

Blockchain Empowered Knowledge Graph for Education

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Abstract

With the vigorous development of research and application of artificial intelligence related technologies in recent years, knowledge graph technology has also received very high attentions. As a carrier form of knowledge, knowledge graph has also been widely stored and used in the education field, but the knowledge graph stored in various education systems need to be confirmed with intellectual property rights and protected by an effective mechanism. In this paper, we propose a new mechanism to empower the intellectual property protection of knowledge graph in educational systems using blockchain technology, which can be effectively applied to all kinds of online education, distance education and adult education systems.

Keyword: Blockchain, Knowledge Graph, Education

I. Introduction

Knowledge graph originates from semantic web [1]. It mainly uses visualization technology to describe knowledge ontologies and their resources, and then finds, mines, analyzes, constructs, draws and displays more knowledge ontologies and relationships between them. With the vigorous development of artificial intelligence technology in recent years, knowledge graph is considered to have very good application prospects, especially in the fields of dialogue robot, big data risk control, intelligent medical treatment, adaptive education, e-commerce recommendation system and so on.

With the rapid improvement of China's education informatization level in recent years, informatization has basically covered the whole process of education, a large amount of education big data has been accumulated in various education information systems. It includes all kinds of teaching materials used by teachers, such as course courseware, teaching plan, teaching video, examination outline, teaching auxiliary materials, as well as various learning materials used by students, such as electronic book, learning materials, past test papers, training question bank and so on. In addition, the educational information system also includes all kinds of teaching and learning behaviors of teachers and students. These behavioral big data include the formation, transmission, reception and processing process information of students' knowledge system. As the key technical basis of cognitive intelligence, knowledge graph can play a very important role in the higher stage of educational intelligence towards "cognitive intelligence". Making full use of educational knowledge graph can realize intelligent application in scenes such as precision teaching and adaptive learning.

However, at present, the common storage format of data in knowledge graph is mainly metadata written based on XML rather than the data model displayed to users. XML is very convenient for computers to transmit data and make machines understand it. When this kind of metadata is saved and transmitted in the open education ecosystem, the problem of intellectual property protection arises. In [2], authors proposed a solution to protect intellectual property rights by using blockchain technology. Based on this, we further discuss the use of blockchain technology to enhance the traceability and protection of knowledge graph data in the open education ecosystem. The rest of this paper will discuss the state of art on the blockchain related research and applications for educational

system and knowledge graph firstly, and then propose our architecture design for using the blockchain technology to enhance the educational knowledge graph system. Finally, we will discuss the future work of the design.

II. Related Work

There are many papers talked about the blockchain application in e-learning and knowledge graph related areas. In this section, we will review them.

A. Blockchain application in e-learning or educational system

In [3], the authors tried to use blockchain to solve the certificate validation issue in e-learning system for a state university of Turkey. Authors developed a blockchain based autonomous and decentralized system, which uses blockchain technology and smart contracts to document, validate, and verify the certification process.

In [4], the authors reviewed related literature in the field of "blockchain + education" in China and proposed some suggestions for the innovation and development of the combination of blockchain and education. They believed that the blockchain research and applications for education information management and materials sharing will be very hot.

In [5], the authors thought that the blockchain technology can enhance the conventional education system in developing countries for its greater accountability and visibility. They proposed an expanded model of Technology Acceptance Model (TAM) by infusing blockchain technology into it, which could assist decision makers to build a smart learning environment for the educational institutes.

In [6], the authors proposed a blockchain based online education solution, which can store students' learning records in a trusted, distributed manner, and provide functions such as credible digital certificates, learning materials sharing with smart contract, and intellectual property protection.

In [7], the authors thought that blockchain technology can help educator and learner to monitor the study outcomes. The study activity data can be stored securely and tamper proof when it is stored in the blockchain network. The e-learning platform with blockchain can help users to make the tamper-proof certificates. And make sure they are real and correct to be permanently allocated to learners, as well as can be verified by anyone. In this way, the overall frauds and tampering of the diploma and degree certificates will be reduced.

In paper [8], the authors thought that as the world is more flexible and unpredictable, high level education is increasingly mobile, multiple levels of administration in high level education result in the communication friction and business delays, which can cause many anxieties and hardships for students. The use of blockchain in high level education system can help to solve this problem. The authors developed an experimental blockchain-based university transcript system, and then analyzed experimental results in applying blockchain technology on protecting higher education transcripts.

In [9], the authors thought that traditional e-learning system is difficult to trace students' study activities. The non-instantaneous diploma verification, as well as the digital or paper file management in education have always been severe problems. The data stored in a centralized e-learning system is easy to be tempered, therefore fairness and authenticity cannot be guaranteed. To solve these problems, they designed an e-learning education certificate prototype system that provides QR codes or dynamic authorization codes to students and third parties, which can instantly verify the digital certificates issued by the system.

In paper, authors reviewed various systems combining machine learning and blockchain technology for the improvement of the education system. The authors thought that blockchain technology can be used to store diploma, degree or other student certificates securely. Such certificate information could be added into the blockchain by their colleges or universities, which can be shared by students themselves and can be accessed by third-party organizations

such as employers. This approach is very safe as changes of organizations or the loss of data is not a concern.

In [11], the authors analyzed the potential educational applications of blockchain, and tried to use blockchain technology to solve some education problems, such as the problems of information asymmetry and lack of trust among parties in e-learning ecosystem. The authors thought that blockchain can be used to maintenance a balance between measuring learning progress and the result. In addition, blockchain can provide a credible way for the talent culture and investment. Because the blockchain ledger traces everything that students have learned in an e-learning system, an employer can use it to offer a student a job that matches up with the student's competences. It will largely reduce the risk of investment bias and talent investment failure.

In [12], the authors proposed a blockchain based framework, which can secure the data of e-learning system. The proposed framework was used to build a safe and trackable data delivery facility, which can link to existing educational data. Using it, institutions can just accumulate their learning activity data without requesting a copy from central servers. Their framework can enhance data security and removes trust concerns among users and third-party institutions in the educational ecosystem.

In [13], the authors mainly explored and studied the blockchain based e-learning system from the characteristics of blockchain technology, such as trustworthiness, decentralization, non-tampering and traceability etc. They proposed a multi-layer logical framework for an e-learning system. An improved Delegated Proof-of-Stake (DPoS) consensus mechanism was also proposed. The generation steps of the blockchain in the e-learning system and the functional process of the consensus mechanism were analyzed in the paper. The conclusion shows that, by using the blockchain based e-learning system, the e-learning education centers distributed all over China can not only help to share the learning resources and to improve the

management efficiency of systems, but also to improve the safety and transparency of their teaching management and scientific research of institutions.

In [14], the authors introduced their study on infusing blockchain technology into the MOOC-based e-learning system. They discussed a few technology features and basic application scenarios of the blockchain, and then provided some solutions for the online e-learning problems caused by infusing the blockchain technology. They suggested that educational institutions should be welcome to digital technology such as blockchain, so that better educational applications can be expected in the future.

In [15], the authors proposed a data management scheme that uses blockchain technology in an e-learning system. The learning data are stored in a distributed storage system of the scheme, the evidence of uploaded learning data is stored in a blockchain network system established by high credible third-party institutions. Once the data in the distributed storage system are tampered, it can be discovered by checking blockchain transactions for the third-party institutions. Additionally, they adopt attribute encryption with a fine-grained access control scheme for e-learning system to make up the lack of privacy protection in the blockchain ledger. The designed scheme also can prevent collusion attacks, which means that even if multiple users collude, they will not get more data from the system.

In [16], the authors discussed and analyzed 21 existing blockchain based solutions in educational applications. They thought that as part of the implementation of ICT in education, both the blockchain technology and gamification technology have been well developed in recent years.

In [17], the authors indicated that considering blockchain as a strategic resource for e-learning system is possible, which can help decision-makers and policymakers to engage into the e-learning system design and development. They want to provide a strategic viewpoint for them to use blockchain technology as a significant intangible resource for education application scenarios. They thought that blockchain offers huge potentialities which bring a lot of benefits

to the entire e-learning ecosystem and different stakeholders, including educational organization, teachers and students.

In [18], the authors conducted a field review to discuss challenges and opportunities of the blockchain technology. They presented some methods combining relevant subjects in the modular online course to promote interdisciplinary blockchain education. Moreover, they provided some pieces of advice on future research and applications on several selected relevant scientific subjects, including management, economics, finance, computer science and network security engineering etc.

B. Blockchain application in knowledge graph

In [19], the authors proposed a novel decentralized knowledge graph construction method by the usage of crowdsourcing method. The business logic of crowdsourcing is implemented by blockchain-powered smart contracts to guarantee transparency, integrity, and auditability. On this basis, their decentralized knowledge graph is used for a deep recommender system.

In [20], the authors designed an experiment to explore the availability and effectiveness of knowledge graph based on blockchain and distributed system storage and traceability. They proposed a scheme of process file storage and traceability of knowledge graph based on blockchain and distributed file storage system. To improve the storage efficiency and save resources, the process files of building knowledge graph are preprocessed by distributed file system. To ensure the security and integrity of those files, the processed files are stored in the blockchain network.

In [21], the authors introduced the first attempt on the implementation of sharing knowledge graphs on OpenKG chain, a blockchain-based trust network. Novel definitions were proposed: K-Point and OpenKG Token, which can be considered to be a measurement of knowledge value and user value. 1,033 knowledge contributors have been involved in two months of testing on the blockchain, and the cumulative number of on-chain recordings triggered by real knowledge consumers has reached 550,000 with an average daily peak value of more than

10,000. They also have tested and realized on-chain sharing of knowledge at an entity/triple granularity level.

In [22], the authors thought that blockchain-based knowledge construction is deemed to be an alternative by adopting smart contract. However, the complexity of blockchain technology is an obstacle to apply blockchain solutions in practical scenarios. They proposed a Blockchain-as-a-Service (BaaS) approach to address the complexity issue. Through their BaaS system, developers can focus on knowledge graph constructions instead of struggling to master blockchain technology. In their paper, they also discussed the implementation of the system and the measurement of the performance.

In [23], the authors proposed a blockchain sharing-empowered knowledge graph storage (BS-KGS) scheme. To achieve optimal transaction sharing strategies, they constructed a dynamic programming algorithm that considers multiple resource constraints. Moreover, their approach guarantees transaction security via implementing several methods, including Verifiable Random Function (VRF), asset mortgage, and Practical Byzantine Fault Tolerance (PBFT) consensus.

III. Proposed Method

The above research papers show that the use of blockchain technology in both educational systems and knowledge graph has great potential and prospects. It can solve problems including learning behavior recording, degree certificate verifying, intellectual property (IP) of courseware protecting, transaction account tracking, and cross-institutional mutual recognition of academic qualifications [24]. However, most of the above solutions are designed for ad-hoc problems or specific functions, and lack a comprehensive solution of blockchain-empowered knowledge graph for educational ecosystem from the perspectives of different users such as educational institutions/agents, students, teachers, parents, and employers. So, we propose the following solution as shown in Figure 1.

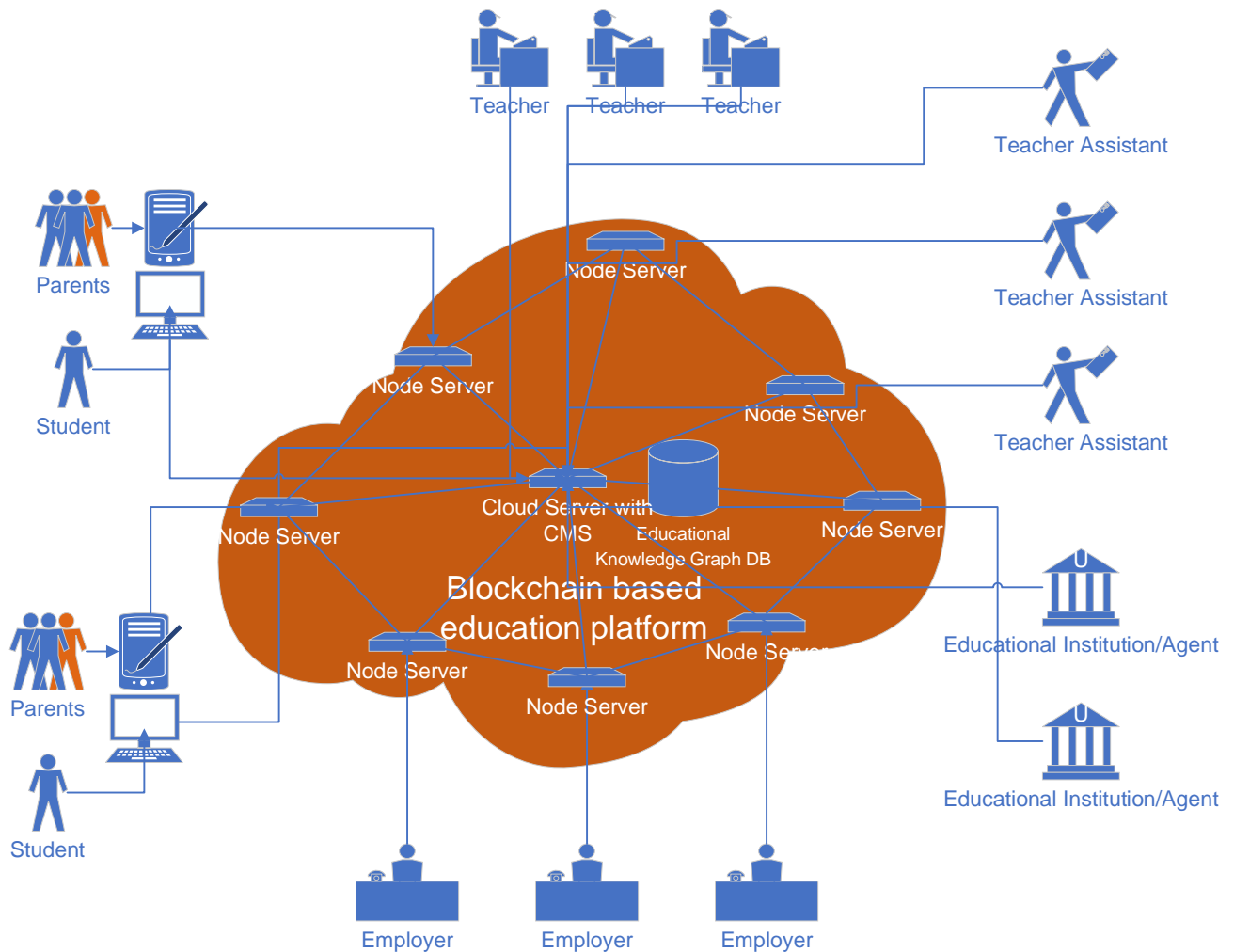


Figure 1. Blockchain empowered knowledge graph for education platform

Comparing with the traditional online educational system, we have added a set of underlying blockchain trust guarantee functions including the function of logging learning behavior for student, the function of querying academic achievement for parents, the function of protecting IP of courseware stored in knowledge graphs and logging teaching activities for teachers and their assistants, the function of recording knowledge graph teaching/learning activities, achievements, certificates, etc. for educational institution or agents, and the function of verifying transcripts and degree certificates for employers.

A series of consortium blockchain server nodes are added into the whole ecosystem. These server nodes can belong to any stakeholder of the ecosystem, including any people or organization who would like to provide a server or computing device, which can be used to replace with traditional

centralized cloud or local servers. Therefore, it can effectively prevent data from being maliciously attacked by hackers or illegally modified by internal staff for some kind of selfish interests. Users can actively put their data on chains, or passively put their specific teaching, learning or transaction behavior data on chains, which can be automatically executed by smart contracts in the system. This design can not only effectively protect the privacy of users, but also ensure that the public data like knowledge graph on chains can be authenticated based on the consistent rules that are agreed in advance by all stakeholders.

IV. Conclusion

Blockchain technology can be used to build an open, trusted and self-organized educational ecosystem. The application of blockchain technology on education can provide more open e-learning system, more credible education records, more accurate education evaluation, longer lifelong learning, more professional teacher development, more secure and interconnected education governance, and better IP protection for educational digital resources such as educational knowledge graph. Our proposed blockchain-empowered knowledge graph educational ecosystem will be expected to help enhance a remote education credit system, including the construction of some major education application scenarios, such as inter-institutional lifelong education, inter-disciplinary education, and modern vocational education etc.

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