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ORIGINAL ARTICLE

Analysis of coordination mechanism of supply chain management information system from the perspective of block chain

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Abstract

Block chain technology can save a lot of intermediary cost by means of decentralized distributed structure, and can solve the problem of data tracking and information security by means of unauthorized timestamp. The security trust mechanism can solve the core defects of the current Internet of Things technology. The flexible programmable characteristics can standardize the existing market order, help to enhance and create trust, and change the mode of cooperation and business cooperation between people. By setting up scenario application mode based on block chain, such as block chain credit financing, block chain procurement financing, etc., we can achieve the goal of shortening the time of supply chain management, improving the quality and meeting the demand. In this paper, the process of supply chain management information system and the key technology of block chain are analysed, and the collaborative mechanism of supply chain management information system from the perspective of block chain is proposed, including the process and consensus collaborative management mechanism, which optimizes the transaction process management and block chain system consensus, accounting and so on. On this basis, the supply chain management information system platform architecture under the collaborative mechanism is designed, which provides a reference path for the performance improvement and platform architecture design of data transaction system based on block chain.

Keywords Block chain · Supply chain management · Information system · Collaborative analysis

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1 Introduction

In recent years, block chain technology has attracted great attention from academia and industry. Many scholars believe that block chain technology is the revolution of Internet technology in the future and a great innovation of information technology. The main characteristic of block chain technology is decentralization, which is a basic protocol of global credit based on cryptographic algorithm. Specifically, Block Chain is a distributed bookkeeping technology based on the Internet (Lee et al. 2015; Kaijun et al. 2018). Bitcoin is a successful application of Block Chain technology, because the books are shared by many parties and can not be usurped. In this paper, block chain technology is applied to supply chain management (SCM), and a dynamic multi-center collaborative authentication model based on block chain is proposed (Bai et al. 2015). The block with time stamp is a strong proof of its existence. Each time stamp incorporates the information of the previous timestamp into its random hash value to enhance the previous timestamp information.

With the rapid development of the new generation of information technology and the improvement of the degree of social informationization, data shows an explosive growth pattern. Data has become a key factor of production and a strategic resource with great potential value. Data transaction circulation has become an important means of value realization, and supply chain management information system has become a hot topic of social research and concern. Different from the traditional commodities, because of the uniqueness of the data, the traditional trading mode and platform operation mode can not well protect the interests of both sides of the transaction and there are certain hidden dangers in the transaction process (Pezeshki et al. 2013; Kaijun et al. 2015). The emergence of block chain technology brings a credible environment for data transaction because of its characteristics of decentralization, trustworthiness and traceability, which makes the trust of both parties to the platform or organization transfer to block chain technology (Bi and Wang 2016). Supply chain management information system based on block chain has become an important direction in the field of data transaction. Because the block chain technology is in the early stage of development, there is a certain gap between the platform and system processing performance, efficiency and the actual transaction scale and requirements, it is necessary to make the platform or system better adapt to the actual business needs through appropriate means.

Although the above literature has thoroughly studied on the supply chain management information system and the application of Block Chain, there are still some key issues to be resolved.

(1) Adaptive rent-seeking and matching between resources supply and demand sides.

The Supply Chain Management Information System is a distributed system. The supply and demand of the public service platform are decentralized and scheduled according to the characteristics of agricultural business resources such as dispersity, magnanimity, randomness, commonweal and heterogeneity. At present, the public service platform has not established the adaptive rent-seeking and matching mechanism of resources, and the utilization ratio of the agricultural business resources and the overall benefit of the system are not ideal. This can not only increase the transaction cost, but also make resource demand and supply parties withdraw from the strategy choice behavior of the public service platform (Hai et al. 2018).

(2) Security and transparency of transaction information and privacy of user information.

On the one hand, the public service platform should ensure the security and openness of transaction information. On the other hand, the privacy of user information should be guaranteed. The existing public service platform does not have a mature and reliable information security mechanism, which cannot guarantee the security and transparency of rent-seeking and transaction, or the privacy of user information (Ke et al. 2018). This is likely to cause unauthorized access to and tampering with information on public service platforms, illegal misuse or misappropriation of the right to allocate and use resources, and the risk of deferred payment.

(3) SCM information system credibility.

Public service platform is a decentralized intermediary organization without the leading or direct participation of government departments, and it is difficult to establish its credibility. This may lead to the risks of illegal operation of public service platform, false publication of information about demand and supply of agricultural commercial resources and malicious breach of contract, which will undoubtedly harm the interests of the public service platform participants. Therefore, establishing the credibility of public service platform through technology rather than power is the key to set up the distributed scheduling and management model of agricultural commercial resources based on public service platform.

In order to solve the above problems, this paper proposes a novel SCM information system based on block chain, and introduces it to the public service platform to provide the running environment and technical support for the public service platform. The block chain can provide distributed rent-seeking and matching mechanism for decentralized public service platform. According to the requirements of different types of information on the public platform, it can provide security guarantee mechanism for the public platform, so as to greatly improve the utilization rate of agricultural business resources, the credibility of the public service platform and the overall efficiency of the system.

2 Block chain concept and its core technology

2.1 Block chain concept

The concept of block chain appeared earlier in Komoto's Bitcoin White Paper, but it was stated in the form of workload certification chain rather than block chain.

In 2015, The Economist published a cover article entitled “The Promise of the Blockchain: The Trust Machine”, arguing that block-chain technology is a technology that creates trust and has a tremendous impact on changing the way people collaborate and business collaborate. The development of block chain has not yet been accepted. Swan M proposed that block chain technology is a de-centralized database with both openness and transparency. China’s Ministry of Industry and Information Technology proposed in its white paper that block chain is a new application paradigm based on computer distributed data storage, point-to-point transmission, encryption algorithm, consensus mechanism and other technologies. Block chains can be generally understood as an Excel table without central management, which has limited functional permissions, such as “add”, “query”, “modify”, “delete”. The table also stores different contents for different tasks. In essence, a block chain is a rule, and in general, it is a process in which a group of people who abide by the rule jointly record contact information (Guo et al. 2013). From the name itself, the block chain is a system composed of blocks and linked by chains; from the form of expression, the block chain is a distributed account; from the technical point of view, the block chain is a distributed chain database. From the point of view of usage, block chain is a credit carrier with high reliability; from the point of view of users, block chain is an information sharing platform without third parties. From the perspective of social development, block chain is the next generation of infrastructure in the process of social development, is an infrastructure to solve the credit problem, based on such infrastructure all social activities will be credible, people can rely on across the credit barrier to return to the essence of things. The block chain and the literature research on the supply chain related to the block chain are shown in Fig. 1.

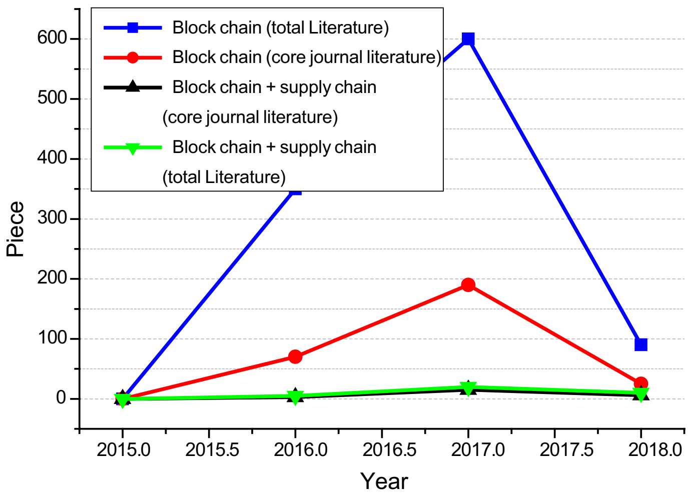


Fig. 1 The correlation between block chain and supply chain research literature

2.2 Block chain core technology and its value

(1) Block chain core technology.

Block chain is essentially based on modern database technology, Internet technology and modern cryptography technology. The application modes of computer technology, such as distributed data storage, point-to-point transmission, consensus mechanism, encryption algorithm and so on, still return to the technical dimension, involving a wide range of aspects. Here we only briefly describe the common representative technologies (Chen and Song 2014).

1. Distributed account books. Transaction accounting is performed by multiple nodes distributed in different places, and each node records a complete account, which can participate in monitoring the legitimacy of the transaction.
2. Asymmetric encryption and authorization. The transaction information stored on the block chain is public, but the account identity information is highly encrypted and can only be accessed under the authorization of the data owner, which can ensure data security and personal privacy.
3. Consensus mechanism. It is not only a means to identify, but also a means to prevent tampering that the checkout nodes reach a consensus and determine the validity of a record.
4. Intelligent contracts. Based on these trusted and unauthorized data, some predefined rules and clauses can be executed automatically.

(2) The value of block chain technology.

1. Decentralized distributed structure can save a lot of cost of intermediary structure, and can be applied to the centralized area of the system, dealing with some transactions originally brokered by intermediaries.
2. Tampering timestamp can solve data tracking and information security problem. Block chain technology provides an innovative means for information security and data tracking. The data blocks in the block chain are connected sequentially and form a data chain which can not be tampered with. The timestamp attaches a set of real data which can not be forged for all transactions. It is very helpful to crack down on counterfeit and inferior behaviour in real life.
3. The security trust mechanism of block chain can solve the core defects of the current Internet of things technology. The traditional Internet of Things (IOT) model collects and manages all data and information by a centralized organization. It is easy to cause data loss and tampering due to life cycle and security problems of equipment. Block chain technology can build the trust consensus of the whole network without trusting a single node, which can solve some core defects of the current Internet of Things technology.

4. Flexible programmability helps to standardize the existing market order. At present, the market order of the society is still not standardized enough, such as the government's subsidies for agriculture, the misappropriation of charitable funds and so on. By using the programmable property of block chain technology, we can embed a piece of code to specify the future use scope of the assets while transferring the assets, so as to solve the above problems thoroughly.

2.3 Block chain technology breaks the bottleneck of traditional supply chain information management

(1) Integrate and reflect real time information in all links of supply chain E.

Block chain can build a platform which includes suppliers, manufacturers, distributors, retailers, logistics and other supply chain links. On this platform, all enterprises form alliances, record the logistics, information flow and capital flow on the chain, track and supervise all the dynamic of the supply chain in real time, and realize the collaborative work. In this way, the core enterprises can penetrate all the supply chain production, quality, logistics and other information, making the whole supply chain transparent, visualization, emergency can quickly locate and respond.

In addition, block chains allow multiple participants in each transaction to access the same transaction record without third-party intermediaries, so they can verify the transaction and identify the transaction. Each transaction has time stamps and can be verified in real time. After the information of supply chain is transparent, the purchasing cost and inventory cost of enterprises will be reduced, and the financial audit will be more concise (Carrus and Pinna 2013; Chen and Su 2016). For example, MM Global Finance facilitates the credit operations of more than 4000 suppliers and partners, handling as many as 2.9 million invoices a year. At present, using block chain technology, III M has reduced the time spent on dispute settlement from more than 40 days to about 10 days, and saved about $100 million in costs. Combined with the Internet of things technology, block chain can also achieve strong sharing of logistics information and coordinate logistics activities. Manufacturers and retailers can also significantly increase the accuracy of demand forecasting and inventory replenishment capacity. Maersk, a world-renowned shipping company, is working with MM to establish an alliance chain among customs, ports, freight forwarders and agents to track the dynamic information of tens of millions of shipping containers in real time. The technology is expected to save about $1.0 billion for Maersk's shipping business.

(2) Sharing books, enhancing product anti-counterfeiting ability and ensuring product quality.

Block chains, as a large-scale collaboration tool, effectively solve the problem of multi-agent information sharing and complex transaction costs by decentralization and mutual trust mechanism. This paper establishes the foundation of supply chain logistics information resources management, and summarizes and analyzes the overall model of supply chain logistics information resources management from three aspects: object dimension, attribute dimension and function dimension, as shown in Fig. 2.

Block chains have transformed the information ownership model from single owner ownership to account information shared by all participants throughout the life cycle of the transaction. It is based on the state of information rather than the transmission of information. In the past, vague information is now clearly visible. At the same time, the block chain is the public issue of ledger, ledger is a decentralized structure, neither party has the ownership of ledger, nor can it manipulate data according to their own wishes. Trading is also encrypted and immutable, so block chains are basically impossible to crack and tamper with. In this way, products can be traced back to any stage of their raw materials (Yang 2013). Recently, Jingdong is working with IBM to study the use of block chain technology in the supply chain traceability, in order to protect the quality of goods. Jingdong allows every commodity to have a unique identity ID. Users get the goods, sweep this ID can be traced back to the commodity's origin, raw materials, suppliers, storage, transportation, production and other information, and these information can not be tampered with. Because identity D is unique, fraud or fraud, or illegal transactions, can be detected. In addition, block chains also speed up the response to emergencies. Once the problem occurs, the block chain can trace the entire process of commodity production to the source, within a few minutes to determine which link of the problem, so as to

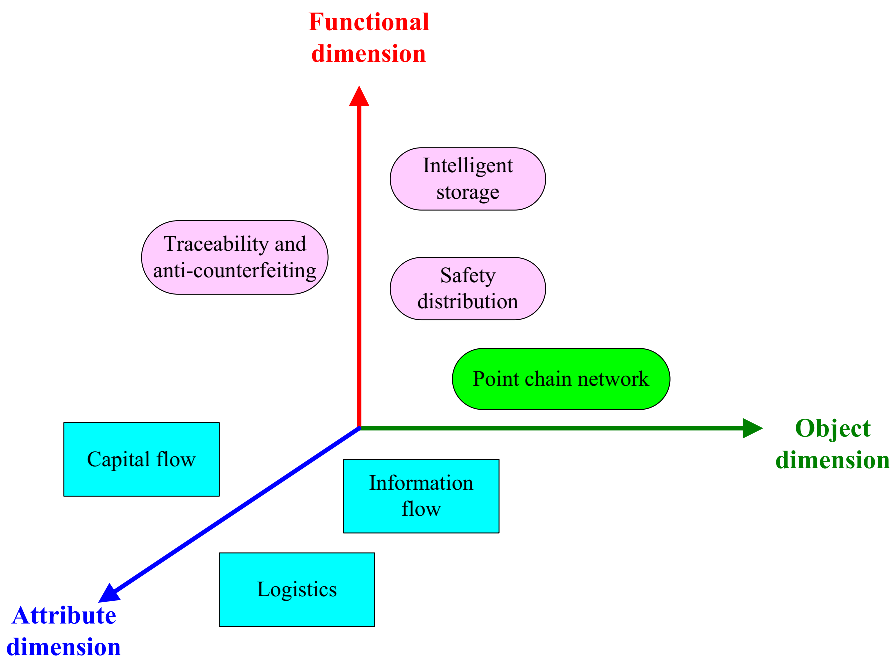


Fig. 2 Logistics information resource management model of block supply chain

make a recall decision. At the same time, in the recall process of industrial products, the shared account characteristics of the block chain can specifically identify the specific batch of problems, to avoid a wide range of comprehensive recall.

(3) Open up data islands, link digital assets, and build a new mode of supply chain finance.

Because of the open, transparent, decentralized and traceable characteristics of the block chain, it is naturally suitable for multi-party participation to build information sharing platform, to help achieve the openness and democratization of information data in the supply chain, to connect fragmented databases into a network, and to protect the private information of enterprises in the supply chain through encryption algorithm. For example, the core enterprise can inform the supplier of the goods needed, but will not disclose the specific name of the supplier to other enterprises in the ecosystem.

In addition, because the block chain breaks the data island of each enterprise, the large data based on the supply chain will have more data sources, thus greatly improving the storage and quality of data, making the large data can play its role better (Wang and Wang 2013). At the same time, the unauthorized modification of block chain data also improves the credibility of the data, making it possible for enterprises to use data for credit reporting, thus promoting the establishment and prosperity of large data trading market.

3 Mode and application of supply chain management based on block chain technology

3.1 Supply chain management mode based on block chain

The supply chain management mode based on block chain technology can shorten the time, reduce the cost, improve the quality and meet the demand. The application of block chain technology in supply chain management is actually to build a block chain platform, relying on this platform to achieve the goal of supply chain management. The main features of the technology feasibility of block chain are as follows:

1. Multicenter
   Each node in the block chain contains a complete set of data, which can be synchronized and checked in real time among multiple enterprises.
2. Reliability
   Data is stored intact in each node of the information flow, and even if one of the nodes is damaged, the data security of the whole network will not be affected.
3. Trustworthy
   Each piece of information on the block chain is irreversible, data can not be tampered with, information distributed in multiple nodes, which can not be destroyed, can not forge a piece of information in empty space.

4. To open up
   It has low data disclosure cost and supports hierarchical encryption.
5. High efficiency
   Intelligent contracts are fully automated without human intervention.
6. Security
   Each transaction records data fingerprint information and uses digital signatures to ensure clear transaction rights and responsibilities. Block chain technology enables open collaboration of services, while ensuring transaction security and trust, applicable to supply chain management.

As shown in Fig. 3, a block chain platform for supply chain management can be constructed. The block chain platform is based on some core technologies and provides corresponding technical modules, such as consensus module, certificate module, log module, memory pool module, intelligent contract module, peer-to-peer computer network module, distributed data storage module, block management module, etc. Based on the module, some platform systems, such as monitoring system, upgrade system, node management system, contract management system, can be implemented. These systems can also be adjusted according to actual needs. On the basis of platform module and platform system technology, block chain realizes

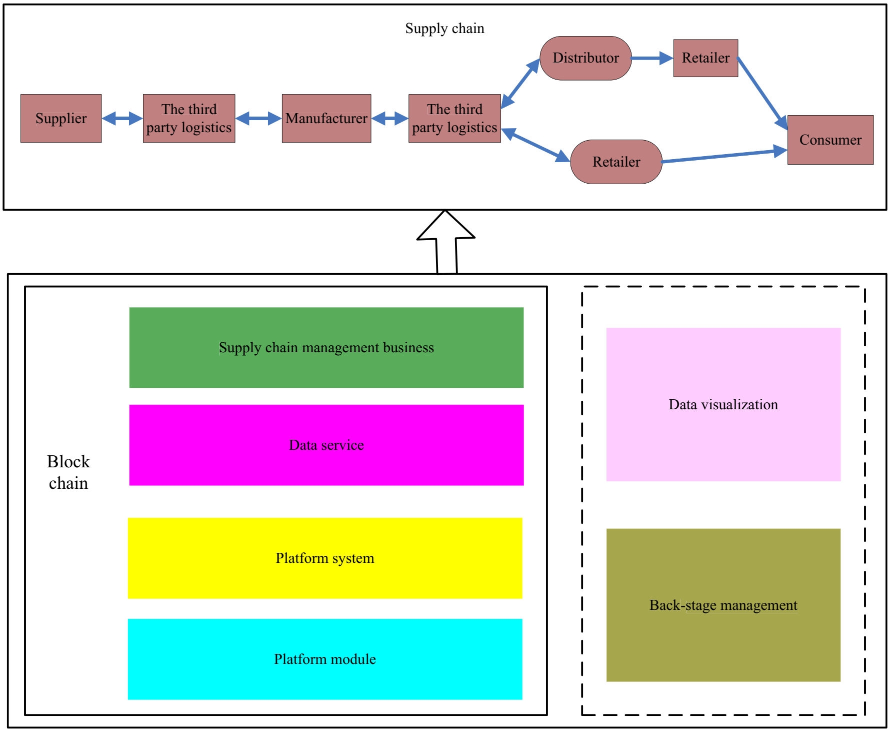


Fig. 3 Supply chain management based on block chain technology

the specific business needed in the actual situation of supply chain management (Hu et al. 2013; Leng et al. 2017). For example, in the aspect of data services to provide operational services, data synchronization, data analysis, data export and other content, in the aspect of supply chain management to provide customer management, transaction information management, procurement management, production management, after-sales management, procurement funds financing, warehouse receipt pledge financing, cross-enterprise points exchange and other specific business content. Relying on the block chain platform, it can realize the data visualization of specific service content and realize the corresponding background management function.

3.2 Authentication model of block chain technology in B2B + B2C supply chain

In traditional transactions, a single central organization is usually used to authenticate the transaction behavior. Certification centers need to be independent, authoritative and fixed. The traditional independent center authentication model of B2B + B2C supply chain is shown in Fig. 4. This paper does not elaborate on the shortcomings of independent certification centers.

Through the analysis of the trading behavior of each trading agent in B2B + B2C supply chain, we can see that the trading agents in B2B + B2C supply chain are dynamic changes, especially the liquidity of customers is greater, and has a great randomness. But B2B + B2C supply chain enterprise internal transaction subject is basically fixed, and the upstream suppliers and downstream vendors in a certain period of time also reflects the greater fixed. Under the authentication mechanism of transaction behavior based on block chain, the internal transaction subject, supplier and seller are the authentication subject of block chain, so it can be considered to construct a dynamic multi-center collaborative authentication model of Supply Chain Based on block chain, which integrates the internal transaction subject, supplier and seller as the authentication collective. At the same time, customers as a

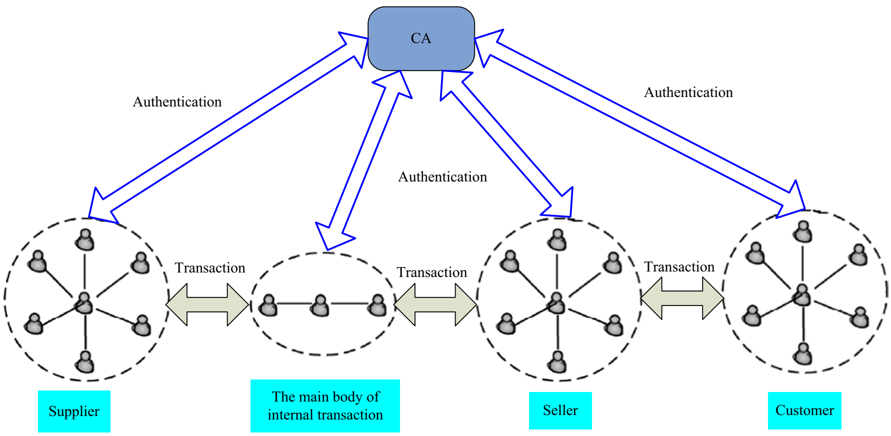


Fig. 4 Traditional independent center authentication model in B2B + B2C supply chain

main body of block chain transactions also carry out transaction behavior certification, but no longer as a certification center, the role of customer participation certification is to make further proof in the case of multi-center collaborative authentication still can not achieve transaction behavior certification.

Compared with the traditional independent center authentication, the dynamic multi-center collaborative authentication model of B2B + B2C supply chain based on block chain does not need to entrust a third party as an independent authentication center, and multi-transaction agents act as different authentication centers to authenticate the supply chain transaction behavior. In the long run, upstream suppliers and downstream sellers are dynamic, which can ensure the number of certification centers and prevent collusion. Each Certification Center is the transaction subject of B2B + B2C supply chain. The benefit game will actively abide by the credit mechanism. Therefore, the dynamic multi-center collaborative certification model of B2B + B2C supply chain based on block chain has high proof and stability of transaction behavior. The dynamic multi-center collaborative authentication model of B2B + B2C supply chain based on block chain is shown in Fig. 5 (CA represents the authentication center).

As can be seen from Fig. 5, any trading entity within an enterprise, supplier, and seller has the ability to prove the transaction behavior. If a trading entity tries to tamper with trading records individually or jointly with other trading entity, other trading entity can prove its illegal behavior according to their own records and kick it out of the supply chain. If one or more dealers try to cheat the customer, because the customer has the ability to prove the transaction itself, the customer can reflect to other dealers as the certification center, and the illegal seller will be kicked out of the supply chain after verification by multiple certification centers. If the customer tries to cheat the seller, the illegal customer will be recorded and disqualified after the cooperative certification by multiple trading centers.

The dynamic multi-center collaborative authentication model of B2B + B2C supply chain based on block chain can guarantee the stability of the whole

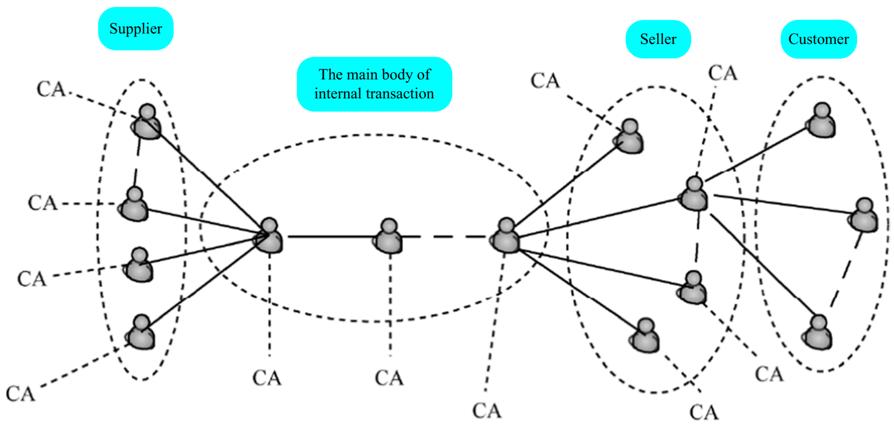


Fig. 5 Dynamic multi center collaborative authentication model for B2B + B2C supply chain based on block chaining

authentication institution composed of multiple trading centers. In this way, it is convenient for the trading subjects, suppliers and sellers to grasp the sales situation and customer behavior of the goods, operate the supply chain together, ensure the high transparency, consistency and authenticity of the trading information, and promote the collective decision-making of the trading subjects, suppliers and sellers within the enterprise.

4 Analysis of management information system synergy mechanism and platform structure

4.1 Multi module autonomous mode

Multi-module cooperative autonomy of energy Internet refers to the use of block chain technology to coordinately optimize the use of energy, supply, transmission of multiple modules of the operation strategy to achieve energy Internet module autonomy and system autonomy. This part will further study the multi-module autonomy mode and build the optimization model of each module operation on the basis of clarifying the operation process of energy Internet control.

(1) Energy utilization module energy efficiency behavior optimization model.

Energy consumption behaviour optimization refers to the user's rational arrangement of energy sources (distributed renewable energy, grid power supply, grid heating, natural gas, energy storage, etc.), through the distribution and transformation among various energy sources, to meet their own energy needs, to achieve the lowest energy cost, minimum carbon emissions and other objectives, the basic model of multi-objective optimization such as the formula (1):

$$\begin{cases} f = \min\left[f_C(E), f_D(E)\right] \\ s.t. \quad \begin{cases} S = RE \\ \underline{E} \le E \le \bar{E} \end{cases} \end{cases} \tag{1}$$

Formula E: The decision variable E of the model includes the energy input of each energy source, the distribution of energy between different equipment, the start-up and shutdown of equipment, etc. The $f_C(E)$ represents the comprehensive energy cost of the user, and $f_D(E)$ reflects the CO_2 emissions from the conversion and utilization of various energy sources. S = RE is the constraint of the energy demand of the user, S represents the energy demand of the user, R reflects the coupling relationship between the input and output of various energy sources. $\underline{E} \le E \le \bar{E}$ represents the energy input constraints from the energy system network constraints, energy storage equipment operation constraints, distributed energy output constraints.

(2) Energy supply module multi energy scheduling optimization model.

Multi-energy dispatch optimization refers to the reasonable arrangement of power supply equipment, heat, gas and other energy storage device charging and discharging plan, to meet the user's energy demand safely and reliably, to achieve the maximum use of renewable energy, the minimum primary energy consumption, the lowest cost of energy supply, the highest reliability of energy supply and other goals. The basic model of multi-objective optimization is shown in formula (2).

$$\begin{cases} f = \min\left[f_Q(P), f_C(P), f_U(P)\right] \\ s.t. \quad \begin{cases} E = NP \\ \underline{P} \le P \le \bar{P} \end{cases} \end{cases} \tag{2}$$

In the formula, the decision variable P of the model includes the extraction of primary energy such as natural gas, coal, coal-fired boiler, gas turbine, fan, photovoltaic and other energy supply equipment energy output, equipment start-up and shutdown status, energy storage device charging and discharging status. $f_Q(P)$ represents the primary energy consumption in the energy supply. $f_C(P)$ denotes the cost of energy supply, including the cost of exploitation of primary energy and the cost of production of secondary energy such as electricity and heat. $f_U(P)$ represents the loss of social benefit caused by abnormal working state of energy supply equipment, and is regarded as the optimization objective of energy supply reliability. E=NP is constrained by the balance of energy supply and demand. N reflects the loss of energy in transmission and transformation. $\underline{P} \le P \le \bar{P}$ indicates energy supply constraints, which come from operation constraints of energy supply equipment and energy storage devices, energy system reserve constraints, energy transmission network capacity constraints and so on.

(3) Energy transfer module multi power flow optimization model.

Multi-energy flow power flow optimization refers to the reasonable arrangement of power flow distribution of electricity, heat and gas in energy transmission network on the basis of energy supply and demand. In special cases, energy storage equipment equipped with energy transmission network can be used to adjust the power flow distribution in time to achieve the goals of the lowest energy transmission cost, the smallest loss and the safe and stable operation of the system network.

$$\begin{cases} f = \min\left[f_C(T, A), f_L(T, A)\right] \\ s.t. \quad \begin{cases} g(E, P, T, A) = 0 \\ \underline{T} \le T \le \bar{T} \\ \underline{A} \le A \le \bar{A} \end{cases} \end{cases} \tag{3}$$

In the formula, the decision variable T of the model is the power flow distribution of electricity, heat and gas multi-energy flow in the energy transmission network. A is a charging and discharging plan for energy network energy storage equipment. $f_C(T,A)$ and $f_L(T,A)$ denote multi energy transmission cost and loss respectively. $g(E,P,T,A) = 0$ is the equality constraint of energy flow in the energy transmission network. $\underline{T} \le T \le \overline{T}, \underline{A} \le A \le \overline{A}$ is the power flow constraint of energy transmission network and the operation constraint of energy storage equipment respectively.

4.2 Process collaboration management mechanism

The process is to reshape the original trading mode or mode through the block chain technology, and according to the technical characteristics of the block chain, reasonable design in consensus, accounting, encryption and decryption. This makes the transaction accounting, the consensus of transaction results, the encryption and decryption of transaction information more reasonable and targeted process to meet the security and optimize the efficiency of process execution, thereby improving the performance of the entire system.

For the platform, it needs to deal with a large number of data transactions, transmission of information, as well as query, authentication and other user requests. According to different request types, process collaborative management cooperates with different nodes in the block chain network to complete corresponding operations. Different nodes have different functions, and transmit information such as accounts through the P2P network. The supply chain management information system mechanism from the perspective of block chain is shown in Fig. 6.

In the process, design to the transaction process from the security point of view, of course, all the nodes that participants are involved in the consensus process, so that the whole system has stronger security, which is also the cornerstone of block chain network security. However, in practical applications, due

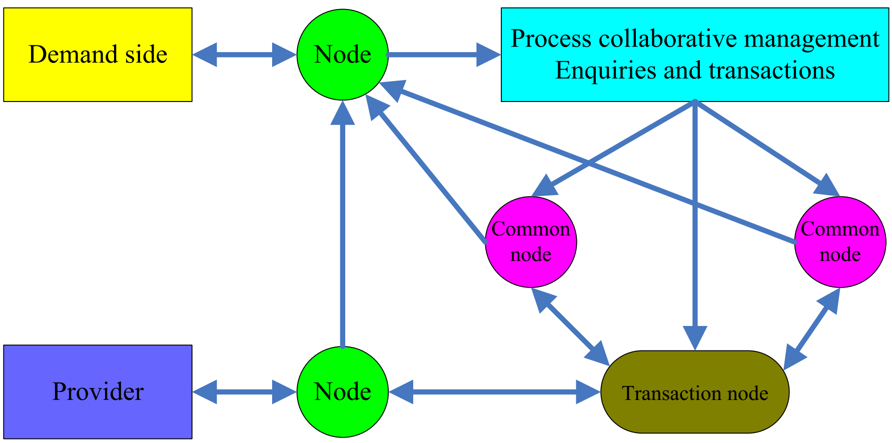


Fig. 6 Process collaboration management mechanism

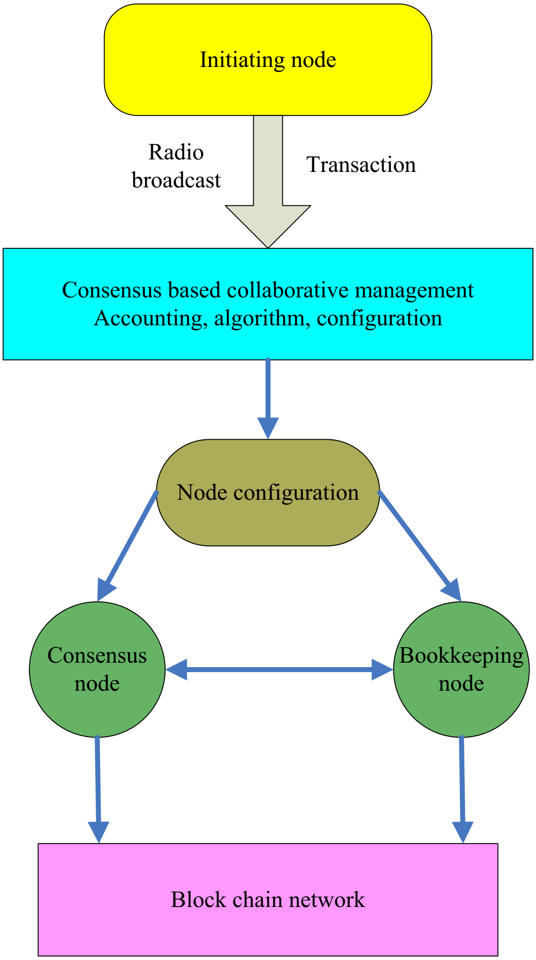
to performance considerations, it is not necessary for all participating nodes to participate in the transaction consensus, accounting and other processes, and some low-quality nodes will drag down the consensus efficiency of the entire system. Therefore, the ordinary node is only responsible for some routine operations, and there is a special transaction consensus responsible for the accounting node responsible for the transaction process mechanism of the whole system, to ensure the consensus of the results of the whole network transactions and accounting. After the transaction is agreed, the accounting node records the result of the transaction, forms a block, publishes the block to other nodes, and each node verifies and submits it to the local account to complete the accounting process. This collaborative management mechanism separates the core and non-core processes or things, and some simple routine queries, authentication and other operations are performed by ordinary nodes. As for the high performance and efficiency requirements of the transaction consensus, confirmation, accounting by a specially selected high-performance transaction node responsible for external, to avoid waste of resources, improve the efficiency of the network.

4.3 Consensus based collaborative management mechanism

There are many consensus algorithms on the block chain, and none of them is perfect, which means that none of them is suitable for all application scenarios. Therefore, according to the specific transaction scenarios, cooperative consensus mechanism is needed to meet the premise of transaction safety and reliability, and can improve the system operation efficiency. Workload proves that it relies on machines to perform mathematical operations to obtain accounting rights. Resource consumption is higher and less supervisable than other consensus mechanisms. Although completely de-centralized, nodes free access, but consensus reached too long, but also will cause a lot of waste of resources. Practical byzantine fault tolerance in distributed computing, different computers try to reach a consensus through message exchange. The consensus mechanism allows strong supervisory nodes to participate, has the ability to classify authority, higher performance, and lower energy consumption. Each round of accounting will be jointly elected by the whole network node leader, allowing 33% of the nodes to do evil, fault tolerance of 33%.

As shown in Fig. 7, nodes initiate transactions and broadcast them to the block chain network. Through consensus collaborative management, nodes with good performance are selected as consensus nodes according to the configuration of nodes. At the same time, different consensus algorithms can be selected according to the amount of transactions and whether the nodes are faulty or not. Generally, small transactions can be considered as transactions when the network is stable. When the node fails, the practical Byzantine fault-tolerant mechanism is automatically activated to protect the security of transactions. Accounting mechanism is also set up in consensus coordination. Cooperating excellent nodes to complete accounting and broadcast the books to the block chain network, other nodes verify and synchronize the books, and complete the transaction consensus and accounting process.

Fig. 7 Consensus based collaborative management mechanism



4.4 Design of consensus algorithm

There is no centralized accounting mechanism in block chain. Therefore, establishment of block chain and data updating and storage require the "consistency process" of all nodes by using consensus algorithm. Consensus algorithm is the core technology of block chain and an important guarantee for establishing credibility of block chain. Because of the large number of participating nodes, the low availability, and huge information amount, public block chain generally adopts consensus algorithms such as proof of workload (PoW), proof of stake (PoS) and DPoS.

The idea of PoS consensus algorithm is to replace the Hash rate based on SHA256 with proof of stake. That is, the recording right of the block is obtained by the node with the highest right in the block chain. Compared with PoW that requires a great deal of computational power, PoS requires only a small amount of computing time and ability to ensure the normal operation of the block chain. The consensus speed of the public block chain is slow. In the process of scheduling the agricultural business resources, the selective incentive weight should be used to guide the agricultural business resources to flow to the remote and underdeveloped areas so as to realize the commonweal attribute of agricultural business resources. Therefore, this paper proposes a consensus algorithm which is more concise and more suitable for agricultural business resource block chain considering weight based on the PoS consensus algorithm.

Its algorithm pseudocode is as follows:

```
(1) Begin
(2) transaction X (ID, request, t) ;
    /*Node X generates a new transaction and requires update. t is the timestamp to ensure that the request is
     made only once. */
(3) listen by every node；
    /*All nodes remain listening*/
(4) broadcast by every node (ID, R)；
    /*Each node broadcasts its message to the entire network*/
(5) Weight=comp(Ri,Wi) for every node；
      /*Each node calculates the equity value of all nodes according to the pre-agreed weight. */
(6) primary =Max（Weight）；
  /*Select the accounting node according to the highest equity value. */
(7) block=comp(X) by primary；
    /*The accounting node calculates the block value of node X*/
(8) MS=broadcast（block）by primary；
(9) if MS is received
      /*If the node receives the messages*/
(10) No.=count(MS);
     /*Record the number of messages received by the node*/
(11) if the No. >=N  for any node
     /*If any node receives more than N messages, N is related to the fault tolerance of the system. */
(12) then updating for every node (X, block);
     /*All nodes update the new block value of node X*/
(13) else give up;
      /*Otherwise, give up the update. */
(14) End
```

4.5 Numerical experiment

4.5.1 Parameter description

In order to verify the applicability and superiority of block-chain technology in agricultural business resource scheduling based on public service platform, two experimental schemes are designed in this paper, and the corresponding scheduling simulation model is constructed by using Matlab. Finally, the experimental results are analyzed and discussed.

The following assumptions and explanations are made to the simulation model:

1. There is a set of agricultural business resource demand nodes, and the parameters are as shown in Table 1. A set of agricultural business resources supply nodes exist, and the specific parameters are shown in Table 2. The parameter weights

Table 1 Demand nodes and demand amount

Unit	Demand amount	Response speed	Selective incentive weight
du_1	740	≤ 0.8	0.2
du_2	270	≤ 0.7	1.0

are shown in Table 3, and the weights of agricultural business resource types are shown in Table 4.

2. All resource types are reachable for demand points.
3. The weights of all parameters are normalized.
4. In order to highlight the typicality of the research object, one of the two demand nodes in Table 1 is set in the central city and the other in the remote area.
5. All nodes are on BN, and the rent-seeking, matching and transaction between the supply and demand of agricultural commercial resources are completed according to the rules and algorithms of BN.

4.5.2 Simulation experiments

Experiment 1 calculates the results of adaptive rent-seeking and matching between the supply and demand nodes of agricultural business resources through the block chain technology in Tables 1 and 2, which aims to verify the feasibility and applicability of block chain technology for decentralized resource scheduling and management. The simulation results of Experiment 1 are shown in Table 4.

In experiment, under the premise of specific resource supply, the average optimal costs of the demand node based on the traditional resource scheduling mode and the block chain technology scheduling are calculated so as to verify the superiority of distributed resource scheduling in system cost through block chain technology (Fig. 8).

The traditional resource scheduling model does not set the weights of the parameters. In order to make the cost comparable in different scheduling modes, experiment 2 only considers node demand, supply quantity, supply price, location of supply and demand node and final trading volume, while the weights of parameters are not considered. The resource supply node and the supply quantity are extracted from Table 2. The scale of the demand nodes is gradually expanded from 1 to 10, and the demand amount is obtained through a random function in [1,500]. According to the idea of set covering model, the formula for calculating the equity cost of demand node based on the traditional model is shown in formulas (4)–(7). Formula (4) indicates that the optimal average cost of the demand nodes is the average value of the minimum cumulative sum of price, distance between the supply and demand nodes, and the product of the demand amount and weight. Formula (5) means that each demand node is covered by at least 1 and at most 3 supply nodes.

$$\min \sum_{i=1}^{n} \left(P_j, \overline{d_{ij}}, Q_C \right) \Big/ n \tag{4}$$

Table 2 Supply nodes and supply amount

Unit	Supply amount	Supply price	Response speed	Resource type	Distance	Distance
su_1	10,000	2.3	0.9	Cold chain special train	1300	180
su_2	200	5.5	0.6	Box-type cold chain truck with multiple temperature zones	1800	240
su_3	300	4.6	0.7	Box-type cold chain truck with a single temperature zone	1200	80
su_4	1150	6.5	0.8	Dumping trailers + cold chain container	1900	120
su_5	70	5.3	0.8	Box-type cold chain truck with multiple temperature zones	1100	340
su_6	100	15.8	0.5	Cold chain aeronautical dedicated line	1700	550
su_7	400	2.5	0.7	Common van + cold chain container	900	680
su_8	300	4.2	0.7	Box-type cold chain truck with a single temperature zone	2100	350
su_9	60	5.2	0.6	Box-type cold chain truck with a single temperature zone	1900	200
su_{10}	80	6.1	0.8	Dumping trailers + cold chain container	1500	400

Table 3 Weights of parameters

Parameter attribute	Weight reference value
Amount	0.5
Price	0.2
Distance	0.5 ($d_{ij} \le 100$)
	0.6 ($100 < d_{ij} \le 300$)
	0.7 ($300 < d_{ij} \le 500$)
	0.8 ($d_{ij} > 500$)
Response speed	0.6
Resource type	0.7

Table 4 Weight of resource type

Resource type	Weight reference value
Cold chain special train	0.4
Box-type cold chain truck with multiple temperature zones	0.7
Box-type cold chain truck with a single temperature zone	0.6
Dumping trailers + cold chain container	0.5
Cold chain aeronautical dedicated line	0.8
Common van + cold chain container	0.9

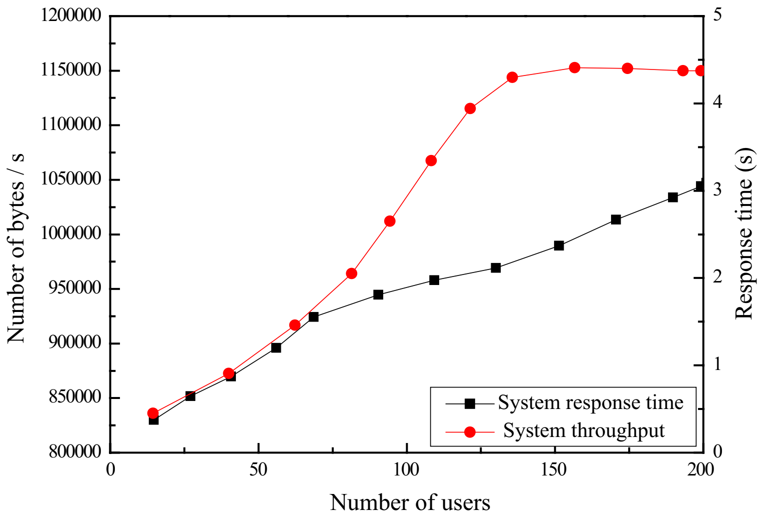


Fig. 8 Average optimal cost of demand nodes in different modes

$$s.t.\ 1 \le \sum_{j} c_{ij} du_i \le 3 \quad \forall j \in J \tag{5}$$

$$du_i = 1 \quad \forall i \in I \tag{6}$$

$$c_{ij} = \begin{cases} 1, & if\ su_j\ cover\ du_i \\ 0 & if\ su_j\ not\ cover\ du_i \end{cases} \tag{7}$$

4.5.3 Analysis and discussion of experimental results

(1) According to the results of experiment 1, under the premise of only 10 resource supply nodes, there are 6 resource supply nodes that meet the requirements of du_1, and only one resource supply node that meets the requirements of du_2. Only three of the seven selected resource supply nodes are small supply points with the supply amount of less than 100 (There are only four small resource supply nodes in the model). This fully shows that block chain technology can allow decentralized agricultural commercial sources to achieve adaptive rent-seeking and matching. Resource scheduling is only related to the ability of the resource and transaction rules, and independent from the information held by the resource owner, so that more small scale agricultural commercial resources can enter into the market and fairly participate in transaction. This is essentially different from the traditional mode of resource scheduling and management.

(2) Setting up selective incentive weights on the resource demand side aims to encourage the spontaneous flow of agricultural commercial resources to remote and underdeveloped areas and to realize the commonweal nature of agricultural business resources. According to calculation, the overage order of 10 resource supply nodes to the demand nodes du_1 and du_2 in experiment 1 is: su_3 (du_2)–su_7 (du_1)–su_9 (du_2)–su_2 (du_2)–su_3 (du_1)–su_8 (du_2)–su_5 (du_1)–su_{10} (du_1)–su_9 (du_1)–su_8 (du_1)–su_2 (du_1)–su_{10} (du_2)–su_7 (du_2)–su_4 (du_1)–su_6 (du_1)–su_6 (du_2). According to this order, the two demand nodes with different geographical positions have no obvious order when they are covered by the supply nodes, which is in line with the established goal of the system. Several experiments have proved that selective excitation weight is strongly related to the three parameters of node size, distance matrix and response speed.

(3) According to the result of Experiment 2, under the premise of fixed resource supply, the average cost of demand nodes based on traditional resource scheduling mode is significantly increased and the cost growth rate is also significantly enlarged with the increase of demand nodes. This is because: Firstly, there are information barriers in the traditional resource scheduling mode and the transaction cost is high. Although the transaction between resource supply and demand has occasionally and randomness, it is relatively fixed, and the resource debris rate is high. Secondly, driven by the benefits, the superior resources will satisfy the nodes with lower demands first. Demand nodes with higher costs in remote and underdeveloped regions are often covered by more inferior sources, thus increasing the average cost of demand nodes. However, resource information is transparent under block chain

technology, and a demand node can be covered simultaneously by several supply nodes. The supply node has very few “fragmented resources”, and the transaction costs can be negligible. As a result, the average cost and growth rate of the demand node are obviously lower than the traditional model. The cost advantage is more obvious in the environment of massive resources.

5 Conclusion

The application of block chain in academic and practical fields can be found to involve less content of supply chain applications. Based on the technical advantages, the application of block chain in all walks of life has been gradually promoted, which can effectively solve many pain points in the field of supply chain. The main purpose of applying block chain to supply chain management is to set up a block chain platform to meet the requirements of supply chain management and to realize the interaction between block chain and supply chain. The application of block chain in the supply chain is not smooth sailing, from the current development point of view, it will still face some challenges and obstacles. For example, the application of block chain landing cycle is long, specific landing needs to master the block chain technology and concept, select the application model, then select a block chain platform to study, and finally block chain application development, which requires a longer period. Employees have high costs, and they have higher requirements on the level, technology accumulation and concept of employees. However, there are fewer cross-section talents between finance and block chain, and the training cost is higher. Block chain selection is difficult, block chain is still a new thing, its development prospects are full of uncertainty, the specific operation of the difficulty is relatively high. The above problems need to be verified and perfected in practice, as well as in-depth consideration and research by academic circles.

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