Application of Computer Technology in Supply Chain Management

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Abstract. With the arrival of the era of "big data" and "Internet +", core supply chain enterprises find that systematically optimizing the collaborative process of supply chain information and exploring the economic value of massive information have a great impact on reducing supply chain cost and increasing enterprise income. This paper mainly studies the application of computer technology in supply chain management. This paper designs and implements a supply chain traceability system based on blockchain, including data synchronization verification, blockchain network structure, smart contract, data management and other sub-modules. The test results show that the system can realize the sharing and management of product data in the system from the aspects of security, timeliness and applicability. It provides exploration and practice for the implementation of blockchain technology in the field of product traceability.

Keywords: Computer Technology, Block Chain, Supply Chain, Product Traceability

1. Introduction

With the modern supply chain production and supply process becoming increasingly complicated, fragmented and geographically decentralized, the traditional technology and concept can no longer adapt to the modern supply chain management. Traditional supply chain in the process of information management, there are bottleneck: first of all, as the enterprise supply chain information flow, logistics and cash flow of the control system, the common complicated chain, more participants, form the network, so the information transfer share are affected by a certain timeliness, thus causing the bullwhip effect of supply chain. Secondly, although the centralized data management can also establish a collaborative platform, it is faced with the problem that the data is easy to be illegally tampered with and blamed. Finally, for consumers and regulators, when they want to know the production history of the products they buy, or to check whether every link is in compliance, under the traditional supply chain supervision system, such information can be traced back one to two weeks or even longer. Blockchain, as a cryptographic structure to store data in a chain, has core characteristics such as multi-party maintenance, data cannot be tampered with and easy traceability [1]. These characteristics coincide with the multi-party cooperation in supply chain operation management and the demand for enhanced information sharing and transparency, so they are considered as the key technical solutions to solve the problems of supply chain management. Applying blockchain to the
supply chain can track every link of the supply chain and improve the overall security of the supply chain.

For the application of blockchain in the supply chain, at present, some research and practice have been done at home and abroad. Keith et al. pointed out that supply chain cooperation can achieve seamless connection among various links, thus achieving low inventory and efficient response capacity of supply chain enterprises [2]. Shireesh designed a prototype supply chain system based on blockchain, smart contract and Internet of Things, aiming to achieve reliable and convenient traceability of supply chain information, and simulated each module in an experimental environment to verify the feasibility of the system [3].

By analyzing the characteristics of block chain and the problems in current supply chain operation, this paper designs a detailed information system of supply chain based on block chain. The system is divided according to the functional application modules of each link of the supply chain. According to the selected development tools, the functional modules of each link of supply chain are developed. Finally, implement the deployment of blockchain and traceability system, and test each module.

2. Supply Chain Traceability Framework Based on Block Chain

2.1. Architectural Design

This section proposes the product information traceability framework (PIT) based on block chain to make the product information traceable throughout the production process, which is convenient for suppliers to control the information of the production, transportation, storage and other aspects of the product, and also convenient for relevant departments to inspect the product information, thus improving the execution speed of various operations in the supply chain. According to the proposed Blockchain-based application development framework for supply chain management, we divide the data that can be stored in the blockchain into the following categories:

2.1.1. Digital documents. In supply chain management, all paper documents should be digitized, which can reduce management and transaction costs. Especially in international trade, a deal might involve a lot of paper, in the traditional business, these notes are often through the way of delivery, may have a time difference due to the delivery and shipping, will happen such problems as "the goods to the bill of lading is not to", digital files can speed up the supply chain in international trade certification process automation [4].

2.1.2. Internet of Things data. IoT devices are an integral part of product information traceability. It can provide us with all stages of production from production to processing information, such as temperature, humidity, chemical composition and other indicators. In product information traceability, Internet of Things data can provide consumers with better reference and help them understand the authenticity and usefulness of product information.

2.1.3. Transaction records. Blockchain system is essentially a decentralized distributed ledger in which every transaction is recorded in the system and cannot be tampered with [5]. Each user has an authenticated copy of the distributed ledger in which transactions can be seen. At the same time, product ownership is recorded in the transaction.

2.1.4. Product traceability label. Blockchain-based product traceability tags differ from RFID and barcodes in that it can be deployed without equipment, reading hardware, or any additional tags to the chassis or pallet. The traceability label is recorded in the module and attached to the product. When the ownership of the product changes, the ownership change of the traceability label is also recorded.

2.1.5. Intelligent contract execution records. Smart contracts provide a common programmable infrastructure in a blockchain system. When there are special transaction requirements, both parties
can deploy smart contracts that meet the requirements of blockchain [6]. All smart contract execution records are stored in the Block, providing detailed transaction records for stakeholders and providing retrospective resolution in the event of a dispute.

Aiming at different entities and business operation processes in the supply chain, and considering the various data involved in product information traceability, we proposed a product information traceability framework based on multi-level blockchain. Through more than a hierarchical block chain link chain and chain data and business, to ensure the data in a block chain efficiently and safely to applied to the actual business, the framework mainly includes four parts: information dynamic synchronous information (information encryption model), anchor model, key distribution model, product traceability labels.

2.2. Key Technology Solutions

2.2.1. Signature addition and verification. When each participant registers the link information, he/she needs to add his/her signature for the registered information. This paper designs a method for adding and verifying signatures. The process is as follows: First, the data to be signed is signed through the.sign() method in the Ethereum web3.js library to get the signature result, and then the result is stored in the blockchain, and the registration details are stored in the database. Inquirers to verify signatures, first read from the database to the detailed information of the query with keccak256 hash () calculation, and then read the signature from block chain as a result, the separating r, s, v series, and then calculate the hash value of received data, add ecrecover () function, if the function returns the data the sender's address, the verification success [7-8]. Signing and calculating keccak256() are done in JS, and verifying the signature is done in Solidity. Then, by mapping the sender's address to the name of the business, the name of the information publisher is obtained, which is directly displayed to the querier. The signature result and timestamp are stored in a structure in the blockchain, which is mapped to the structure by the ID of the goods to establish a one-to-one correspondence relationship between the goods and their information [9].

2.2.2. Enterprise credit management methods. In the research of multi-index comprehensive evaluation, the construction of reasonable evaluation index system is the premise of scientific evaluation. Generally, the principles to be followed in the design of the evaluation system include "comprehensive indicators", "non-overlapping" and "easy to obtain", as well as "scientific nature", "rationality" and "applicability" [10].

In this paper, the supplier's credibility is designed to be composed of the following three aspects: delivery performance index, average satisfaction score and cooperative enterprise's comprehensive cooperative choice index. Credibility is defined as the average of the three. The delivery performance index and cooperative choice index of cooperative enterprises can be calculated from the data automatically generated in the execution of other smart contracts before. The generation of satisfaction score requires a prerequisite operation, that is, the receiving party scores the shipper. After receiving the goods, the consignee can give an integer score within 0-100 on the platform according to its satisfaction with the delivery behavior of the supplier. A score of 0 is the least satisfied, and a score of 100 is the most satisfied. The following scenario is taken as an example to illustrate the implementation process of the credit management measures:

In several transactions in the supply chain, A serves as the supplier, B1, B2,..., Bn is the consignee of the transaction with A, then the calculation method for evaluating the credibility of A is:

$$R_A = \frac{1}{3}(C_A + S_A + P_A)$$  (1)

In formula (1), Ra is A's credibility, CA is A's delivery performance index, SA is A's average satisfaction score, and PA is the enterprises that have cooperated with A (B1, B2,..., Bn) comprehensive cooperative selection index of A. The full value of all three terms is 100, so the
maximum creditworthiness is also 100. The actual creditworthiness results in an integer between 0 and 100. The definition and detailed calculation rules of each part of RA are as follows:

\[
C_A = \frac{100 \cdot M_{Asuc}}{M_{All}} 
\]

\[
S_A = \sum_{j=1}^{n} \frac{\sum_{j=1}^{n} A_{B/A_{ij}}}{\sum_{i=1}^{n} N_{B/A}} 
\]

\[
P_A = \frac{1}{n} \sum_{i=1}^{n} \frac{100 \cdot N_{B/A}}{N_{B}} 
\]

3. System Implementation and Testing

3.1. System Implementation

The supply chain system runs on the blockchain network, which is built by super ledger Fabric and deployed in the Ubuntu operating system. After software installation and configuration is completed, Peer nodes, orderer nodes, application channels and organizational structure are configured.

According to the configuration file used in the prepared Cryptogen module, the traceability network in the blockchain system is built. The federation chain network consists of nine nodes, among which, an OrdererOrgS organization, an Orderer, is defined. The organization contains one node, and the Orderer node provides sorting service. The four PeerOrgS organizations, Org1, Org2, Org3 and Org4, respectively contain two nodes and one ordinary user. The first node in each PeerOrgS organization, peer0, acts as an anchor node to communicate with other organizations in the traceability network, and all nodes in the network can visit each other according to the domain name.

The configuration of the alliance chain network is saved in the file named crypto-config.yaml, and the cryptogen module is called to generate the configuration file used by the account system to initialize the Fabric network system. After the system is initialized, the Orderer node and Peer node are started, and then channels are created and added.

3.2. Performance Test

This paper tests and analyzes the performance of the blockchain supply chain system. When choosing as the underlying block chain system development platform, can decide whether to large-scale application of the key factors is to block chain platform of high and low performance, the most closely watched indicators for transaction throughput TPS, the index system reflects the block chain can deal with the number of transactions per second, per second if the TPS concurrency is too low, it is easy to cause the network congestion. This section tests transaction throughput TPS, transaction success rate, transaction latency, resource consumption (CPU/ memory/network IO) and other metrics. There are many factors that affect the performance of blockchain platform, such as server configuration, number of nodes in the network, etc.

Caliper is used as the test tool. Caliper is a block chain performance test framework. After the configuration file is defined, the performance test is conducted against the block chain network built in this paper, and a series of test results are obtained and HTML test report is generated.

4. System Test Results

4.1. Performance Test Results
Table 1. Performance test results table

| Test rounds | Type  | Sending rate | Average latency | Throughput |
|-------------|-------|--------------|-----------------|------------|
| 1           | Open  | 50 TPS       | 2.74s           | 24 TPS     |
| 2           | Open  | 150 TPS      | 15.38s          | 49 TPS     |
| 3           | Open  | 500 TPS      | 21.26s          | 47 TPS     |
| 4           | Query | 50 TPS       | 0.09s           | 49 TPS     |
| 5           | Query | 200 TPS      | 8.34s           | 82 TPS     |
| 6           | Query | 500 TPS      | 19.87s          | 77 TPS     |

As shown in Table 1, Open tests the writing performance of opening accounts and books, while Query tests the reading performance of querying accounts and books. A total of 3 rounds of tests were conducted for the OPEN test, and the transmission rates were set at 50, 150 and 500 respectively. According to the test data in the above table, when the number of requests per second reaches 150, the throughput reaches a peak of about 50 TPS. When the transmission rate continues to increase, the throughput fluctuates around 50. When the transmission rate is high, the data of transaction failure appears, but the overall success rate of the transaction is more than 99%. The measured transmission rate reaches the upper limit at around 450, which is less than the preset value in the test benchmark configuration file. Query is also tested in three rounds. The results show that the throughput peaks around 80TPS when the number of requests per second reaches 200. The measured transmission rate also reached the upper limit at about 450, and all transactions were successful.

For the OPEN test, when the number of requests per second is less than 50, the average transaction delay is about 2.5 seconds, and the response speed is fast, which can meet the basic needs of users to open accounts and write books. When the number of requests per second increases to more than 500, the transaction latency peaks at around 20 seconds and the response is slow.

For the Query test, when the number of requests per second is less than 50, the transaction latency is less than 1 second, the response time is fast, and the user can quickly return data when querying the ledger data. When the number of requests per second exceeds 500, the transaction latency peaks around 20. Overall, the transaction latency of the Query operation is lower than that of the Open operation.

4.2. Resource Consumption Test Results

The resource consumption test data were compared according to the number of test rounds. Since there are many types of resource consumption data measured, the following table only shows partial data of the two rounds of OPEN test for result analysis.

![Resource consumption Round 1 test results](image)

Figure 1. Resource consumption Round 1 test results
As shown in Figure 1, the transmission rate set in the first round of Open test is 50. Taking Docker node as an example, the average CPU occupancy is 19.53% and the average memory occupancy is 103.6MB at this time, which means less resource consumption.

![Figure 2. Resource consumption Round 3 test results](image)

As shown in Figure 2, round 3 of the Open test set the send rate at 500. Still taking Docker node as an example, the resource consumption was the largest in the three rounds of tests, with an average CPU occupancy of 32.75% and an average memory occupancy of 293.8MB.

In general system testing, it is required that the resource utilization rate of each application node should not be higher than 80%. For Ubuntu (Linux) system, it should be controlled below 65%. In the above test results, when the transmission rate reaches the peak of the system, the maximum CPU utilization rate will exceed 70%, but the average value is still below 50%, meeting the requirements of the system test.

5. Conclusions
Blockchain's multi-party maintenance, immutability of information, and smart contract support make it a reliable new way to break through supply chain solutions. This paper proposes a framework based on blockchain to solve the problem of product traceability in supply chain environment. In this paper, the blockchain based supply chain traceability system is implemented and tested. Starting from the sub-module, the supply chain traceability system is realized to run in the alliance chain network. The system development is elaborated in detail from the configuration of the blockchain network infrastructure, the realization of privacy protection, the realization of smart contract data structure and functional interface, and the interaction between the front end and the blockchain network. Finally, the function and performance of the system were tested, and the test results were analyzed. The Blockchain-based supply chain traceability system designed in this paper completed the main functions required for drug traceability, supplemented and realized the deficiencies of existing studies, and the system worked well as a whole.

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