

Incentive Mechanism of Online Learning Based on Blockchain

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Abstract. Incentive mechanism plays an important role in online education. In order to better play the role of the incentive mechanism, it must rely on contemporary information technology, such as blockchain technology, big data technology and so on. In this paper an incentive mechanism based on blockchain technology is proposed with which can establish a good trust relationship between multiple learning resource nodes and improve data security during the process of online education. A structure of online learning resource chain is proposed in this paper also. And a dynamic optimization framework of learning resource chain by analyzing a series of problems faced in the process of online education is formed. The private chain of learning resource is constructed on the basis of the design of incentive smart contract. The learners and the builders of learning resources can obtain the dynamic rewards by performing a smart method of contract. The experimental results show that the incentive method based on blockchain can well mobilize participants' enthusiasm for resource construction and dynamic improvement of resource quality, and effectively solve a series of problems in the learning process.

1 Introduction

With the rapid development of cloud computing, digital media and network technology, the construction of online digital learning resources has achieved certain results [1, 2]. In terms of quantity, learners have sufficient digital learning resources to learn, but in terms of quality, learners have minimal choice. Guaranteeing the credibility, integrity, data privacy and other issues of digital resources is difficult when users access the resources due to the replicability of data resources, thereby becoming a key problem for the rational sharing of data and the timely updating of resources for resource builders [3]. At present, resource builders and legal resource users have performed some studies on data resource protection. However, no unified credible means is available, which is un conducive to the efficient integration and management of learning data. Blockchain is an innovative application model in the field of computer technology, featuring decentralization, security and autonomy. The most representative innovation of blockchain technology is the chain block structure based on time stamp, consensus mechanism, economic incentive based on consensus algorithm and programmable smart contract [4, 5].

At present, blockchain technology has been applied in different ways, such as public chain, alliance chain and private chain. These methods point out a new direction for the construction of online learning resource copyright protection and resource timely dynamic update.*

This paper continuously explores the application of dynamic construction, real-time update, optimization of online learning resources and resource security access on the basis of the study of blockchain technology and the characteristics of online learning resource construction. An online learning resource construction framework based on blockchain technology is proposed to address the problem that online learning resource builders in university are not motivated enough to optimize and update resources in time. A blockchain-based incentive smart contract is designed on the basis of this framework. The validity of the resources about to be linked up can be verified and the dynamic updating of digital learning resources can be encouraged by running the smart contract program. The access, effective maintenance and real-time data update of specific learning resources are studied on the basis of the cooperative mechanism of private and local chains. Private blockchain can effectively promote and motivate the updating and maintenance of node resource data and solve the problems, such as sharing of trusted online learning resource data, through the node control of smart contract.

2 Related Work

Problems, such as dynamic incentive of data resource update, resource security access and resource copyright protection are encountered in the process of data resource sharing, storage and access based on cloud

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platform. At present, three protection methods are used for online subject data. The first approach boils down to data encryption. The resource owner encrypts the resource for network storage. In this case, data decryption is required to access the data resource [6]. The second comes down to network administrator control. Administrator control refers to the members of the network with the identity of management users who have the authority to manage the storage and access architecture of data and perform service verification based on the management architecture. For example, the framework needs to create and issue a digital certificate for the user and implement information protection by signing the digital certificate to register a proper user in the system [7, 8]. Users of different roles have different permissions. The third method is to manage storage and access permissions through access control at the application layer. All application access must be reviewed and authorized before data access permission is granted [7]. Only authorized users can obtain data decryption permission. Data application authorization can solve the actual control problem of application access. In accordance with the application characteristics of private cloud environment, literature [7] proposed an access control application scheme based on encryption system.

3 Framework of Digital Online Learning Resource

The construction, updating and sharing of online learning resources require the participation, coordination and support of resource provider builders (for example, college teachers), resource management institutions and institutions (college) alliances. Combined with the different characteristics of participants' needs, this paper proposes an online learning resource construction and dynamic updating architecture based on blockchain smart contract. In accordance with the different knowledge types of participants and the behavior characteristics of the same type of subjects in the process of learning resource construction, the architecture constructs the online learning resource data chain based on teachers and students in universities.

3.1 Problem Description

From the overall perspective, the construction, updating and sharing of online learning resources in universities involve the division of labor and cooperation among multiple universities, and are also a systematic project across departments or colleges. The process of platform construction and operation mostly involves information acquisition system, comprehensive cost, personnel, process and other factors. The locality of individual colleges does not involve the use of online learning resources sharing between universities but only within certain universities to ensure the long-term operation of the platform. Dealing with complex campus departmental benefit allocation problem still needs to take huge time cost due to the lack of effective

authentication mechanism to effectively coordinate the relationship between the various aspects. This condition is un conducive to the efficient construction and update of online learning resources, and a series of problems, such as information and resource asymmetry, still exists. Therefore, the overall planning and management of online resources should be maximized from the perspective of online learning resource management. Resource providers should have the most accurate grasp of resource quality. However, resource management organizations only have certain management authority for resources and often cannot grasp the quality of content. Therefore, the key of resource quality is the node of resource supply. For a certain course or knowledge point, video explanation plays an extremely good role for learners to master knowledge. From this point of view, the quality of learning resources plays a crucial role. A resource explainer is the resource provider who needs to update the connotation and denotation of knowledge points regularly so as to access them on network nodes.

The resource construction process of a certain structure can be supplied and maintained by many people for a certain knowledge point. However, in the resource network for this knowledge point, only a node with the best resource quality and the fastest re-source completion can put its own resources into the access resource library. The resources on the resource chain need multiple suppliers to compete reasonably and obtain the recognition of all nodes on the chain, so as to make their own resources on the chain. However, resource demanders (learners) access resources in accordance with the ID on the resource chain and learn that resource storage is local to each resource node rather than being directly stored on the chain. The resource chain only provides the unique address of a resource, that is, the ID number. For the resource supplier, maintenance shall be conducted in real time in accordance with the development of resources. Certain resource incentives, such as rewards in the form of resource incentive coins, will be given after the maintenance process is recognized by the nodes on the chain. This process forms the following resource private chain and access public chain. In this paper, resource up-chain and access practice are conducted in a small scale.

3.2 Constraints of Online Learning Resource

This paper takes the construction of online learning resources in the construction of the double-first-class discipline of our university as an example to describe the relationship of resource constraints. Every double-first-class discipline construction needs the support of first-class courses. Online learning resources need to be established for each course. Each learning team can form a private chain, and the private chain between team members can form a competitive relationship on the chain of knowledge points of course resources. Students are learning multiple courses, so the private chain established by each course must be linked to students' public learning chain. The on-chain constraints for a particular resource should satisfy certain constraint relations. For example, each knowledge point only has

a node ID in the private chain by taking software engineering learning video resources as an example. At the same time, the chain of every knowledge point needs to be recognized by the nodes on the chain. Suppose a dynamic resource chain of N courses is constructed at the initial stage. The resource constraint relationship in the concrete construction process can meet the following conditions.

- (1) The intersection between any two courses is an empty set.
- (2) The number of resource nodes on the chain is less than the number of knowledge points required by a course.
- (3) The union of each knowledge point ID should be equal to the complete set of knowledge points.
- (4) The intersection between any knowledge ids should be an empty set.

3.3 Smart Incentive Contract of Digital Resource Chain

In recent years, the success of Ethereum [9,10] has made smart contracts attract worldwide attention and become one of the most promising blockchain application technologies. Smart contract is an event-driven, stateful code contract, and algorithm contract [11,12], also known as encryption contract. It is also a computer program that can conduct transactions between subjects who do not trust each other in accordance with certain rules [8]. With the development of cloud computing, local data of learning resources are required to be uploaded and stored in the cloud in a centralized manner, thereby making the data more vulnerable to integrity damage [13]. The chain of blocks can be completed on the basis of cryptography technology through the mechanism of distributed multi-node consensus [14,15]. It does not tamper the record of the whole process of value transfer in accordance with decentralized, tamper-resistant, transparent rules, and other characteristics.

This article uses blockchain smart contract to build a safe, credible, and reliable decentralized chain of learning resources and improve the resource efficiency and security.

3.3.1 Working Principle and Block Structure Design of Resource Smart Contract

A smart contract consists of three phases: contract generation, contract issue and contract execution. The contract generation stage refers to the joint participation of multiple users to complete the formulation of the contract, clearly mark the function of the contract, determine the final contract text, and complete the program design.

To ensure the validity of the contract, multiparty participants need to sign according to their private keys. The state changes and the contracts are removed from the block after all the transactions within the contract are executed. The whole process is completed automatically by the system, which is open, transparent, and non-tamperable. Ledger is stored in the form of blocks and forms a chain structure with hash values as indexes to

form a blockchain [16]. Each block designed in this paper is divided into two parts: block head and block body. The resulting blockchain resource structure is shown in Fig.1. The blockchain generation process is shown in Fig.2.

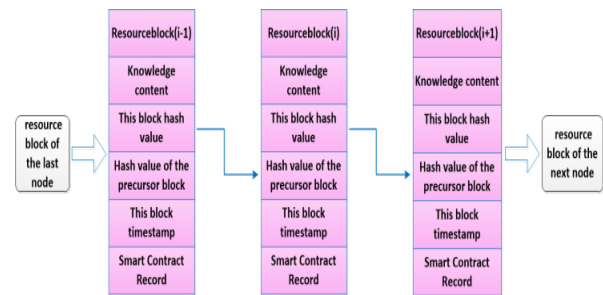


Fig. 1. Learning resource blockchain structure.

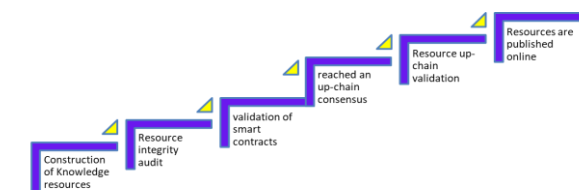


Fig. 2. The generation process of learning resource blocks.

3.3.2 Working Principle and Block Structure Design of Resource Smart Contract

Every required learning resource needs to compete on the chain. Knowledge resource construction at a certain moment can be considered a competitive node by teachers. Speed competition is conducted when all teachers have announced the current requirement for resource competition. The nodes that complete the construction of knowledge points first issue an application to the resource chain, and all nodes on the blockchain run smart contracts to evaluate key elements. If the resource requirements are met, then this knowledge is added to the blockchain. The other nodes update the data, and the miners compete for the next resource to be added to the blockchain. The chain loading process is shown in Fig.3.

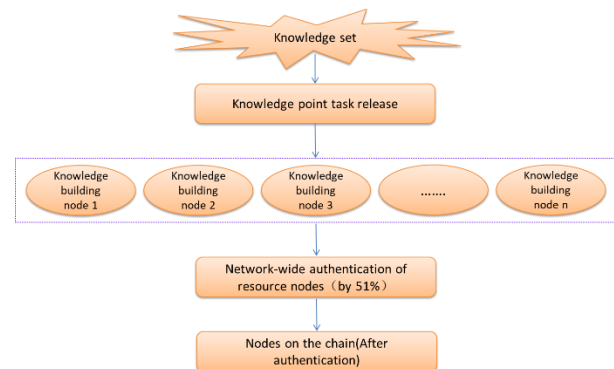


Fig. 3. Linking process of resource block node.

And the contract workload proof method process is shown below.

- (1) A “competition” game should be played after the release of all knowledge building tasks. During the construction process, the nodes of the tasks should be

completed first, and the construction results should be sent to other personnel.

(2) For the nodes that receive the knowledge point construction results, the validity of the construction results shall be verified first. The network ledger information shall be synchronized after the verification of more than 51% of the nodes.

(3) If two or more nodes constitute a successful knowledge task at the same time, then two ledgers are allowed to be established, and the final synchronous ledger can be further selected after the successful construction of the next node.

(4) The ledgers in the network are related to each other, and the change in any node affects the information change after the node.

The contract is packaged into a collection of contracts, the hash value of the set is calculated, and the contract sets the hash value of the assembly into a block and spread to the entire network of other nodes. The node receiving the block verifies the hash value stored in it against the hash value of its own set of contracts. All nodes will reach a consensus on the newly issued contract, and the consensus contract set will spread to all nodes in the whole network in the form of blocks after several rounds of sending and comparing. The contract signing process is shown in Fig.4 and the hashing process of specific data is shown in Fig.5.

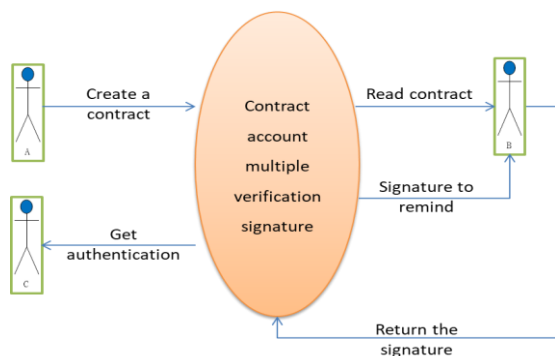


Fig.4. Contract signing process.

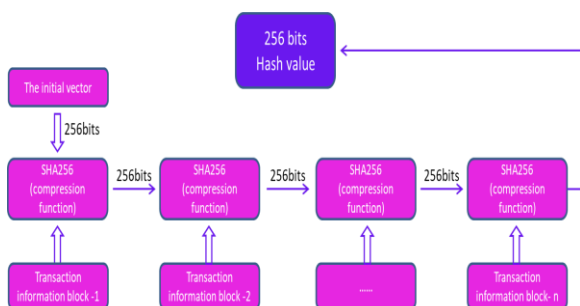


Fig.5. Hash value generation process.

For the trigger condition after the release of the contract, each contract will be in accordance with a certain time constraint relation between executions. The conditions of the transaction will be waiting for a validation sequence which is used to verify whether the contract has been spread to every node. The node will first perform signature verification to ensure the validity of the contract, and verification by agreement after consensus will be

executed successfully. All of the hashing processes which are mentioned above are based on Merkle trees.

Digital incentive currency management mainly includes two parts: consumption and acquisition of incentive currency. Intelligent and automatic operations of smart contract technology are based on blockchain. If learners need to acquire some interesting learning courses or resources, then they need to spend a certain amount of incentive currency at first. They can earn more incentive currency after learning, which can effectively reduce students' giving up halfway in the learning process of learning resources. Teachers and students can share high-quality resources, ask questions, answer questions and other processes to obtain incentive coins. Incentive currency model has a strong guiding effect on the real-time dynamic updating of resources. At present, different departments and universities use different resource management platforms. Users can share resources directly through point-to-point communication by using the distributed ledger technology of blockchain, effectively solving the problem of cross-platform resource sharing and reducing operating costs.

3.3.3 Learning Resource Chain Construction Process Based On Incentive Currency

Driven by incentive mechanism, obvious competition occurs among knowledge builders to promote the optimization of knowledge building process and dynamic up-date of resources. The resource builder can obtain the corresponding incentive coins for the learning resource nodes with high utilization rate through the incentive sharing mechanism of resources. This process is to further promote the resource builder's continuous optimization power and form a dynamic optimization resource cycle system. The optimization cycle is shown in Fig.6.

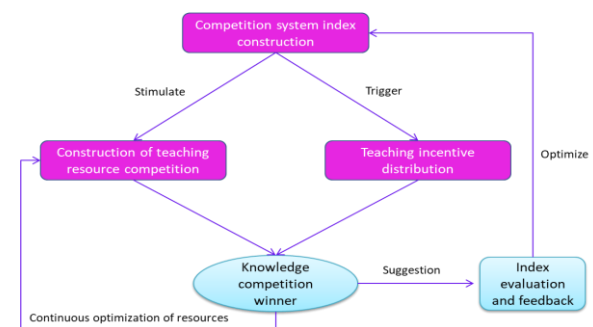


Fig.6. Resource construction cycle optimization.

3.4 Experiment and Analysis

On the basis of the immutability of blockchain, this paper creates an exact tam-per-free record of all contract events occurring on the chain without the need for third-party credit authentication to ensure the reliability and verifiability of the contract. Smart contract is used as the upper application of blockchain network to realize the autonomy of contract. On the basis of smart contract theory, the experiment environment of Ethereum private chain was simulated, and the smart contract was constructed by simulating resources. The environment for

this experiment was as follows: CPU Intel i7-8550U, main frequency 2.0 GHZ, memory 8 GB, operating system Windows 10(education edition), and programming language Solidity.

Table 1. Comparison of knowledge node access rates

Knowledge point name	Previous visit rate (%)	Current Hit rate (%)
software life cycle	73	93
software crisis	89	91
waterfall model	90	94
rapid prototyping model	92	97
feasibility analysis	88	96
data flow diagram	82	89
data dictionary	87	89
requirements analysis	88	96
entity relationship diagram	90	95
state transition diagram	91	96
modular design principle	90	94
coupling and cohesion	88	94
design of structure drawing	87	96
program flow chart	86	90
structural design principles	89	93
decision table	91	96
decision tree	85	96
specification of coding	90	94
black-box testing	92	97
white-box testing	84	96
software maintenance	88	95

The learning organization of the original offline learning resources is scattered, and online learners cannot choose the data resources with strong pertinence according to their own preferences. The online learning resources based on blockchain smart contract are marked and stored in accordance with the characteristics of the resources at each node, completing the characteristic access of data resources. This paper takes software engineering course as an example to illustrate the resource access of learning knowledge points and the comparison of learning effects. The typical knowledge points in this course and the comparison table of the access rate of knowledge points (before and after the adoption of blockchain technology) are listed in Table 1. Compared with traditional resource presentation methods, the access efficiency of digital resources based on blockchain technology is improved to some extent, which is shown in Fig.7.

In terms of the precision of resource access, learners can better match the required learning resources in accordance with the characteristics of resources. For example, learners can quickly find relevant knowledge points in accordance with the established corresponding relationship of resources and the resource keywords. The comparison of the precision of resource access is shown in Fig.7. A learning effect assessment is performed for each knowledge point, and the learning effect is compared with the increase in performance analysis to compare the knowledge point mastery, as shown in Fig.8.

In this paper, the security guarantee mechanism of resource access mode is analyzed on the basis of the characteristics of blockchain to analyze the optimization of security performance. Increased security promotes the continuous updating of learning resources.

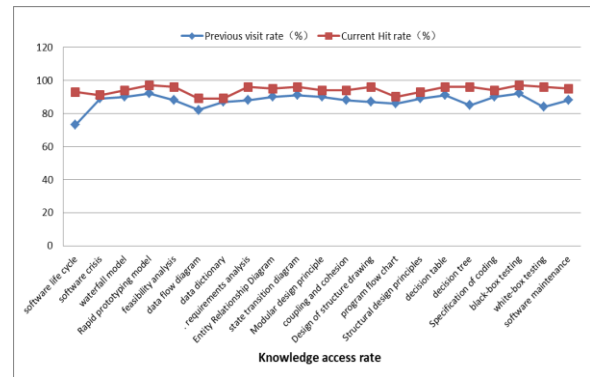


Fig.7. Knowledge access rate. This figure compares the access to knowledge points before and after the use of blockchain contract.

As shown in Fig.7, the visiting rate of knowledge points is improved to some extent, indicating that online learning resources based on blockchain technology are greatly improved in attracting students' interest in learning. Blockchain learning resources can better obtain the attention of resources compared with the access to traditional online resources, with varying degrees of improvement.

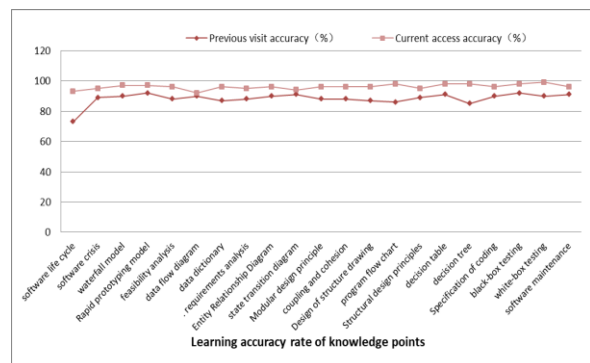


Fig.8. Learning accuracy rate of knowledge points. This figure compares the accuracy of learners' access to resources before and after the use of blockchain technology.

The precision of resource access depends on the precise correspondence between visiting interest points and learning resources. On the basis of big data technology, this paper establishes an accurate correspondence between the learners' learning preferences and learning resources. The results which can be seen in fig.8 reflect that although the exact correspondence between knowledge points learning resources and learning requirements do not reach a complete accuracy. And the accurate access rate of resources is substantially, improved compared with the original and current learning resources. The maximum accuracy increased by 20%, the minimum accuracy increased by 2%, and the average accuracy increased by 8.1%.

4 Conclusion

Although smart contracts have not been widely used, their technical advantages have been widely recognized by researchers. Blockchain-based smart contract technology is deterministic, consistent, terminable, verifiable and decentralized. Smart contracts can guarantee the same output for the same input when running multiple times on different computers or at different times on the same computer. Smart contracts are immutable and traceable through digital signatures and timestamps in blockchain technology. All parties to the contract can observe the contract itself and all its states and execution records through certain interactive methods, and the execution process is verifiable. The decentralized nature of blockchain makes it impossible for any party in the contract to unilaterally modify the content of the contract or interfere with the execution of the contract, greatly reducing the risk of human intervention. Thus, smart contracts based on blockchain technology avoid interference from malicious acts, ensuring that the contract is tamper-free and transparent throughout the execution process. In this paper, the competitive linking of resource nodes is completed on the basis of smart contract, thereby improving the enthusiasm of resource maintenance. It provides continuous and orderly optimization resources for learners.

Acknowledgements: This work was supported in part by the Natural Science Foundation of Hunan Province under Grant Number 2018JJ2193&2023JJ40081, Scientific Research Fund of Hunan Provincial Education Department under Grant Number 21A0599& 22A0686, the Key Project of Teaching Reform in Colleges and Universities of Hunan Province under Grant Number HNJG-2021-0251& HNJG-2021-0252&HNJG-2022-0371.

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