Resources of Online Education, *Multimedia Tools and Applications*. 79 (2020): 9735–9755. <https://doi.org/10.1007/s11042-019-08059-1>.
- [2] Cook, C. W. & Sonnenberg, C., Technology and Online Education: Models for Change, *ASBBS eJournal*. 10 (1) (2014): 43-59. <https://doi.org/10.19030/cier.v7i3.8638>.
- [3] Kirkpatrick, K., Technology Brings Online Education in Line with Campus Programs, *Communications of the ACM*. 58 (12) (2015): 17-19. <https://doi.org/10.1145/2834055>.
- [4] Chen, Guang et al, Exploring Blockchain Technology and Its Potential Applications for Education, *Smart Learning Environments*. 5 (2018): 1-

10. DOI 10.1186/s40561-017-0050-x.
- [5] Wang, Menghao et al., Research on the Application of Vocational Education System Based on Block Chain Technology, Adult Education. 6 (2020): 28-34. DOI: 10.3969/j. issn. 1001-8794. 2020. 06. 006.
- [6] Huang, Shao'an & Liu, Yanghe, The Institutional Attributes and Multiple Institutional Functions of Block Chains, Tianjin Social Sciences. 3 (2020): 89-95. DOI: 10.16240/j.cnki.1002-3976.20200528.001.
- [7] Fan, Lingjie, *Self-Study •Blockchain: Principles, Techniques and Application*, China Machine Press. 2019.  
<http://github.com/flingjie/learning-blockchain>.
- [8] Wu, Wei, *Block Chain Practice*, Tsinghua University Press. 2018.  
<http://www.wqbook.com>.