

Design and implementation of the food supply chain traceability system based on the blockchain

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Abstract. Traditional enterprise-level food supply chain traceability systems are notoriously expensive and complex to set up, but there is a solution that can successfully address both of these problems: the food supply chain traceability system. This study, on the other hand, suggests a blockchain-based food supply chain traceability system business system. The paper is concerned with the food supply chain traceability system. The authentication and authorization procedures, traffic scheduling, and settlement monitoring are examples of some of the operations that make use of the blockchain infrastructure. In the meanwhile, the throughput of the system is increased by making improvements to the consensus method. Users of this system can provide customized service needs for food supply chain traceability systems by using this system. The issue of locking up the system in the food supply chain traceability system is successfully solved by the system, which embodies a great deal of application potential inside the food supply chain traceability system.

Keywords: blockchain; food supply chain traceability system; smart contract; automatic settlement.

1. Introduction

Companies and food supply chain traceability systems generally make use of specialized multi-protocol label switching (MPLS) circuits in case of food supply chain traceability systems. This is done to assist in ensuring both security and dependability [1]. However, MPLS VPN (Virtual Private Network) special line has some shortcomings, such as food supply chain traceability system locking, inflexible control ability, and expensive price. The challenges that are faced by the current traditional food supply chain traceability system have been resolved thanks to the development of a food supply chain traceability system (software-defined WAN, food supply chain traceability system), which emerged as a result of the trend toward cloud computing and the convergence of cloud networks. Software-defined Software Defined Network (SDN) realizes better flexibility, efficiency, and controllable [2] by separating the control plane and data plane and developing programmable advantages, and the use of SDN technology in the food supply chain traceability system results in the formation of a service known as food supply chain traceability system. However, due to the fact that the majority of food supply chain traceability system controllers and CPE (Customer-Premises Equipment) equipment are tightly coupled together. When users move the food supply chain traceability system, there is a greater possibility that information on both sides has been tampered with. When attempting to utilize the food supply chain traceability system, users thus confront the challenge of preventing the system from being locked. This is not capable of meeting the rapid deployment and customization requirements of the food supply chain traceability system, which therefore places certain limitations on the growth of the food supply chain traceability system.

In this work, we present a blockchain-based food supply chain traceability system business system. This system will leverage the deployment mechanism of blockchain to give access function, and it will be implemented in the food industry, and automatically settle the amount through smart contracts, reduce the cost and improve efficiency. From the perspective of business entities, the system has three major entities: users, food supply chain traceability system, and third-party organizations. To resolve the issue of the consistency of the data throughout the whole network nodes, this study makes use of the blockchain consensus process. The chosen consensus method maintains the accuracy of the upper chain information by verifying the business processes that take place between the user and the food supply chain traceability system using a smart

contract. This ensures that the upper chain information is accurate. All the data on the chain can be used as the source of settlement parameters, and the blockchain zero knowledge certificate can protect the identity privacy of the user, the security calculation can protect the privacy of the transaction data, and the security chip can guarantee the secrecy of the contract code. Using blockchain technology to further improve the system, the system explored DPoA + PBFT as a consensus algorithm, expect to further improve the consensus efficiency, effectively solve the problems between users and multiple food supply chain traceability system authentications, contract signing, deployment, and tariff settlement. The aforementioned issues may be resolved by enhancing the performance of the consensus algorithm in order to boost the throughput of the system. It is believed that the study would pave the way for the creation of a blockchain-based system for the traceability of food supply chains.

A distributed ledger system is known as the blockchain, which is short for blockchain. It is maintained collaboratively by a number of parties, and encryption is used to provide security for both transmission and access. This makes it possible to store data in a consistent manner, makes it harder to alter the data, and avoids repudiation. The essential feature of blockchain is that in a distributed system, each node can maintain the consistency of data without the control of the central node, so it has the advantages of high reliability, transparency and credibility, forgery, and tamper-proof.

The blockchain system implements a variety of open sharing and node access techniques, [4] each of which is determined by the particular design system and application scenario being used. In general, the blockchain system may be deployed in three different ways: public chain, private chain, and blockchain. [5] These three modes are described below. The blockchain is used by a certain user group that has similar interests, and access to the nodes is restricted for those users. Only authorized nodes can be accessed, and authorized nodes can participate in consensus and data reading and writing according to the rules. The consensus mechanism of blockchain, [4], is more inclined to efficiency, which is a weakly centralized model and is more suitable for the business needs between enterprises.

Blockchain is widely used in the food supply chain system. In terms of blockchain technology and the food supply chain traceability system technology, the integration of the two will accelerate the development of both sides. Traditional networks have problems such as static deployment, long deployment cycles, and expensive costs, which restricts the deployment and communication of blockchain networks. Blockchain networks require the deployment of reliable, low-cost, public Internet links available to all users. Because the food supply chain traceability system supports real-time application performance and predictable service guarantee, the network deployment of the blockchain can be optimized through the food supply chain traceability system technology. In the research of the food supply chain traceability system, the researchers also actively apply blockchain technology to the food supply chain traceability system.

Due to the fact that the network of the food supply chain traceability system is susceptible to assaults, it is possible to put a blockchain layer between the application and control layers of the food supply chain traceability system [10]. Because of the immutable and tamper-proof characteristics of blockchain technology, as well as distributed storage and a multi-party consensus process, the food supply chain traceability system's network data can be trusted to remain secure and reliable. The telecommunication food supply chain traceability system is actively using its benefits in network resources and terminal resources. This may be found in the sphere of communication [11]. Mainstream telecommunication food supply chain traceability systems both in the United States and elsewhere have outlined blockchain-related enterprises. This is particularly true in mobile communication roaming situations, which have been the subject of much research [12]. For example, in traditional roaming communication, the network food supply chain traceability system is faced with [13] problems such as a large number of roaming contracts, difficult deployment, and automated settlement. These problems will be more prominent, especially when roaming and 5G applications become more common. In February 2020, Telekom innovation laboratory based on blockchain building telecom roaming business system, simplify the network food supply chain traceability system between wholesale roaming, wholesale voice and on-demand data in the field of business use

case process, between the food supply chain traceability system, can achieve mutual trust to automated business process, provide better communication services for mobile users.

Referring to the roaming scenario of mobile communication, food supply chain traceability system users through the tunnel access to the food supply chain traceability system, technically can also switch between the food supply chain traceability system through flexible scheduling, but currently, users schedule between different food supply chain traceability system, flow scheduling, and statistical information is not trust, flow information tampering is likely to occur. Therefore, consumers are only given the option of selecting a single food supply chain traceability system, which results in the more visible issue of locking the food supply chain traceability system. This study analyzes the business system of a food supply chain traceability system based on blockchain, which can effectively handle the issues of authentication and contract signing. The purpose of this exploration is to find a solution to the problem of mistrust, deployment, and tariff settlement between users and multiple food supply chain traceability systems, and can enhance the throughput of the system through an improved consensus algorithm.

2. System architecture design

This paper proposes a blockchain-based food supply chain traceability system business system, which uses the deployment mode of blockchain to provide access function, and automatically settle the amount through smart contracts, reduce the cost and improve efficiency. From the perspective of business entities, the system has three major entities: users, food supply chain traceability system, and third-party organizations.

2.1. Blockchain part

This system adopts the deployment mode of blockchain. The participants of blockchain include the food supply chain traceability system, users, and third parties. Blockchain is mainly responsible for the contract signing, scheduling, network quality information recording, and automatic settlement.

2.1.1 Blockchain deployment mode

A Smart contract is a piece of code running in a blockchain virtual machine or container, which is used to control the transaction process and ensure the consistency and integrity of the transaction data. In this system, it is used to realize the business functions such as signing and settlement, identity verification and authorization, data investigation, and evil punishment between users and the food supply chain traceability system. Smart contracts are divided by function, specifically as follows:

(1) Identity verification and authorization authentication module: responsible for identifying the reading and writing permission of users and the food supply chain traceability system.

(2) Signing module: responsible for the signing of multi-party contracts.

(3) Bookkeeping module: responsible for obtaining scheduling and network quality records from the collection system during the scheduling process.

(4) Settlement module: it is responsible for settling the bills between the users and the food supply chain traceability system.

(5) Penalty module: responsible for recording the violations of the food supply chain traceability system, the third party, and the users, and being used as proof for the later punishment.

2.1.2 Blockchain scheduling mode

In the scheduling process, the scheduling module in the food supply chain traceability system dispatcher obtains the contracted data to the blockchain, and the information on scheduling and network quality is added to the blockchain by the acquisition module in conjunction with the data processing module. The blockchain, using the consensus method that has been chosen, checks the information of one bookkeeper and two parties to guarantee that it is accurate. This is done so that the upper chain can be trusted. The chain structure of the blockchain ensures the immobility and traceability of the upper chain information, which provides a data source for automatic settlement.

2.1.3. Automated settlement

Users and the food supply chain traceability system client upload the traffic and price data to the blockchain, while the food supply chain traceability system client will upload the network scheduling records to the blockchain. All the data on the chain can be used as the source of settlement parameters, and the automatic settlement can be completed by calling intelligent contracts. In this way, the data traceability, intamability, and accuracy of the settlement amount are guaranteed, but also easy for supervision.

2.2. Non-blockchain part

The non-blockchain component is comprised of the following four subcomponents: the client, the food supply chain traceability system components, the operation management module, and the business system that manages the users of the food supply chain traceability system. The food supply chain traceability system and the user are, respectively, the supplier and the user of the network traffic. They are both considered to be part of the user group. A third-party organization has the capacity to administer the basic components and operation management module of the food supply chain traceability system. The intelligent network scheduling that is performed by the food supply chain traceability system is determined by the data included in contracts as well as the quality of the networks. The components that make up this system may be broken down into the following categories: scheduling, acquisition, data processing, network probing, and scheduling agent. The scheduling module is the one that is in charge of organizing the schedule for the network. Real-time traffic acquisition is the responsibility of the acquisition module, which is accountable for both ends. Data processing is the responsibility of the data processing module, which sits between the scheduling and acquisition modules. Additionally, the network probe and scheduling agent are installed on the user's device as well as the devices that make up the food supply chain traceability system. The operation management module is a centralized system, that provides operation and maintenance functions for the blockchain. It is responsible for membership authentication, license access management, node, application access management, through CA (Certificate Authority) account or node authentication submodule, and is responsible for certificate management. The client is the medium for interaction with the blockchain. Users register the blockchain account through the client and authenticate their identity by inputting identity information or unit qualification information. After obtaining the user access certificate after passing the authentication, they can call the blockchain light node to connect to the blockchain network.

3. System function module and process

The blockchain function module of this system can be divided into four links: license management, contract scheduling, tariff settlement, and data adjustment, which are specifically expanded as follows.

3.1. License Management

Certification and authorization is an indispensable function of the blockchain platform, based on the blockchain of food supply chain traceability system business system aims to build a blockchain platform, control users, applications, node access, to want to join the platform of blockchain users and their deployment node identity authentication and permission management, create a credible trading environment. Users and nodes will need to sign authentication using access certificates in order to participate in the blockchain. Users that connect to blockchain device apps such as clients and node devices are required to load CA certificates before they are able to interact or perform services inside the blockchain. These CA certificates include communication licenses and service licenses. In the system, the authentication means that all the users who add to the blockchain and the nodes they have will conduct an identity information audit, including ID number, organization code, relevant qualifications, etc. After passing the authentication, the CA system is called to issue certificates to the users or nodes, giving them permission to enter the blockchain network.

3.2. Signing and scheduling

First food supply chain traceability system for blockchain license management process, through the access end connected to the blockchain platform, when the food supply chain traceability system to join the platform, food supply chain traceability system with a third party signed network quality contract, the contract records the network quality parameters and price settlement method, signed after the food supply chain traceability system to join the platform, the contract uploaded to the blockchain platform. Then the user joins in the blockchain license management process, through the access end connected to the blockchain platform. When the user joins the platform, the user signed a contract with a third-party demand. The contract records of the user required network quality parameters, signed after completing the user joins the platform. The contract is uploaded to a blockchain platform, generated the smart contract also provides the settlement, punishment, etc. After the signing, the food supply chain traceability system is responsible for intelligent network scheduling according to the signing data and network quality. The food supply chain traceability system includes a scheduling module, acquisition module, and data processing module. The acquisition module regularly obtains the network quality data from the user and the food supply chain traceability system network probe and sends it to the scheduling module. The scheduler of the food supply chain traceability system obtains the contract data from the blockchain platform, and the scheduling module schedules the best food supply chain traceability system for users according to the contract data and network quality data. And in the process of communication, the scheduling module according to block from the block demand contract data and acquisition module real-time push network scheduling quality data, judge the user connected network food supply chain traceability system provides network quality meets the requirements, if not meet the requirements, directly from the user signed food supply chain traceability system screening optimal food supply chain traceability system, network switch.

3.3. Fee Settlement

Rate settlement process initiated by the food supply chain traceability system, food supply chain traceability system using the client call smart contract trading, smart contract execution settlement module, can read from the books to this period of time using the food supply chain traceability system service each user used the total flow, and calculate the amount respectively, finally write the execution results into the books, written data cannot be tampered with. Users can make external payments based on the amount of data in the ledger. Since then, the automatic tariff settlement during this period will be completed.

Choosing the food supply chain traceability system to initiate settlement transactions is considering that the core goal of the system is to enable the food supply chain traceability system and users to do point-to-point settlement, while the third party organization only plays the role of supervising and providing services. Therefore, the initiative is still in the user and the food supply chain traceability system. However, owing to the inconsistent equipment of the user, the system that tracks the supply chain of food takes the primary responsibility for conflict resolution.

3.4. Data adjustment

In order for the system to function properly, some data will need to be modified. Changes in user demand parameters, modifications to the parameters and pricing of the food supply chain traceability system, repairs to inaccurate data on the chain, fines imposed by the food supply chain traceability system, and so on are examples of such changes.

3.4.1 Adjust the demand parameters

There will be a time term in the user's demand contract, which is negotiated by both parties. During this period, users cannot change their demand parameters, which is to ensure the interests of the food supply chain traceability system and the efficiency of the system. After this period, users can apply for the adjustment of the demand parameters.

3.4.2 Adjust the parameters of the food supply chain traceability system

There is also a time limit in the network quality contract of the food supply chain traceability system, which is negotiated by both parties. However, considering the particularity of the food supply chain traceability system network, if an emergency leads to a temporary modification of the parameters, you can apply to a third party and make an adjustment after passing the audit. In addition, in the case of an emergency, the food supply chain traceability system can apply for an emergency change of the food supply chain traceability system parameters. However, the food supply chain traceability system emergency application has a certain number of restrictions and can be changed after the external audit. In this way, the food supply chain traceability system can directly apply to a third party to adjust the network quality parameters without considering the time period of the current contract.

3.4.3 Change Error data

Users or food supply chain traceability system after finding traffic or settlement data problems, report to the third party, send a verification request to the scheduling module and acquisition module, the scheduling module and acquisition module to verify through local cache records, then send the verification results to regulators, the third party according to the investigation call smart contract, smart contract execution differential adjustment module, differential adjustment data into the books, the third party to notify the user or food supply chain traceability system handling the result of this event.

3.4.4 Punishment process

Users shall report to a third party after discovering the network instability or quality problems provided by the food supply chain traceability system. The third party can verify the situation in three ways, namely:

- (1) Verify the network quality with the food supply chain traceability system probe;
- (2) Verify the quality of the network with the acquisition module;
- (3) Verify the situation with the sensor and acquisition module of the food supply chain traceability system.

The third-party selects a way to verify. After receiving the network quality situation, analysis, and judgment, and then calling the smart contract, the smart contract execution punishment module generates the punishment contract transaction. After the punishment record is written into the ledger, the third party will notify the user and the food supply chain traceability system. Moreover, over a period of time, the scheduling module will reduce the chance of problematic food supply chain traceability systems providing services, as a punishment that do not meet the network quality requirements.

4. System consensus algorithm optimization

4.1. Consensus algorithm

Consensus reaching in distributed systems relies on reliable consensus algorithms, which often address the question of which node initiates the proposal in the distributed system, and how other nodes agree on this proposal. The mainstream consensus algorithms of blockchain are PBFT (Practical Byzantine Fault Tolerance), Raft, DPOS (Delegated Proof of Stake), and so on.

4.2. Selection and optimization of the consensus algorithm

In this system, the design is based on blockchain, but because of the special application scenario of network scheduling, and the hope that more users and food supply chain traceability system can add to this system, the existence of evil nodes cannot be completely eliminated in the design. Therefore, this system adopts a PBFT consensus algorithm that can accommodate fault nodes and evil nodes. PBFT algorithm can accommodate fault nodes and evil nodes, high security, using

encryption technology to prevent deception attacks and replay attacks. The technique has a high consensus efficiency and a consensus latency that ranges between about 2 and 5 seconds. The requirements of commercial real-time processing and the desire for high-frequency transaction volume are both essentially satisfied by this technology. However, the PBFT method is not capable of facilitating the successful arrival of a consensus by a large number of nodes. When there are a large number of consensus nodes, the overall operational efficiency is reduced. To solve the greatly reduced efficiency of the PBFT consensus algorithm with a large number of nodes, we optimized the consensus algorithm. According to the idea of DPoS, the DPoA consensus mechanism applicable to this system is proposed. Different from traditional DPoS, DPoA does not randomly select consensus nodes according to the number of tokens or coin age as the election standard but takes the whole nodes' storage capacity and network stability as measures to obtain better fairness and network efficiency. This system uses DPoA + PBFT as the consensus algorithm. The PBFT algorithm reduces the exponential-level Byzantine protocol running complexity to the polynomial level, realizing the consensus of the strong node consistency and high efficiency in a distributed environment. The number of PBFT algorithms' processing of transactions (Transactions Per Second, TPS) per second is about 400-800, which is greatly more efficient compared with the Bitcoin 7TPS and about 20TPS of the Ethereum blockchain. The DPoA algorithm solves the problem of many consensus nodes and greatly reduced the efficiency of the PBFT algorithm, obtains higher availability, and further improves the consensus efficiency. In the business process, when there are many nodes, DPoA + PBFT algorithm is used to select consensus nodes through DPoA algorithm, and then reach consensus through PBFT algorithm to broadcast the new block. When there are fewer nodes needing to reach a consensus, only PBFT is needed to reach a consensus. The blockchain food supply chain traceability system will benefit from the improvement of the consensus algorithm, which will further increase the efficiency of the consensus process.

4.3. Test and analysis

The foreground and the backdrop are the two components that make up the system. The Hyperledger Fabric 2.0 project framework, together with Docker, Git, and a number of other technologies, is used in an environment based on the Ubuntu operating system. The front end is written in goweb, while the back end is developed in the go programming language. It is possible for it to meet the actual needs of the food supply chain industry chain through the design of smart contracts, which also allows it to solve the problems associated with the traditional food supply chain traceability system, which includes the ease with which information can be tampered with, opaque information, and low storage security. Based on this, the blockchain system is implemented by using the HyperledgerFabric platform, which has higher security and credibility than the traditional traceability system.

As can be seen from Figure 1, when the frequency chain is the same, the total response time of the traceability information increases with the larger size of the traceability information, but the average time does not change significantly, below 3.0 ms. From Figure 2, as the scale of traceability information increases, TPS fluctuates around 30.

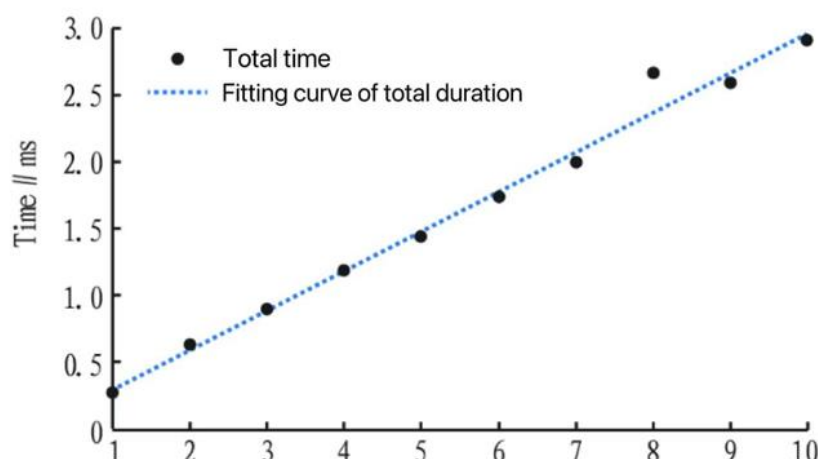


Fig.1. T P S performance test diagram

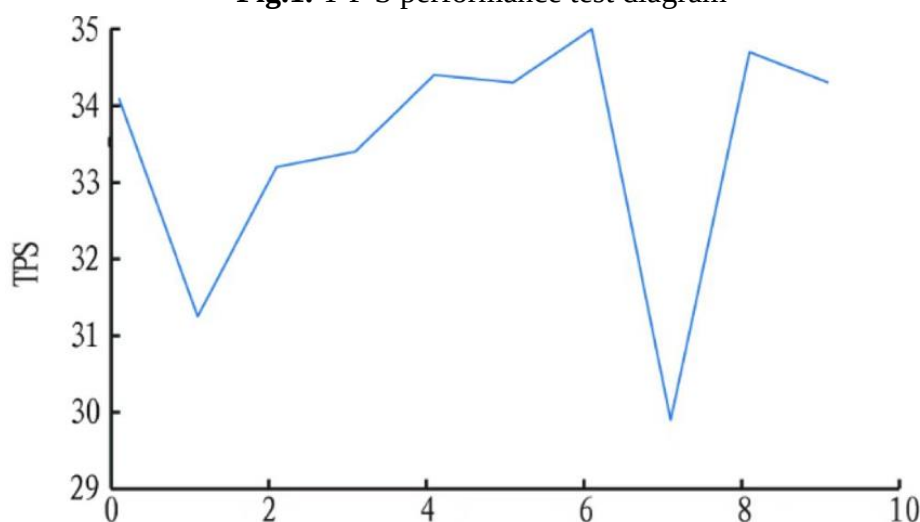


Fig.2 Upstrand response time test

As can be seen through the test, based on blockchain food supply chain system response time under the same request frequency, under different traceability information scale is stable, that the system has stability, the chain time is millisecond level, scalability is for food supply chain consumers, producers, market supervisors of food supply chain trusted traceability system.

5. Conclusion

The possibilities of low-cost and readily available Internet connectivity may be used by businesses to develop enterprise-level food supply chain traceability systems, which are made possible by food supply chain traceability systems. Because of this, there is less of a need to rely on costly conventional business WAN communication technology. Tunneling technology allows users of the Food Supply Chain Traceability System to quickly and easily access both the Food Supply Chain Traceability System and the Food Supply Chain Traceability System. This technology also helps users save money by reducing the need for traditional MPLS VPN leased lines, which are very expensive. However, since most food supply chain traceability system controllers are tightly coupled to CPE (Customer-Premises Equipment) equipment, And when users switch to the food supply chain traceability system, Both parties have unbelievable problems, Very likely, such tampering with traffic information, Therefore, at present, users are faced with the problem of food supply chain traceability system locking when using the food supply chain traceability system, Unable to meet the personalized and agile deployment, To some extent, restricting the development of food supply chain traceability system, In order to solve the problem of food supply chain traceability system locking faced by users,

The blockchain-based trusted quality control and traceability system of food supply chain for consumers, producers and market supervisors is proposed.

This paper combines the food supply chain traceability system with blockchain technology to give a specific system architecture and puts forward a blockchain-based food supply chain traceability system business system. When it comes to concepts, the tamper-proof quality of blockchain technology for data storage enables the reliable storage of numerous schedules and data collecting. This is accomplished via the use of the distributed ledger. When scheduling user traffic across the food supply chain traceability systems, this has the potential to overcome the issue of reciprocal trustworthiness across the systems. This necessitates the redesign of business function modules as well as interface activities like contracting, scheduling, collecting, and settlement of conventional network and food supply chain traceability systems. This technology combines the blockchain platform with the food supply chain traceability system so that it may be compatible with both the conventional network and the system for tracing food supplies throughout the supply chain. It also keeps the control interface between the food supply chain traceability system and the user/food supply chain traceability system equipment, as well as the data interface between the user equipment and the food supply chain traceability system equipment. This is in addition to keeping the data interface between the user equipment and the food supply chain traceability system equipment. Food supply chain traceability system and user/food supply chain traceability system equipment as the client and block chain communication for data upper chain and acquisition, Through this system, can effectively solve the problems of authentication, contract signing, deployment, and tariff settlement between users and multiple food supply chain traceability systems, An upgraded consensus algorithm is another method that may be used to boost the throughput of the system. Through this system, the user can put forward personalized food supply chain traceability system service demand, by the system between the user and different food supply chain traceability system automatic, tamper flow scheduling and settlement, when the food supply chain traceability system default, user flow can be automatically switched between the food supply chain traceability system, effectively solve the problem of food supply chain traceability system lock.

There are still some deficiencies in this paper, It incorporates the features of the blockchain, But the current blockchain technology is not mature, Chain speed and consensus efficiency also need to be improved, in addition, Although the compatibility is high in the loose-coupling mode, the scheduling algorithm of food supply chain traceability does not realize the upper chain, In the future, we will consider reliably running scheduling algorithms for food supply chain traceability through smart contracts, however, because the scheduling algorithm of food supply chain traceability is very complex, Running on smart contracts leads to a significant reduction in the scheduling algorithm performance, Future work direction based on this problem for in-depth research, Make further improvement and improvement.

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