Application of Block Chain Technology in Cross Border Food Information Tracing

Jing Sun* and Xueling Zheng
Health and Elderly Caring Industry School, Shandong Institute of Commerce and Technology, Jinan 250103, Shandong, China

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Abstract: In recent years, blockchain technology has swept the world, because of its complete integration of encryption algorithm, chain storage, consensus mechanism and other technologies, which makes it a transaction mechanism that can conduct business communication when distributed nodes are not familiar with each other. It breaks the traditional trading mechanism of centralized management, high cost, opacity and other problems. This paper mainly studies the application of blockchain technology in cross-border food information traceability. This paper proposes an improved PBFT algorithm based on node partitioning, introduces partitioning and credit mechanism into the PBFT algorithm, and describes the algorithm improvement process in detail. According to the consensus algorithm of improved Ethereum blockchain, a traceability design scheme of food supply chain based on improved Ethereum blockchain is designed. Firstly, the traceability process of supply chain is analyzed and a traceability process scheme based on blockchain is designed. Then, a traceability system architecture based on blockchain technology is established and the specific implementation method of the traceability system architecture is explained.

1 INTRODUCTION

With the improvement of people's living standards, consumers pay more attention to the quality and safety of products than to the basic needs such as price and variety. In recent years, food, medicine and other industries that are directly related to people's life and health have repeatedly experienced quality problems, which have significantly increased consumers' doubts about product quality and safety and their sensitivity to it (Tsang and Choy, et al. 2019). In recent years, such as "melamine", "inferior gelatin event", "longevity vaccine event" and so on product quality and safety incidents after exposure, these bad products not only harm the health of body and mind of the consumer, more sharply reduces the consumer's trust in the food and drug quality and safety, but also make the enterprise suffered huge economic losses (Tan and Gligor, et al. 2020). Therefore, it is imperative to establish an effective food traceability system. Using modern information management technology to assign a unique identification code to each product, the identification code records the relevant process information, which can realize the tracking and traceability of the product (Sharma and Jhamb, et al. 2020). Once quality problems are found after the products are marketed, they can be quickly traced out and recalled to reduce food safety risks (Pendrous, 2017). In addition to the food field, traceability technology has also been applied in the fields of medicine, tobacco, daily chemical industry and so on (Sander and Semeijn, et al. 2018). Based on the technological progress and the need of market competition, consumers can scan the QR code pasted on the goods through mobile phones to obtain the business unit, customs declaration number, entry time and other information of the goods, which has become a supplementary means for consumers to obtain information and government departments to master data (Mengjia and ZENG, et al. 2019).

The application of blockchain in the field of traceability has its unique advantages and is currently a hot research direction (Kamath, 2018). The retroactive application of blockchain technology also appeared in the world one after another (Deng and Feng, 2020). The European Union has established a series of food control systems to address food safety issues, and proposed for the first time that food can be traced back to the source of raw materials from the table (Gao and T-PBFT, 2019). The United States has

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issued a series of bills on food safety guarantee and risk control, elevating food quality management to the national level (Zheng and Feng, et al. 2021). The French government also proposed to establish a food safety traceability system, and the traceability information should cover the operation of each node of the food supply chain. India has also established a food traceability system, requiring enterprises responsible for production and processing to record the operation information of the whole process of food from raw materials to finished products (Han-Back and Moo-Sub , et al. 2018). Meanwhile, the processing company's own information should be prepared and recorded in the traceability label, so as to ensure that food can be traced back to the source of food production when consumers buy it (Zhao and Wu, et al. 2020).

Based on the blockchain technology and in combination with the cross-border food traceability project, the research of this paper aims at the problems in the cross-border food traceability system, and makes improvements on the consensus of the application of blockchain and the additional difficulties in nodes, so as to build an efficient and accurate traceability food production chain.

2 APPLICATION OF BLOCKCHAIN TECHNOLOGY IN FOOD TRACEABILITY

2.1 Blockchain - Based Traceability Architecture

Blockchain-based food traceability system architecture design, the architecture from bottom to top is divided into operation layer, data acquisition layer, network layer, data layer, display layer and user layer, a total of 6 layers, each layer corresponds to different technical applications and entity objects. Through iot equipment operation process of each link of the supply chain data, and through the wireless network transmission to the supply chain of each node, and then through the supply chain elected master node data information for the deal and food packaged into data information blocks, the entire network to reach consensus, chain block, block chain data will be stored in the block chain network, each node. The information on the chain can not be tampered with and is true and reliable. Users can trace the source of consumer food and inquire the production process of products through the development platform.

2.1.1 Operation Layer

Each link of the supply chain includes the selection and purchase of raw materials, food processing, processed food inspection, food warehouse storage, processed food packaging and packaged food sales. The raw material supplier shall purchase raw materials from the place of production in accordance with national regulations and company rules, and input the variety, quantity and source of raw materials into the system.

2.1.2 Data Acquisition Layer

When the whole supply chain is running, each stage chooses its own collection method according to its own characteristics. In the raw material procurement link of the supply chain, raw material information can be input through a handheld terminal and generate a two-dimensional code. Processing manufacturers can scan the two-dimensional code to check the detailed information of raw materials and verify the authenticity of the information when purchasing raw materials. Raw materials in the production line for processing, through the intelligent sensor raw material processing production environment in the process of information into the system, and generate the corresponding qr code information, quality inspection personnel on the inspection of qualified products to the food with food quality inspection information, such as processed foods after complete quality inspection and packaging will complete qr code information on the package. In the process of logistics transportation, an RFID tag is assigned to each package to facilitate the query of package information in transportation and transit warehouses. Consumers using mobile terminals can scan the QR code on the food package to understand the detailed operation of the food.

2.1.3 Network Layer

The network layer mainly uses wireless transmission technology. GPRS can provide users with long distance data transmission, and can realize the transparent transmission of collected data. ZigBee and WiFi signal frequencies are the same, but implementation standards are different. ZigBee has good stability, small data transmission and low power consumption, and is suitable for use in the production stage of raw materials. WiFi has poor stability, short transmission distance but large data volume, which is convenient and practical for consumers to query the detailed information of goods.

2.1.4 Data Layer

Each node of the supply chain detects data through Internet of Things devices and transmits it to its own platform via wireless network. After receiving the data, the platform will broadcast it to other nodes of the supply chain. Each node of the supply chain first selects the master node, and then the master node sorts the data information received according to the time stamp and packages a certain amount of data to generate blocks. Then the blocks are broadcast to other nodes of the supply chain, and consensus is reached on the generated blocks through DPOA and PBFT consensus mechanism and the blocks are linked up.

2.1.5 Display Layer

This layer designs the relationship between user authentication and data access rights and defines the block chain data access interface. For qualified users, they can query the information collected in the whole link of the supply chain through the data access interface and display the information to users in accordance with certain specifications.

2.1.6 User Layer

The user layer reflects the division of each link of the supply chain into suppliers, processing manufacturers, carriers, retailers, etc., as well as regulatory authorities according to their different functions.

2.2 PBFT Algorithm and its Improvement

2.2.1 PBFT Algorithm

PBFT is a distributed consistency algorithm based on state machine copy replication. To ensure the normal operation of the algorithm, a view replacement protocol, a checkpoint protocol and a consistency protocol are designed in PBFT.

2.2.1.1 View Replacement Protocol

In the PBFT consensus process, all node states must be consistent, that is, in the same view. A view contains a primary node and several other backups, all of which have the same view number V. The master node receives requests from clients in order of time, and initiates consensus protocol to broadcast requests to the slave nodes. View changes are triggered by a timeout mechanism that prevents the slave node from waiting indefinitely for the request to execute. If the slave node I does not receive the request sent by the master node in view v over timeout, the slave node will start the view replacement protocol and change the system view number v to v+1 to elect a new master node. In PBFT, assume that the set of all nodes is S and the node numbers are {0,1,2... , | S | - 1}, when from the node execution view change agreement, view code v + 1, the new master node number calculated as follows:(1)

$$p = v \bmod |S| \tag{1}$$

2.2.1.2 Checkpoint Protocol

The information of the PBFT consensus process is kept in the replica log, occupying the node memory, and the checkpoint protocol can be used to clean up the information and free the node memory. In the PBFT, when the sequence number of the execution request is divisible by some constant, a checkpoint S is generated from the node. Once the stability of the checkpoint S is proved, the slave node will discard all pre-prepare, prepare, and commit messages in its log with a sequence number less than or equal to S, as well as previous checkpoints and checkpoint messages. At the same time, the checkpoint protocol is used to set the next sequence number range: (2)

$$H = h + k \tag{1}$$

h is the sequence number of the last stable checkpoint, and K is the fixed value set.

2.2.1.3 Conformance Protocol

Consistency protocol is the core protocol of PBFT algorithm, which uses a three-stage protocol to broadcast requests to slave nodes, including pre-prepare, prepare and commit.

2.2.2 Improve the Model

In a large-scale distributed system, layering technology and agent technology are the basic technologies of large-scale computing and complex communication. The I-PBFT model proposed in this chapter is based on the concepts of layering technology and agent technology. In the i-PBFT algorithm, the consensus model is divided into two layers: the upper layer is the agent node region, and the lower layer is the consensus node partition. Each agent node in the upper layer of the consensus model is the local master node of a partition in the lower layer, and there is a global master node in the agent node. The PBFT conformance algorithm is performed within each partition, while the partitioning level is dynamic and the number of partitions can be changed as needed.

In the i-PBFT algorithm, the nodes in the whole network are divided into four categories: client, global master node, agent node and consensus node. In the algorithm, the nodes are partitioned first. In the process of node partitioning, the view replacement protocol of the original PBFT algorithm is changed in this paper, and the master node and agent node are selected according to the node credit value. One master node and several agent nodes are selected. Set the number of agent nodes as K. After the agent nodes are selected, the remaining nodes are merged into the partition where K agent nodes are located to form a PBFT consensus network with K partitions. In addition, the number of nodes of each type is variable throughout the network, and the total number of nodes is constantly changing.

3 MODEL SIMULATION EXPERIMENT

This paper uses Python language to implement a small multi-node blockchain experimental system, PBFT algorithm and I-PBFT algorithm proposed in this paper are simulated. The algorithms are compared and analyzed in four aspects: communication overhead, fault tolerance, transaction delay and throughput.

3.1 Transaction Delay

In order to test the trading delay of the algorithm, the client constantly initiates trading requests in the experiment and records the time of completion of each consensus. For the accuracy of the experiment, the average value of 100 transaction delays is taken as the algorithm's transaction delays, and the test is carried out in the case of different number of nodes to get the final results.

3.2 Throughput

In order to test the throughput of the algorithm in the same environment, the client was set to send 200 Transaction requests in the experiment, record the Transaction completion time, and then calculate the number of transactions completed Per unit time, namely TPS(Transaction Per Second), according to the data obtained from the experiment.

4 SIMULATION EXPERIMENT RESULTS

4.1 Transaction Delay Test

Table 1: Node delay comparison

	5	10	20	30	40
PBFT	0.12	0.47	1.27	3.14	4.96
I-PBFT	0.03	0.07	0.19	0.38	0.71

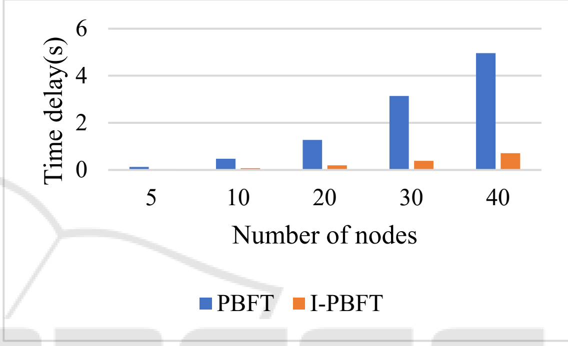

Figure 1: Node delay comparison

As shown in Table 1 and Figure 1, the transaction delay of the PBFT algorithm increases significantly with the increase of nodes, and the delay of the I-PBFT algorithm is far less than that of the PBFT algorithm. The average delay of PBFT is 1.99s, and the average delay of I-PBFT algorithm is reduced to 0.27s. With the increase of the number of nodes, the communication overhead of PBFT algorithm increases exponentially in the consensus process. In this paper, the node partition method is adopted to reduce the communication overhead of the node to about 1/4. Meanwhile, the four partitions synchronously carry out consensus, and the transaction delay is nearly 8 times lower than that of PBFT.

4.2 Throughput Test

As shown in Figure 2, the throughput comparison between i-PBFT and PBFT algorithm in the number of nodes from 15 to 50 is shown. The throughput of the I-PBFT algorithm is higher than that of the PBFT algorithm. The average throughput of the PBFT is 102TPS, and the average throughput of the i-PBFT is increased to 152TPS.

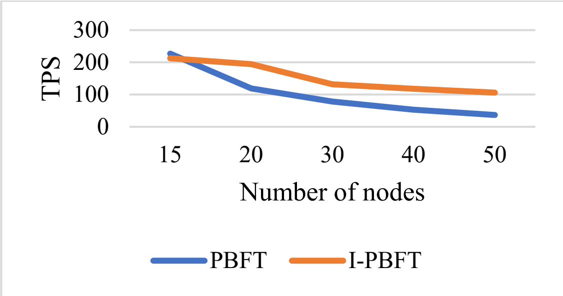

Figure 2: Throughput comparison

Compared with PBFT algorithm, I-PBFT algorithm reduces the communication times of nodes in the consensus process, effectively reduces the network communication overhead, and reduces the generation of malicious nodes through the node credit mechanism. Experimental results show that I-PBFT algorithm performs well when there are more nodes, and its delay and throughput are better than PBFT algorithm.

5 CONCLUSIONS

The main work of this paper is to solve the problem of cross-border food safety traceability. Due to the problems of centralization and information tampering in the cross-border food traceability system, the authenticity of food information in the whole traceability process cannot be guaranteed. Therefore, combining with modern blockchain technology to solve the problem of data centralization, food information is not controlled by a certain node or link of the supply chain. Through the analysis of the current food supply chain data acquisition mode and other industry data acquisition mode, this paper puts forward a comprehensive combining qr code and RFID solutions to solve the problem of food information collection, in combination with manual input of food processing environment parameters, such as planting, so that greatly reduces the traceability platform of supply chain operating costs. This paper designs an improved consensus algorithm based on PBFT, optimizes the consistency protocol, and proposes an improved PBFT algorithm for node partitioning based on credit, I-PBFT. The experiment proves that the consensus efficiency of the optimized consensus algorithm is improved, and the consumption of network communication is reduced, which proves the feasibility of the algorithm.

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