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Research on Network Information Management of Green Vegetable Supply Chain Based on Blockchain Technology

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Abstract

Through the analysis of the green vegetable supply chain information and the characteristics of blockchain technology, the data management platform of the green vegetable supply chain network was reshaped in architecture, and the blockchain technology was embedded in the data management platform framework of the green vegetable supply chain network. In addition, we will use the characteristics of blockchain technology to solve the data storage and application problems of the green vegetable supply chain network management platform, create a new ecological model of intelligent green vegetable supply chain data management optimization, and strive to solve the security of the green vegetable supply chain data management problems such as poor performance, low reliability, and difficult management.

Keywords

Blockchain technology; green vegetable supply chain network; information management.

1. Introduction

At present, the core supplier management information system, physical transportation information system and customer information system of green vegetable are changing frequently. And the massive supply chain data management information poses a great challenge to the traditional data management and analysis system. The modern green vegetable supply chain data information is significantly different from that in traditional days. For one thing, modern supply chain data information comes from intelligent management systems, manual statistics and the like. For another, the data structure of green vegetables is quite different, and the data contains a lot of data information, text information, picture information[1]. Block chain which is suitable for the analysis and processing of complex data is considered to be a disruptive innovation after big data and cloud computing and all industries are paying great attention to it[2]. It provides all permitted members with the visibility of information exchanged throughout the transaction cycle, and further improves the transparency of the data and the reliability of transactions.

In the traditional green vegetable safety traceability system, the data system is scattered and complex, and the use of paper records has the tendency to make mistakes. However, as a more complete information recording method, blockchain can calmly deal with this challenge. Blockchain can greatly enhance the transparency of the green vegetable supply chain, help improve the recall and verification process, and strengthen consumer confidence[3]. At the same time, the information asymmetry leads to high costs for the core participants in the green vegetable transaction, and the blockchain which is called trust machine can improve the core enterprise's control of the supply chain, which makes it possible to efficiently and accurately trace the quality of vegetables and related information. When the information, logistics, and capital flow of green vegetable transactions are recorded on the chain, a new business model

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will be created combined with the Internet of Things technology, which will further bring huge business opportunities, and promote huge changes in national food safety and agricultural production and trading.

2. Research review at home and abroad

Blockchain technology is an information processing technology that uses a special algorithm to verify information and upload it to distributed nodes without relying on a third party to form a chain structure[4]. Driven by many factors, blockchain technology begins to develop, and has rapidly extended to many fields such as trade settlement and artificial intelligence[5]. Wu Yanni analyzes the core characteristics of basic technologies such as decentralization, non-tampering, open sharing, and the safety and reliability of storage of the blockchain[6]. The current rapid development of blockchain technology has become a new round of driving the advancement of the information industry. Scientific research institutions all over the world want to use it as an opportunity to promote technological change and accelerate industrial reshaping[7]. Liu Ye's research shows that the application and development of blockchain technology has brought impact and solutions to the high cost and low work efficiency of central nodes in the traditional technology field[8]. Sun Shiqi discusses the mechanism of intelligent manufacturing supported by blockchain technology that can break the barriers of traditional manufacturing information segmentation, help companies continue to optimize operating processes and operating costs, and improve operating efficiency. Blockchain technology helps to improve the transparency and flexibility of the value chain of manufacturing enterprises, and can more flexibly deal with problems in production, logistics, warehousing, marketing, sales, after-sales and other links[9]. The idea of Subramanian H is to build special nodes between different platforms and managers can read and write data information in distributed nodes to achieve synchronization and consistency of data information in network blocks[10].

At present, scholars have proposed the application of blockchain technology in the manufacturing supply chain related fields such as raw material procurement, production management, product supply and after-sales service, but no scholar has studied its application in the construction of agricultural intelligent management platforms such as green vegetable supply chains and uses to solve the storage problem of core enterprise resource data and improve the security and utilization of enterprise data. Integrate blockchain's distributed storage, point-to-point transmission, asymmetric encryption, smart contract and other technologies as innovative applications in the core enterprise data management platform to improve the data application and operation efficiency of the core enterprise. More importantly, blockchain technology has the characteristics of high data storage security and information traceability, which provides a new platform architecture and technical ideas for intelligent data management systems. Blockchain technology is still in its infancy in the data management field of core enterprises in the green vegetable supply chain. The application of blockchain technology to the framework of the intelligent data management platform of the core enterprises in the green vegetable supply chain has broad prospects.

At the same time, blockchain is suitable for multi-party participation and information exchange scenarios due to its non-tamperable, decentralized, and asymmetric encryption characteristics. It can help to achieve data democratization, connect decentralized databases, and protect participating parties through encryption algorithms. The privacy of the party will also provide more data sources for big data analysis based on the supply chain, improve data quality, reduce the risk of data leakage, and make big data credit investigation possible.

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3. Demand analysis of the introduction of blockchain technology to the green vegetable supply chain data management platform

3.1. Problems in information management

In the green vegetable supply chain network, tasks such as procurement, production, logistics, and after-sales are usually centrally managed and coordinated by core companies. However, with the complexity of the business environment and the refinement of business processes, this traditional centralized supply chain management model has encountered a series of problems. In the traditional business operating environment, there are many difficulties and shortcomings in supply chain management. The typical ones are as follows:

The supply chain of green vegetables includes all aspects of the production and trading of green vegetables. The supply chain covers a wide range from the planting and products to the consumers, which has weak supervision therefore the consumers have no way to verify the quality of the vegetables. The growers and middlemen who use various harmful substances seriously harm the interests of other participants in the green vegetable supply chain and consumers. First of all, the harm caused by excessive use of harmful substances to customers has seriously damaged the image of the participants in the transaction. Secondly, consumers paid a price that was inconsistent with the value of green vegetables, which causes economic losses. Of course, in response to this situation, the China Green Food Development Center provides certification for qualified vegetable planting bases. However, due to many factors such as anti-counterfeiting of signs and inadequate supervision in later stages, many problems such as incomplete information on vegetable production and substandard quality are still caused.

Isolated islands of information is endless. In the traditional supply chain model, information is distributed in many different participating departments, and information such as procurement, production, logistics, sales, after-sales service, supervision, is fragmented. And there is a lack of a trusted carrier or platform that gathers all relevant information formed around commodities. The existing islands of information have led to a series of problems such as unbalanced data interaction, low communication frequency and efficiency, and complicated information verification, and even lead to conflicts between offline and online information and duplication of work links. The degree of information sharing in the supply chain system directly affects the speed of enterprise resources. The asymmetry of information leads to serious upstream and downstream information barriers. The safety inventory of the enterprise cannot be reached. The upstream and downstream enterprise information in the supply chain is not fully shared, and the supply chain data is not transparent which is unable to form a harmonious service chain.

The relationship between supply chain cost and efficiency. The integration of supply chain requires cross-departmental resource sharing, which improves the efficiency of the supply chain on the one hand, and also increases the cost of the supply chain on the other hand. The supply chain covers all links of procurement, production, sales, and consumption, including procurement and logistics, production, logistics and sales, consumer consumption and after-sales service, which is a wide range. In reality, insufficient supply chain supervision and a lack of comprehensive and effective cost control have led to rising costs and lower efficiency.

Lack of trust mechanism and low binding force. The basis of the improvement of supply chain efficiency is supply chain collaboration, and the premise of collaboration is trust. Related departments in the supply chain will have information interaction and sharing requirements due to business relationships, but because the departments in the supply chain will have different needs due to factors such as time, cost, and service. From the current point of view, the supply chain lacks an effective trust mechanism, and the binding force is relatively small. The existence of trust issues will affect the business development of corporate departments in the supply chain, leading to distortion of information flow.

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The amount of information from all parties is too large and the management is difficult. Although the core enterprise is the protagonist in the supply chain, its ability to control the supply chain is limited. When it expands the scope of management upstream and downstream, it will lead to a sharp rise in costs and a sharp drop in efficiency. At the same time, the core enterprise's ability to influence is also limited. When encountering evenly matched suppliers, the right to speak is also small. Take suppliers as an example, normal excellent companies can manage one to two suppliers at most, because with the division of labor, the number of suppliers increases exponentially, which surpasses the management capabilities of core enterprises. Therefore, core companies generally hand over the management of lower-level suppliers to the first-level suppliers. This model easily leads to information asymmetry and information release delays, which makes it impossible for core companies to control the circulation of green vegetables in real time, resulting in the risk of information fraud and tampering.

By constructing a data information management platform based on blockchain technology, the above problems can be effectively solved. Supply chain applications based on blockchain technology can obtain massive amounts of data, record resource flow information, and effectively meet corporate needs on the basis of traceability, evidence storage, mutual trust, and information communication. Relying on blockchain technology, departments in the supply chain can quickly establish trust relationships, and due to the immutability of data, the degree of information asymmetry is greatly reduced, and the cost of communication between departments will be reduced.

3.2. Choice of Blockchain Technology by Green Vegetable Intelligent Data Management Platform

Blockchain technology can be divided into three categories according to the access mechanism. They are public blockchain, private blockchain and consortium blockchain. The public chain is open to the public network, and all personnel can access and process data through block nodes. Private chain is a privately controlled network chain structure. It has no main features such as regional centralization and distribution, and can only be regarded as a blockchain in a broad sense. Consortium blockchain can set login permissions, retain some centralized control functions, and have powerful and extensible information processing functions, mainly to establish a network framework for specific companies or organizations. The technical personnel of the core enterprise can set the node authority of the consortium blockchain, and the personnel with special authority can read and write data information on the node, which also ensures the security of the data. Generally speaking, the consortium blockchain has the advantages of low operating cost, strong trust, high data storage security, and the ability to customize system access permissions, which is very suitable for the construction of enterprise data platform framework.

It is possible to build a consortium blockchain surrounding core enterprises including vegetable growers, suppliers, distributors, retailers, logistics companies, end users by using blockchain technology, and record the flow of capital, information, and goods in the chain. It is worth mentioning that the goods flow on the chain can be combined with the Internet of Things technology to simplify collaborative work. In this way, the blockchain can record and share the latest developments in all aspects of the supply chain in real time, and core companies can achieve a penetrating grasp of the supply chain. They can timely understand the production, quality, and transportation of orders, and improve transparency and visualization of the supply chain. Among them, transparent timely management can reduce enterprise operating costs, provide immediate support for enterprises to respond to emergencies, and provide convenience for auditing.

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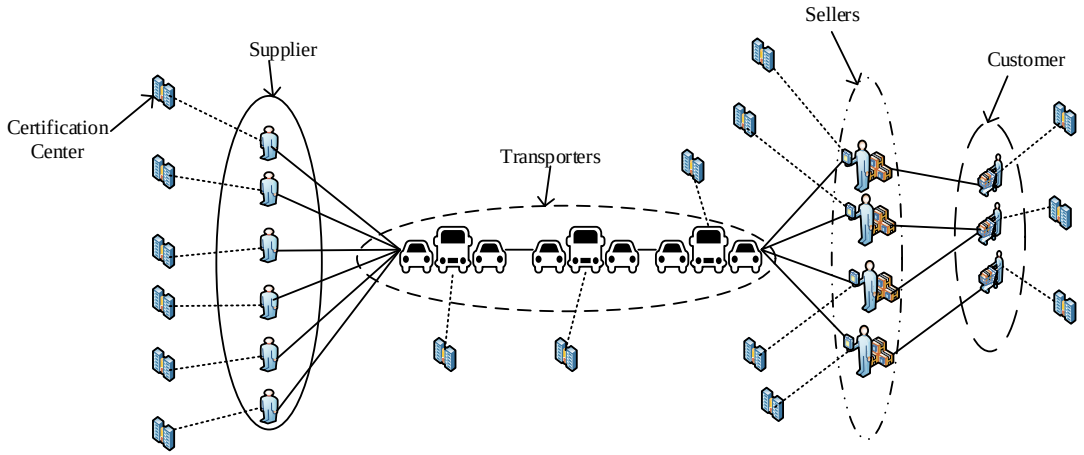

Figure 1: collaboration process of green vegetable supply chain network based on consortium blockchain

3.3. Security analysis of supply chain data platform based on consortium blockchain

Under the blockchain alliance chain technology, all nodes of the supply chain data platform can participate in the data processing process, and the network nodes jointly verify the legality of data transactions on the supply chain data platform. The platform no longer relies on any trust institutions or three-party intermediaries when running, and even if some nodes in the system are damaged, it will not affect the security of the entire supply chain data platform. At the same time, the supply chain data platform relies on the characteristics of distributed storage, P2P transmission, asymmetric encryption, smart contracts and other features of the blockchain alliance chain technology to ensure the non-tampering and traceability of enterprise supply chain information. Even so, the supply chain data platform still faces a series of security issues. Scholar Kraft D proved that the attack process of hackers on the supply chain data platform satisfies the characteristics of Poisson distribution [11], and the length of the data block chain ultimately determines whether the supply chain information can be successfully authenticated. If the probability that the real node in the grid data platform obtains the accounting right is set to p, the probability that the attacking node obtains the accounting right is q, and p+q=1, the probability that the attacker can finally eliminate n block gaps is P_n. It can be expressed as

$$p_n = \begin{cases} \left(\frac{q}{p}\right)^n, p > q \\ 1, p \le q \end{cases} \tag{1}$$

The extended length of the blockchain of the enterprise data attacker satisfies the Poisson distribution, and its expected value is

$$\lambda = n\frac{q}{p} \tag{2}$$

Assuming that a normal enterprise data transaction is linked to n blocks, during this period an attacker imitates the normal authentication method to launch an attack on the enterprise data and platform, the probability p_ξ of successfully tampering the transaction by forging the transaction node is

$$P_\xi = \sum_{k=0}^{\infty} \frac{\lambda^k e^{-\lambda}}{k!} \bullet \begin{cases} \left(\frac{q}{p}\right)^{n-k}, k \le n \\ 1, \quad k > n \end{cases} \tag{3}$$

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When the probability q that the attacking node obtains the accounting right does not change, as the block gap h gradually increases, the success rate of illegal data tampering gradually decreases; when the block gap is the same, the probability q that the attacking node obtains the accounting right increases larger, the higher the probability of data tampering. When the attacking node obtains the accounting right probability q=0.5, no matter what the value of the block gap, the data can be tampered with, which means that to tamper with the data illegally, more than half of the data platform must be cracked at the same time, launch a "51% computing power attack". But in terms of cracking technology, it is difficult to implement 51% attacks on data platforms without being noticed by the maintainers. And it is almost impossible to tamper with the information on the alliance chain with the current level of computing power, so when the data scale is large enough, the blockchain alliance chain can ensure that the data will not be attacked or tampered due to cracking technology or computing power.

4. Technical framework of intelligent blockchain data management platform from the perspective of alliance chain

From the perspective of the blockchain alliance chain, the technical framework of the data management platform can be divided into five levels: data collection layer, data network layer, data consensus layer, data contract layer, and data use(application) layer.Each level has its own core function, and each level cooperates with each other to form the basic framework of an intelligent data management platform. The technical framework of the intelligent data management platform is shown in Figure 2.

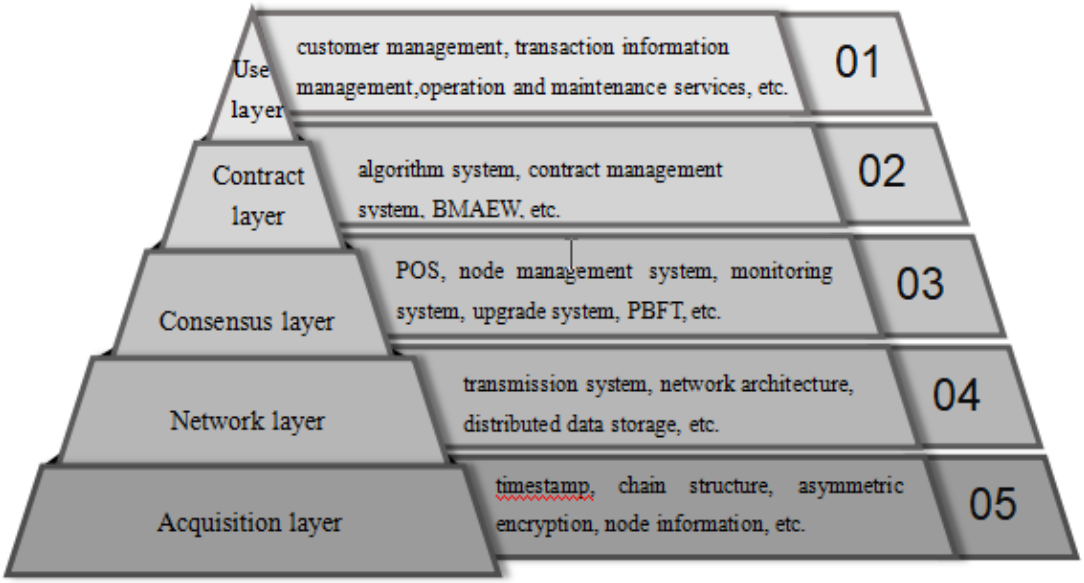

Figure 2 :Technical framework of intelligent data management platform

4.1. Acquisition layer of intelligent data management platform

The collection layer is the physical area and basic module of the intelligent data management platform, which specifically includes timestamp, chain structure, asymmetric encryption, node information, transaction details, data filtering and aggregation, etc., through the collection layer to extract the procurement of corporate resources over a period of time , Production and supply, product transportation, service purchase and other basic data information. After the information is collected, different types of basic data are screened, aggregated and transformed through asymmetric encryption technology and hash function to eliminate the heterogeneity of the data, and the private key, ciphertext and public key of the block are generated at the same

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time. After the basic data format is unified, the basic information and transaction codes are encapsulated in a time-stamped block.

4.2. Network layer of intelligent data management platform

The network layer of the intelligent data management platform includes transmission systems, network architecture, certificates, distributed data storage, logs, memory pools and block management, etc., to ensure that all alliance chain block nodes can participate in the information of the intelligent data management platform During transmission verification. The network layer uses a P2P network architecture for data transmission. The network layer nodes interact with a flat topology structure. Each block node undertakes both data transmission and information authentication.

The intelligent data management system will collect the time-stamped block node data and link it to the main chain of the alliance chain through the P2P network architecture. When other nodes link to the new block information, they will verify the authenticity and validity of the data block according to the data structure, timestamp, address source, key instructions, etc. If the data block is legal, the block node will check The time series stores the data in the main body of the alliance chain block and continues to forward it to neighboring nodes; if the block receives illegal data, the network node will immediately stop spreading the data to ensure that the illegal data will not be on the intelligent data management platform forward.

4.3. Consensus layer of intelligent data management platform

The alliance chain technology fundamentally solves the problem of consensus and trust between blocks in the intelligent data management platform. The distributed block nodes of the alliance chain can quickly reach a consensus for different types of data. The consensus layer of the intelligent data platform includes Proof of Stake (POS), node management system, Ripple proof of consensus algorithm (RPCA), monitoring system, upgrade system, Byzantine fault tolerance (PBFT) Other technical elements, the combined application of multiple consensus mechanisms is the key factor to realize the intelligent data management platform to reach node consensus in the shortest time, and to ensure that the entire alliance chain is not attacked by illegal data.

4.4. Contract layer of the intelligent data management platform

The contract layer specifically includes algorithm systems, smart contracts, contract management systems, business monitoring and early warning, etc. Smart contracts and contract mechanisms are the essence of the contract layer. They are intelligent and can automatically trigger programs to execute the contract without interference from human participation and external factors. This improves the data of the smart management platform while ensuring the fairness of the contract layer. Processing efficiency [12].

$$F(w)=\{F_1(w),F_2(w),F_3(w)\} \tag{4}$$

$$\max F_1(w)=\sum_{j=1}^{n} f_{j1}(w_j)=\max \sum_{j=1}^{n} f_{j1}(\alpha_j w_{j1}+\beta_j w_{j2}+\cdots+\lambda_j w_{jk}) \tag{5}$$

$$\max F_2(w)=\frac{n}{n}\bullet(\prod\nolimits_{j=1}^{n} F_{j2}(w_j))^{1/n} \tag{6}$$

$$\min F_3(w)=\sum_{j=1} f_{j3}(w_j)=\sum_{i=1} R_j \le R_0 \tag{7}$$

Among them, F(W) is the first-level objective function, involving three sub-goals of economic, social and ecological environmental benefits; $F_1(w)$ is the overall benefit of the supply chain,

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which is gathered from the k economic benefits of n core green vegetable companies in the chain and strives to maximize; $F_2(w)$ is the overall social benefit of the supply chain, and the purpose is to maximize the coupling and coordination between enterprises in the chain. The right side of formula (6) is the calculation model for the coupling and coordination of multiple subsystems; $F_3(w)$ is the overall ecological and environmental benefits of the supply chain, and the purpose is to control the overall maximum usage $\leq R_0$; $f_{j3}(w_j)$ represents the maximum allowable usage R_j of the j-th enterprise in the chain.

At the same time, the contract layer encapsulates various algorithm mechanisms, script codes, and more complex smart contracts derived through combination. The smart data management platform embeds the program for processing corporate data into the contract layer, draws up the content of the smart contract and the activation conditions for the execution of the contract, and embeds it into the smart data management platform in the form of script code. When the enterprise management system is running, various enterprise data codes are embedded in specific blocks and broadcast to all nodes through the block network. Once the smart contract meets the trigger conditions, it will immediately monitor the code and automatically activate the contract commands to complete The analysis and processing of smart data is no longer affected by any signed contract terms, enabling block nodes to actively or passively transmit and process data information.

4.5. Application layer of intelligent data management platform

The use (application) layer specifically includes customer management, transaction information management, procurement management, production management, operation and maintenance services, report services, data services, etc. The application layer encapsulates various application scenarios of the alliance chain in the intelligent data platform, and is also an interactive processing platform for enterprise internal information. Green vegetables can realize the efficient operation of various enterprise data information flows between enterprise departments through the application layer, thereby ensuring the normal operation of the intelligent data management platform. Blockchain technology closely integrates and optimizes all aspects of enterprise data processing, forming a new system of enterprise intelligent data management platform technical architecture.

The application layer can judge the current operation of the entire intelligent data management platform according to the direction of resource flow and the management system, form analysis reports and automatically respond to problems that arise, and also provides basic operational guarantees for the processing and calculation of distributed storage data. The enterprise data block reads the data it needs through the interface provided by the alliance chain group, and in this process establishes an enterprise information interaction mechanism and completes the pre-set functions. The application layer of the intelligent data management platform can determine the problems in the operation of the intelligent data management platform or manufacturing equipment through the analysis report of data transmission quality, information demand status, and information distribution efficiency, and troubleshoot problems in a timely manner to ensure the normal operation of the enterprise. The future improvement measures of the enterprise and the development direction of the modern manufacturing industry make predictions. The application layer provides the technical platform, analysis results, operation strategies and management methods for the enterprise data distributed management system, and also provides the basic framework support for the intelligent data platform.

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5. Conclusion

With the rapid development of blockchain technology in the past two years, various fields, especially manufacturing companies, have paid more and more attention to the application of blockchain technology, and are trying to rely on this technology to develop my country's planting industry to a new level. At present, the application of blockchain technology in the intelligent data management platform of the green vegetable supply chain is still in the exploratory stage. There are few experiences to learn from and there are a lot of barriers and uncertain challenges. It requires continuous technological innovation and experience exploration. It is hoped that this research can provide an innovative reference for blockchain technology in the intelligent data management of the green vegetable supply chain.

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