Exploration & Research on Distance Education System Based on Blockchain Technology

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Abstract. In this paper, it mainly explores and studies the distance education system based on blockchain technology according to the characteristics of blockchain technology, such as “decentralization, de-trust, non-tampering and traceability”, etc. First of all, it designed a multi-layer logical structure; Second, it proposed an improved DPoS consensus mechanism; Third, it analyzed the generation steps of the blockchain in the system and the functional process of the consensus mechanism. As a result, by using the distance education system based on blockchain technology, the distance education centers distributed all over China can not only strengthen the sharing of teaching resources and improve the management efficiency, but also better improve the safety and transparency of their teaching, scientific research and management.

Keywords. blockchain; distance education; logical structure; consensus mechanism; DPoS

1. Introduction
At present, the distance education is China faces many difficulties due to the huge land area and large number of participants. We all know that there is a distance learning center (or Open University) in every province, city and autonomous region, as well as many small distance education centers (or branches of Open University) in the regions and counties of jurisdiction. As a result, each distance education center establishes its own distance teaching resource library and software platform, while these platforms are connected through the Internet to form a multi-platform and multi-center structure for students to access teaching resources online. However, there are several prominent problems of this structure. Firstly, student information is chaotic. Their school roll and learning process information are stored on different platforms and cannot be unified. Therefore, it is difficult to manage and use these information and guarantee their safety. Secondly, there is a huge number of curriculum resources, with the problems of repeated construction, copying and piracy. Thirdly, the enterprise cannot effectively verify the credibility of the student information because there is no way to eliminate the data fraud.

Blockchain technology has sufficient application scenarios in the construction of distance education system in virtue of its characteristics of “decentralization, de-trust, non-tampering and traceability”. The details are as follows: The distance education system is combined with the blockchain and its consensus mechanism, smart contract and cryptographic technology to write the student’s learning process from enrollment to graduation as into the block as the basis for graduation and store it in the network node by
taking the block as storage carrier. Moreover, consensus algorithm is used to ensure the credibility of block content, while the student data can be protected with a protection scheme of “timestamp + blockchain”. In this way, it can not only ensure the privacy of student data information, but also realize the access and sharing of data information by different organizations. Therefore, the integration of blockchain technology and distance education can better improve the safety and transparency of teaching, scientific research and management of distance education centers. It is fully applicable to the students’ credit management, entering a high school, employment, academic and qualification certificates, industry-university cooperation and teaching resource management, etc., and is of great value to the healthy development of education and employment, mainly reflecting in the following four aspects:

1.1. It is able to the data volume requirements in the big data technology environment
As everyone knows that China is a huge country, with a large population and uneven economic development. The distance education has a broad market prospect, which can make the students in the central and western regions also enjoy the high-quality teaching resources in the developed areas along the southeast coast. Its large amount of data can fully meet the environment requirements of big data technology.

1.2. Decentralization
There is no centralized central control in the blockchain system. All nodes can partially or fully back up the information in the blockchain and the data loss at any node will not affect the normal operation of the system. Therefore, it is very credible in terms of data storage. Multiple distance education centers can be regarded as equal institutions and there is no obvious center, which can match such decentralized structure very well.

1.3. Collective maintenance
The blockchain system is jointly operated and maintained by all nodes in the network, so the remote education centers distributed in all regions have the responsibility and obligation to participate in the management and maintenance of the system. Besides, there are special personnel arrangement. It is very suitable for this mode of operation.

1.4. Information safety
The blockchain encrypts data with digital signature algorithm and it is jointly authenticated by all nodes in the network. Therefore, it is difficult to tamper with the data of each transaction. This feature can provide a strong guarantee for the learning information, certificate verification and resource protection of a large number of students in the distance education system.

2. Logical Structure Design of Distance Education System Based on Blockchain Technology
Through the inquiry of a large amount of literature and comparative research, this paper analyzed the shortcomings of the current distance education system and designed a distance education system based on blockchain technology that is suitable for large-scale teaching and integrates school roll and academic information management and curriculum resource management. In consideration that Bitcoin system cannot build more advanced applications due to its insufficient expansibility, Ethereum is adopted as the underlying architecture of the blockchain technically to support smart contract[1]. On the basis of B/S architecture, it designed and developed a distance education management system based on blockchain, with many advantages. Firstly, it can store the teaching information (such as school roll, academic degree information and curriculum resource) on the blockchain; Secondly, it can ensure the authenticity and traceability of the data; Thirdly, it can provide a unified query interface to facilitate the employers and users to verify the authenticity of relevant information.
In essence, blockchain is a decentralized distributed database, but it is different from the traditional databases. All data stored on the blockchain exists in the form of transactions. So in order to store academic information data on the blockchain, it is necessary to turn the actual operation into transactions and attach the information to the transaction for storage[2]. In view of the huge capacity of teaching resources and the impossibility of directly storing the contents, such as courseware and videos, etc., on the block, their links can be stored on the blockchain, while the links point to the resources in the resource database. In addition, there is little correlation between student information and curriculum resource information, so it is recommended to store them separately. Therefore, we adopt a three-line structure. The first line is the blockchain used to store student information, the second one is the blockchain used to store teaching resource certification and copyright information, and the third one is used to store and manage the specific resources of distance education. The system designed in this paper adopts a layered architecture, including storage layer, contract layer, big data technology layer, data interaction layer, data service layer and application layer, as shown in Figure 1.

The storage layer stores the blockchain information of student information, curriculum resource and specific teaching resource information, etc. The important information, such as education background, school roll and certificate information, etc., can be recorded on the first blockchain. The curriculum resource can be recorded on the second blockchain. In this way, it can take advantage of blockchain characteristics: non-tampering and traceability of written trace, as well as can avoid data safety and trust issues caused by hacker intrusion or data tampering by the administrator in the traditional centralized database. The specific teaching resources with a large number of contents, such as courseware and videos, etc., can be stored in the traditional database. The links related to resources are stored in the curriculum resource blockchain, which make it possible to access the specific resources in the traditional database.

The contract layer mainly includes various script codes, algorithms and smart contracts, thus realizing the process of information release and registration on the blockchain. Smart contract is an agreement attached to the blockchain in the form of code finally and signed by all project participants with the purpose of performing the blockchain ledger record function[3]. Various conditions for triggering the contract are encapsulated in the smart contract. So once the contract conditions are met, the system will execute automatically without interference from any external factors. Furthermore, the smart contract layer communicates with the blockchain layer via RPC and write data information into
the blockchain through transactions, so as to realize the functions of authentication and inquiry for the blockchain layer data.

The data interaction layer is used to call the API of the smart contract layer in the system through Web.JS, control the writing and reading of data and provide functional interface to the application layer for calling. It is developed with Node.JS, quickly realizes the software framework construction with the help of Spring Framework and Hibernate, calls the contract layer to communicate with the blockchain layer via Web3.js and provides REST API to the application layer for calling[1].

The big data technology layer is realized by adopting Hadoop big data technology. As an open source programming architecture, Hadoop adopts a distributed storage system to clean, store and process massive data. In the Hadoop architecture layer, data is stored in Hive, or HDFS, or HBase, and is read in thousands of nodes through a distributed system. The data processing capability of the big data technology layer are provided to users in the form of service, mainly including three services of the data service layer: (1) Data mining: The big data technology first utilizes data mining algorithm to obtain massive data from the Internet; (2) Statistical analysis: The data service layer conducts statistics and analysis for the data discovered in the process of data mining, thus obtaining the required results; (3) Visualization. The results of statistical analysis are presented in the form of visual report, and the users’ decision analysis is supported in the form of intuitive charts.

The application layer interacts with actual users through a friendly interface, provides specific services, such as the modules of registration and login, school roll recording, evidence collection, curriculum certification, copyright protection, resource management, teaching plan management and accounting management, etc., and communicates with REST API of the data interaction layer in virtue of HTTP protocol[1]. The function of registering and logging in module means that the visitors can log in to the system by means of ID number, password and picture verification code. The study credit record module is divided into the user terminal and the background management terminal. Among them, the user terminal has the permission to view his/her own credit records, while the background management terminal has the permission to view all the users’ credit records, or add the new school roll information for a user, etc. Similarly, the certificate storing and obtaining module is also divided into the user terminal and the background management terminal. Among them, the user terminal has the permission to view the certificates written in the blockchain and submit the application for storing certificate, while the background management terminal has the permission to screen records in the background and participate in the review of storing certificate after receiving the user’s application for storing certificate.

3. Consensus Mechanism Design
Generally speaking, the blockchain should have an efficient and feasible consensus algorithm to solve the trust problem among nodes. Currently, consensus mechanism show a lot of types with the development of blockchain. As everyone knows that the distance education system involves thousands of students and large-scale teacher groups all over the country. If all teachers and students become the blockchain consensus participants of the distance education system, the network maintenance cost of the system will increase greatly, which is not conducive to its effective operation. Therefore, according to the different role characteristics of the objects involved in the distance education system and the network topology structure of each node, only the nodes trusted by the users of the distance education are selected to generate the information block of the system. This is also the basic principle reached by the distance education system consensus based on blockchain. The Delegated Proof of Stake (DPoS) refers to a mode that a small number of authorized nodes are selected by voting from a large number of nodes to generate blocks. It has a very fast reaching rate of data consensus rate (in seconds) and matches the performance requirement of the distance education system. Therefore, it is the first choice for this project.

In fact, DPoS mechanism is similar to board voting. In the blockchain network, all nodes form an alliance and each node in the alliance votes to elect a delegated representative. Finally, the representative with the highest number of votes will become the delegated node, which is responsible
for processing and verifying the transactions among network nodes. The whole consensus process of DPoS mechanism mainly includes the election process of delegated node, the process of generating blocks by delegated node. All delegated nodes are jointly responsible for authenticating the operation of nodes in client terminal, verifying the signature and timestamp of data transactions, and managing and updating the information. Furthermore, the delegated node will store the transactions and data generated by the whole network nodes in the current time period to a block, as well as broadcast this block to the whole network nodes. After the whole network nodes verify the new block, the delegated node will add the new block to the blockchain.

However, there may be a problem of not voting actively when DPoS consensus mechanism authorizes nodes to elect due to the large number of nodes, thus affecting the consensus efficiency. In order to solve the above problem, we have improved DPoS. That is, in view of the reliability and administration authority of the distance education center, we can ignore the thousands of student nodes, the enterprise nodes with large liquidity and difficulty to manage and the education authority nodes with a small number of participants, but only select the the delegated node in the node set of remote education center, thus simplifying this problem a lot. For the education authority notes, enterprise notes and student nodes, the smart contract can be used to complete the required functions. In case of electing and voting the delegated node in the node set of remote education center, the delegated node can exercise the power of agency, perform the generation and verification of block, and solve the problem of the excessive cost of system consensus due to the huge number of nodes. And when selecting the delegated node, the reward and punishment mechanism is adopted to drive all participating nodes to vote actively, and count and optimized the voting result of delegated node, so as to ensure the smooth operation of DPoS consensus mechanism.

4. Generation Steps of Blockchain
The generation steps of consensus mechanism and blockchain are shown in Figure 2. Step 1: All distance education centers jointly form the alliance node to verify and add new nodes; Step 2: Each node utilizes the consensus mechanism to elect the delegated node; Step 3: All alliance nodes jointly develop and participate in the formulation of remote education management smart contract, stipulating the rights and obligations of each participant. In addition, the contract will be translated into corresponding codes, broadcast to the whole network through the P2P network, and transmitted into the blockchain by the delegated node after passing the verification; Step 4: The smart contract checks the data in the transaction database at regular intervals. After the contract conditions are met, it will execute the contract terms and generate the results of executing contract into a new block, and then connect this block to the end of the existing blockchain, thus forming a complete blockchain[3]. Step 5: After the blockchain is generated, it is necessary to issue a request to the blockchain alliance node network when a node needs to add, delete, query and verify information. For example, if an enterprise intends to inquire about a graduate’s graduation certificate and relevant learning information, the enterprise node is required to send its identity, credit and application details to the designated node and broadcast them to the whole network. After the designated node verifies its information, such as identity and credit and so on, it is able to inquire the corresponding block information. After inquiring the relevant information, the inquired content of the block information with timestamp will be sent to the whole network for verification. After checking the information of the nodes in the whole network, the designated node will feed back the obtained information to the requestor node, namely, the node where the enterprise to employ the student is located. As a result, the node can obtain correct information of the student.
5. Functional Design of Consensus Mechanism

The functional realization of the consensus mechanism of the distance education system based on blockchain is mainly divided into seven sub-modules, including node registration sub-module, voting sub-module, statistics sub-module, consensus calculation sub-module, voting result optimization sub-module and production block sub-module.

As the basic operation of the consensus module of the whole system, node registration sub-module is responsible for the basic creation, deletion and modification for the delegated nodes and voting nodes in the network. Voting sub-module is responsible for completing the voting operation of the nodes of the whole network in each round of voting, mainly including three sub-functions: voting yes, voting no and abstaining. Votes statistics sub-module is responsible for counting the number of votes in each round of voting, mainly including three function: statistics of the “yes” votes, statistics of the “no” votes and statistics of “abstaining” votes[4]. Consensus calculation sub-module mainly have two functions: credit value calculation and voting result optimization. Among them, the credit value calculation includes credit penalty calculation and credit reward calculation. Credit penalty for nodes aims to quickly remove the untrustworthy nodes from the delegated nodes. Voting result optimization refers to counting the voting results after voting, so as to generate a new set of delegated nodes. It is achieved by calculating the number of votes according to the status of nodes, the credit value, the number of “yes” votes and the number of “no” votes. Production block sub-module is mainly responsible for the production block, verification and cochain[4]. (1) Production block: The delegated node stores the transactions and data generated by the whole network nodes in the current time period to a block, as well as broadcasts this block to the whole network nodes. Every designated time interval, the delegated node writes the transactions and data generated during this period into the block; (2) Verification: The delegated node verifies the data and block information in the block after receiving the new block that is broadcast. It mainly verifies whether the specific content in the received block is valid, with the judgment basis of receiving approval of two-thirds of delegated nodes in the whole network; (3) Cochain: The delegated node adds the block passed the verification to the blockchain, thus forming a data chain.

6. Conclusion

On the one hand, the integration of blockchain technology and distance education can better improve the safety and transparency of teaching, scientific research and management of the distance education
centers. On the other hand, the distance education centers are distributed all over China. By utilizing the distance education system based on blockchain technology, the students in the central and western regions can also enjoy the high-quality teaching resources in the developed areas along the southeast coast. Moreover, the high and new technology can be applied broadly in the distance education market.

In this paper, it designed the logical architecture and consensus mechanism of the system, but further research is still needed for the design of smart contract and the implementation details of the system.

7. References

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