Application Design of Road, Bridge and Tunnel Engineering Information Management Based on Blockchain

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Abstract: In the process of information management of road, bridge and tunnel projects in the field of infrastructure, the traditional centralized management method has problems such as difficulty in data supervision, difficulty in data traceability, and easy tampering of information. To this end, combined with the blockchain technology, a blockchain application architecture based on the underlying architecture of the alliance chain and the middleware platform is proposed—the road, bridge and tunnel project information chain architecture. The test results show that the application can not only effectively ensure the security of road, bridge and tunnel engineering information, but also has high performance, and has certain application value in the management of road, bridge and tunnel engineering information.

Keywords: Engineering Information Management, Blockchain, Application Architecture.

1 INTRODUCTION

With the rapid growth of the scale of China's transportation infrastructure construction, the rapid improvement of the level of industrialized manufacturing, and the continuous advancement of digital construction, combined with the urgent needs of China's road and bridge tunnel industry upgrading and transformation, how to further improve the overall level of informatization of the road and tunnel industry is an important task [1] in front of us, which coincides with the development of new infrastructure [2]. To this end, researchers have designed distributed information management applications for road, bridge and tunnel engineering, which greatly improves the efficiency of information management, but there are still problems such as easy data tampering, difficult supervision of users, and untrustworthy traceability. The birth of blockchain [3] technology provides a solution to the problem of data privacy, security and integrity of road and bridge information management. A. Lanko, N [4] will play the role of blockchain technology in the safety traceability of bridge construction, electronically record the key information of each link through RFID technology, record it in the bridge database based on blockchain in real time, and form tamper-resistant information after authentication, realize the tracking and traceability management of bridge engineering safety, and use blockchain nodes to represent all transaction parties in the bridge engineering construction process, and any

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information processing behavior of transaction parties on the blockchain is transparent. So as to achieve effective supervision of all parties involved in bridge engineering.

In order to solve the above problems, this paper constructs a road-bridge engineering information management application based on FISCO BCOS blockchain, which integrates the road, bridge and tunnel through detailed architecture design, and uses smart contract technology and test its performance.

2 RELATED THEORIES

2.1 Smart Contracts and Blockchain

The concept of smart contracts, proposed by Nicosab [5] in 1995, is designed to digitally define a code container that reflects a real-world contract, and when the participants meet the required conditions of the contract and execute it, the computer will automatically execute the contract agreement within the code container. Due to the technical conditions at the time, smart contracts were not used. Blockchain originated from the Bitcoin [6] system, which is essentially a peer-to-peer distributed system with a unique consensus protocol and incentive mechanism [7] that guarantees the decentralization, transparency, traceability, trustworthiness and immutability of system operations. Bitcoin is also known as Blockchain 1.0. The combination of smart contracts and blockchain technology gave birth to Ethereum with the goal of solving the problem of mutual trust in the financial field, which is called Blockchain 2.0. In order to improve the universality of blockchain technology, researchers propose that blockchain should go beyond the financial field, provide decentralized solutions for various industries, and build an intelligent Internet of Things era called blockchain 3.0. This article uses blockchain 3.0 technology to build blockchain applications.

2.2 Related Study

Blockchain technology as an emerging technology has been deeply discussed and tried to be applied to all walks of life, among which Liu Tianyu[8] and others focused on analyzing the application scenarios of blockchain technology and the current problems, and looked forward to the future technology trends, which clearly proposed that the combination of blockchain technology and transportation infrastructure is one of the major topics in the development of blockchain technology, and the application of blockchain technology can provide solid technical support for the future construction of road, bridge and tunnel infrastructure. Caixiang Fan [9] tested and analyzed the performance of the current mainstream blockchain in different application scenarios, among which the performance of the consortium chain is much better than the performance of the public chain, FISCO-BCOS in the consortium chain is the least delayed, and the transaction throughput is better than that of Hyperledger Fabric, which is also a consortium chain. Literature [10] et al., as the underlying developers of FISCO Alliance Chain, further discussed the application form based on FISCO BCOS based on practical application landing examples, and summarized its layout and practice in technology, application and ecological construction: FISCO is suitable for providing information technology support for intelligent transportation infrastructure construction.

In order to solve the problem of modern traffic information management, researchers at home and abroad have used a variety of advanced technologies. Among them, literature [11] constructed a BIM bridge model, which visually displays the progress of bridge construction through the model, and compares the planned progress with the actual progress.

The information management technology of the construction process of the steel precast components of the main beam of the bridge was developed to realize the information sharing and construction control in the construction process. However, the study only uses general database technology and document management technology to build the data layer, and the entire system lacks the protection of data security, and there is a problem that the record data is maliciously tampered with, resulting in untrustworthy system management. Literature [12] developed a blockchain-based quality information management framework covering Hyperledger Fabric-based architecture and a series of solutions, and experiments verify that the framework can decentralize the management of quality information to achieve consistent and secure quality information management. However, the underlying blockchain technology used by the framework has the problem of weak performance and high latency [9].

Based on the above analysis, blockchain technology can be applied to provide information technology for the information management of transportation facilities such as roads, bridges and tunnels, and blockchain technology is more secure than traditional information management and data storage technology.

3 ARCHITECTURAL DESIGN

3.1 Operate Architecture

The architecture design [13] is divided into two parts: architecture construction and architecture operation, and the architecture construction process is shown in Figure 1: first, the receiving party, regulatory agency and each participant deploy the underlying network nodes representing themselves locally, and connect with each other through the network interface to form the underlying node network of the alliance chain. Then, the acceptor builds a middleware platform locally, connects with the application service layer through the network interface to form a web network service, connects with the bottom layer of the consortium chain, and creates a database as a storage location for block information. Finally, the receiving party accesses the middleware platform through the web network service, deploys the smart contract, and generates the contract interface. The construction process is shown in Figure 1 alphabetical order: first the participants access the web network service, and the web service determines whether the participant has the right to use the contract interface, if it does not have permission, the access request is rejected, and if it has permission, the participant can call the contract interface to execute the smart contract function, and record the road and bridge tunnel project information and the transaction information between the participants in the bottom layer of the alliance chain.

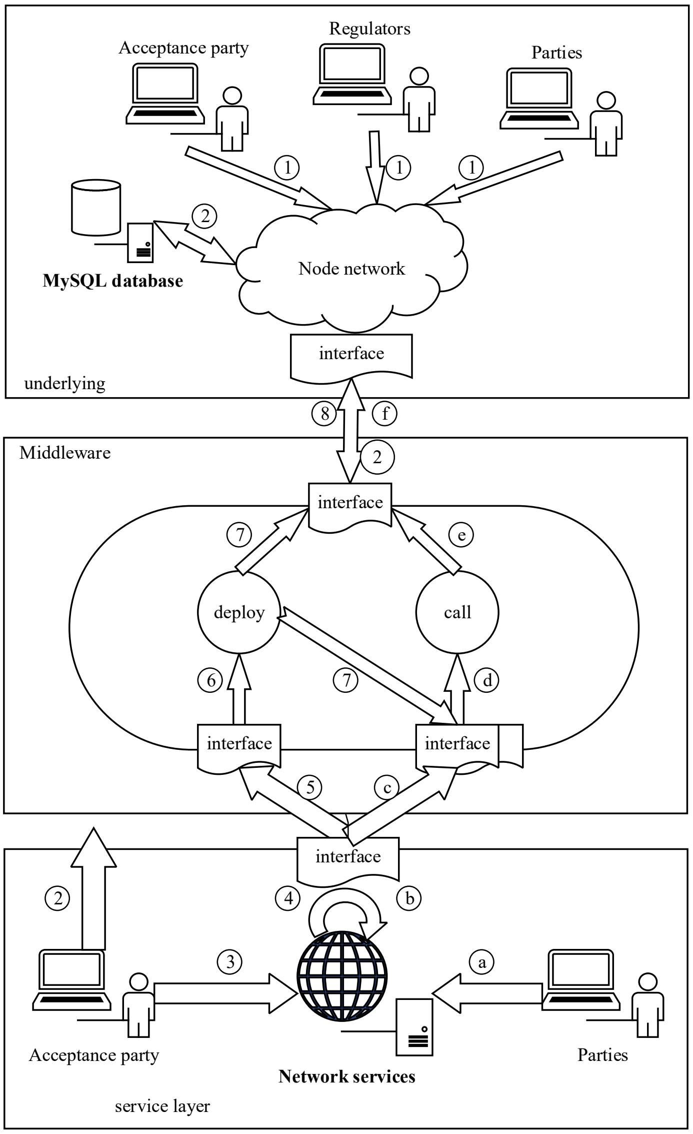

Figure1. Application operating architecture design

3.2 Node Group Architecture

In order to adapt to the requirements of real business scenarios, FISCO BCOS adopts a group architecture to support blockchain nodes to start multiple groups, and the transaction processing, data storage, and block consensus between groups are isolated from each other, which not only ensures the privacy of blockchain applications [14], but also reduces the complexity of O&M. In the multi-group architecture, the consortium chain nodes are divided into free nodes and group nodes, and each node in the group is divided into consensus nodes and observation nodes, as shown in Figure 2 below.

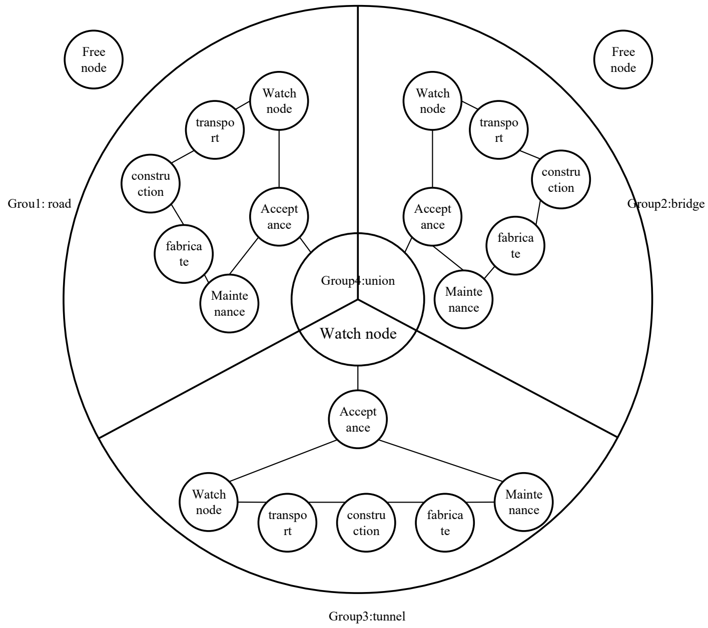

Figure2. Application node group architecture design

Figure 2 has three parts of repeated graphs, each of which represents a node group, which in turn can be divided into roads, bridges, or tunnels. Each group contains all the nodes of the node layer in Figure 1, which are owned by the participants and regulatory agencies in the road and bridge tunnel construction process, and in particular, the acceptance nodes and a group of observation nodes in each group form a group 4. The construction logic of the node group architecture is: group 1, group 2 and group 3 each represent an engineering project, the transportation, construction, manufacturing, and maintenance of the project are held by the corresponding participants, when the engineering information needs to be recorded, these nodes and the acceptance nodes owned by the manager use the PBFT consensus algorithm to reach consensus, and after the consensus is successful and the observation node held by the regulator is confirmed, the block containing engineering information will be on the chain. Group 4 is a special group, the consensus process is for the three-party project managers to reach a consensus using the PBFT consensus algorithm, and the information block is uploaded to the chain after being confirmed by the regulator.

4 APPLICATION PERFORMANCE TESTING

JMeter is used for performance testing: JMeter relies on the Java environment, and after configuring the JDK, it simulates the scenario of multiple users calling the web server interface concurrently by setting a thread group with a fixed request time. Use this tool to test the contract deployment interface and transaction execution interface of the application, and obtain the interface call error rate ERR, transaction throughput per second TPS, and average transaction response time RTT, and obtained conclusions based on these data.

JMeter was used to stress test five sets of different numbers of threads for the contract deployment interface and the transaction execution interface. First, set the number of thread groups to 500, 1000, 2000, and 4000, with a request interval of 1 second and a maximum thread duration of 900 seconds. Then set the sampler to HTTP request, add the server IP, port number, request mode, request parameters and other information, and save it as a JMX file. Finally, run the jemeter command in the command window to run the JMX file, and the test results are shown in Table 1 below.

Table 1. Formatting sections, subsections and subsubsections.

sum	Contract interface			Trade execution interface		
	ERR/%	TPS	RTT/s	ERR/%	TPS	RTT/s
500	0	5.3	5.4	0	5.2	5.3
1000	0	6.9	9.1	0	6.9	9.0
2000	0.15	6.6	16.5	0	6.7	16.2
3000	4.03	7.5	22.4	0	7.5	21.1
4000	10.20	6.1	25.3	0.13	6.4	31.3

5 CONCLUSION

Aiming at the problems of difficult data supervision, data traceability and easy tampering of information in road and bridge tunnel engineering, this paper designs an information management application based on the FIS-CO BCOS alliance chain. The architecture of the application organically integrates all participants in the road and bridge tunnel engineering construction process, and uses secure and loophole smart contracts to construct application services, which ensures the security of engineering information and realizes the digital management of road and bridge tunnel engineering information. It can be seen from the experimental results that application performance can achieve the effect required by the actual application. The next research of the application is to dynamically increase the number of blockchain nodes and expansion groups online, accept the data incoming from physical devices, and comprehensively manage the collected information.

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