Research on Blockchain-Based Organization Collaboration System

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Abstract. Collaboration log, which can be used to reflect the trust of an organization and applied to subsequent analysis and audit, is constantly generated during the organization's collaboration. Common systems usually store them by a third-party organization, which exists at risk of tampering. Regarding this issue, blockchain can safely manage the collaboration logs owing to its decentralized and unforgeable features. In this paper, we implement an organization collaboration prototype system for spare parts procurement based on the Software As A Service(SaaS) collaboration model and Hyperledger Fabric solutions. To validate the performance of the prototype system, we conduct some performance tests on the prototype system. The result shows the feasibility of our proposed system.

Keywords: collaboration log, organization collaboration, blockchain, collaboration model

1. Introduction

With the development of information technology, more and more enterprises use information technology to improve business efficiency [1]. In the supply chain, there are a lot of data transmission operations such as purchase orders and invoices among enterprises. These are evidence of reflecting the trust of enterprises. Therefore, we should save them as collaboration logs which are applied to subsequent analysis and audit. At present, a convenient method is to save the collaboration logs to the database of the third-party organization for management. However, this method has the risk of editing the collaboration log, so that some organizations can avoid responsibility. Regarding this issue, blockchain can safely manage the collaboration logs owing to its characteristics of decentralized and unforgeable. The decentralization of blockchain can ensure that the collaboration log is not endorsed by a large organization, but by the consensus of multiple organizations, which avoids the risk of
tampering and ensures the effectiveness of the collaborative log. In addition, unforgeability can ensure the authenticity of the collaboration log, which is supported by cryptography, distributed storage, and other technologies.

The rest of this paper is organized as follows. We first elaborate on the existing business collaboration model(Section 2). Then, we introduce blockchain technology(Section 3). Next, we select the appropriate technology to design and implement an organization collaboration system for the business scenario of spare parts procurement(Section 4). We further conduct some performance tests of the system(Section 5).

2. Business Collaboration Model
On one hand, transmitting the data among organizations is the basic method to guarantee the availability of business collaboration. On the other hand, data is the lifeblood of an organization, so we should not open the data unconditionally. Therefore, we need to balance the relationship between the availability of business collaboration and openness of data. At present, there are two popular business collaboration models as bellow:

1. Building a data-sharing system [2]. Each organization publishes data to the data-sharing system at the regular time. The architecture is shown in Fig.1. The advantages of this architecture are low coupling and data access normalization. However, its insufficiencies are obvious, such as the poor real-time performance, entrusting third-party management of shared data, and risk of data leakage.

![Fig. 1 Business collaboration architecture based on data sharing system](image1)

2. Exposing a series of data interfaces to provide business data through SaaS [3]. Each organization realizes business collaboration through the interoperability of interfaces. The architecture is shown in Fig.2. The advantages of this architecture are high real-time performance and data independence. However, the interface specifications and authorization mechanisms of each organization are inconsistent, which makes it difficult to extend on a large scale.

![Fig. 2 Business collaboration architecture based on SaaS](image2)
3. Blockchain Technology
Since the occurrence of bitcoin, blockchain technology has been widely concerned in the fields of finance, enterprise, academic, and so on [4]. At present, the popular blockchain systems are Ethereum [5] and Hyperledger Fabric [6]. In Tab.1, we make a comparison of these systems.

Unlike bitcoin [7], Ethereum is a next-generation smart contract and decentralized application platform. Developers can write smart contracts combined with their own business scenarios to develop the corresponding Distributed APPlication(DAPP). As a public blockchain implementation, Ethereum is decentralized, allowing all individuals and groups to join the blockchain. However, due to the openness of smart contract and blockchain joining, Ethereum's smart contract vulnerabilities frequently appear, which also leads to Ethereum's inability to be an enterprise blockchain solution.

With the urgent demand of enterprises for blockchain solutions, Hyperledger Fabric is designed to meet such a requirement. Hyperledger Fabric is an implementation of consortium blockchain. With the reason of permission, it ensures the trust of blockchain members, which is the basic requirement of enterprise blockchain solutions. Moreover, Hyperledger Fabric is designed with modular theory, so it is highly extensible. For example, encryption module, consensus module, and so on all support customization. As a blockchain solution, developers only need to select the appropriate access mechanism, consensus algorithm through configuration, and write the corresponding smart contract to build a blockchain network. At present, Hyperledger Fabric has been applied in a variety of enterprise application scenarios.

|          | Ethereum                         | Hyperledger Fabric                  |
|----------|----------------------------------|-------------------------------------|
| type     | public blockchain                | consortium blockchain               |
| feature  | decentralized                    | permissioned                        |
|          | DAPP development support         | modular, extensible                 |
| scenario | personal                         | enterprise                           |

Tab.1 Comparison between Ethereum and Hyperledger Fabric

4. Technology Selection and System Design
On one hand, the SaaS-based model will reflect the collaboration relation more clear than the data-sharing system and ensure data independence. On the other hand, the blockchain member is not allowed to participate unconditionally. Therefore, we choose the SaaS-based model and Hyperledger Fabric as our technology selection. For the rest of this section, we will take the business scenario of spare parts procurement as the specific business background to build an organization collaboration system. Then, we will analyze the business process, system architecture, data structure of the collaboration log, and design of the smart contract. In the spare parts purchase business scenario, it is mainly composed of two types of organizations, namely the spare parts purchasing organization and the spare parts supplying organization. Its business process is as follows:

1. The purchase module of the purchasing organization system calls the stock module of supplying the organization system to purchase.
2. The stock module reduces the inventory and returns the result to the purchasing organization.
3. After the purchasing organization receives the returned results, the purchasing operation is completed. Write the collaboration log to the blockchain.

Based on the above process analysis and the characteristics of Hyperledger Fabric, we propose a system architecture of our organization collaboration system, which is shown in Figure 3 [8]. We can find that architecture is mainly composed of the following components:

1. **Organization.** This component consists of at least an application and a database. Its main function is used for organization collaboration and collaboration log generation.
2. **Ordering service.** This component is a part of the Fabric network. It is mainly used to collect transactions, order transactions, and generate blocks. In our collaboration system, multiple order nodes form a cluster to provide services, using etcdraft consensus algorithm. In principle, each organization is not required to deploy an order node. Generally, there are five order nodes to ensure the high availability of the cluster, so only five organizations deploy the order node respectively.
3. **Peer.** This component is a part of the Fabric network. It is mainly used to store blocks. In principle, each organization should deploy at least one peer node.

For one thing, the collaboration log should be applied to future business scenarios as abstractly as possible. For another, the collaboration log can solve the current business scenario of procurement. Therefore, our collaboration log is mainly composed of four fields: (1) *id* donates the unique identity of the collaboration log, which is represented by UUID; (2) *from* donates the identity of the collaboration initiator; (3) *to* denotes the identity of the collaboration recipient. (4) *content* denotes the content of the collaboration log which saves an object and its structure can be extended by itself. In the purchase business scenario, *content* is used to store the calling module, the called module, and the returned result. We assumed that organization 1 is the purchasing organization, and organization 2 is the supplying organization. Then the JSON format of the collaboration log generated by them is as follows: 

```json
{id: UUID, from:org1, to:org2, content:{src_app: app1_purchase_module, dst_app:app2_stock_module, response: return_value}}
```

In order to write the collaboration log to the fabric, we need to abstract the collaboration log into the fabric state, which is composed of key and value. The part of the key is composed of string “LOG_” and collaboration log *id*, while the part of the value is the JSON format of the collaboration log. In addition, considering that the collaboration log is stateless, the smart contract of Hyperledger Fabric only needs to provide the interface for creating and querying the collaboration log.
5. Experiment

In this experiment, we simulate the business cooperation of three organizations, two of which are parts supplying organization and one is parts purchasing organization. These experiences are performed on a physical machine with Intel (R) core (TM) i7-9700k CPU@3.2GHz Processors and 32 GB ram, running CentOS 7.7(64 bit). We use VirtualBox to create three virtual machines. Each virtual machine is allocated with a single CPU, 4G ram, and running CentOS 7.7(64 bit), where each virtual machine represents the running node of an organization. We use the etcdraft as our consensus algorithm and the Stupid as our testing software to test the performance of the fabric network. The test content is the performance of creation and query of collaboration log which is mainly measured by TPS (Transactions Per Second). Considering that the max message count parameter of the block will affect the change of TPS, we adjust this parameter to observe the change of TPS, and the value ranges are 10, 25, 50, 75, 100, 150, and 200.

Fig. 4 shows the result of our performance test. From the experimental results, we can find that the TPS of query operation is higher than the create operation and the maximum TPS of query and create is generated when the max message count is about 150. Moreover, TPS grows linearly before the max message count is 50 and slows down between 50 and 150, and the performance decreases after 150.
6. Conclusion
In this paper, we have proposed a solution to the organization collaboration system which is applied in the spare parts procurement scenario. We give the design of the system including the system architecture, data structure of collaboration log, and smart contract. Moreover, we implement a prototype system and perform performance tests on the system. We find that the TPS will get the best performance when the parameter of max message count achieves almost 150. We believe this solution is feasible to build an organization collaboration system. In the future, we intend to extend our system to adapt to more complex organization collaboration scenarios.

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