

Research on Intelligent Logistics Application based on Blockchain Technology

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Abstract: With the rapid development of information technology, intelligent logistics has become the development trend of modern logistics industry. As an innovative technology, blockchain technology has the characteristics of decentralization, data tamperability and high security, which provides new opportunities for the development of intelligent logistics. This paper first introduces the basic principles and characteristics of blockchain technology, and then analyzes the application scenarios of blockchain technology in intelligent logistics, including logistics tracking, supply chain management and so on. Then, it discusses the key technologies of building intelligent logistics platform based on blockchain technology, such as consensus mechanism. Finally, the advantages and challenges of intelligent logistics application based on blockchain technology are summarized, and the future development trend is prospected.

Keywords: Blockchain Technology; Smart Logistics; Supply Chain Management.

1. Introduction

In today's globalization, the logistics industry plays a vital role. It connects producers, distributors and consumers, and is a bridge for the flow of goods and services. However, the traditional logistics system faces many challenges, such as low efficiency, opaque data, security issues and fraud risks. In order to solve these problems, the concept of intelligent logistics came into being.[2] Smart logistics uses modern information technologies, such as Internet of Things (IoT), big data analysis, cloud computing and blockchain technology, to intelligently manage and optimize logistics activities, improve logistics efficiency, reduce costs, and enhance the reliability and trust of supply chain. [1] Smart logistics system based on blockchain technology provides a decentralized, safe, transparent and efficient solution, which is expected to bring revolutionary changes to the logistics industry. It is an important direction of the development of logistics industry, which will bring great value to logistics enterprises and supply chain participants. With the continuous maturity of technology and the increase of application cases, the future of intelligent logistics will be brighter and make greater contributions to the sustainable development of global economy.

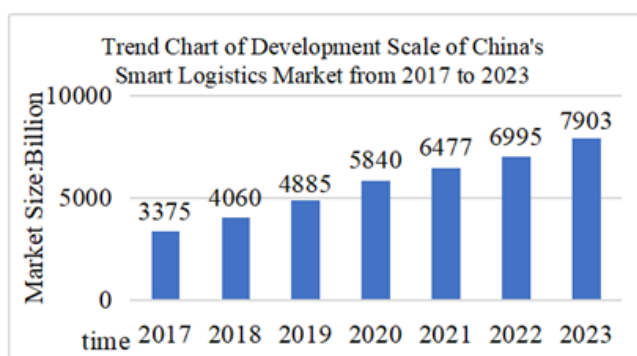


Fig 1. Trend Chart of Development Scale of China's Smart Logistics Market from 2017 to 2023

2. Blockchain Technology and Smart logistics overview

(1) Brief introduction of smart logistics

Intelligent logistics is a new management mode which relies on information technology and makes logistics activities intelligent and automatic.[10] By collecting, processing and sharing the information in the process of logistics, it improves the efficiency and accuracy of logistics and reduces the cost of logistics. Key technologies include Internet of Things technology, big data analysis, artificial intelligence and so on.

The characteristics of intelligent logistics are mainly manifested in automation, informationization and networking. Through automation equipment and technology, realize unmanned operation of logistics process and improve operation efficiency; With the help of advanced information technology, real-time processing and sharing of logistics information can improve the transparency and controllability of logistics; With the help of network technology, the rapid transmission of logistics information and collaborative operation can be realized, and the operation efficiency of the whole logistics system can be improved.

(2) Brief introduction of blockchain technology

Blockchain technology is a distributed account book technology, and its working principle is to record data on a blockchain that cannot be tampered with, to realize reliable transmission and storage of information. Specifically, the working principle of blockchain can be divided into the following five steps, as shown in the working principal diagram of blockchain:

1) Create blocks: The data in the blockchain is stored in the form of blocks, and each block contains some transaction records and other metadata. When new data needs to be added to the blockchain, a new block will be generated by some specific algorithms, which contains hash values about the new data.

2) Verification blocks: Blocks added to the blockchain need to pass verification. The verification process is mainly to

check whether all transactions in the block conform to the rules and verify whether the algorithm for generating the block is correct. Only verified blocks can be added to the blockchain.

3) Add to the chain: New blocks will be added to the blockchain. Each block in the blockchain contains a link to the previous block, forming a chain structure. This can ensure that the whole blockchain is orderly and continuous.

4) Consensus reaching: Nodes in blockchain need to reach agreement through consensus algorithm.[7] The purpose of

consensus algorithm is to solve the trust problem among nodes in distributed system and ensure the consistency of data. Common consensus algorithms include Proof of Work and Proof of Stake.

5) Update chain: When the consensus is reached, the blockchain will be updated and synchronized to all nodes. Each node will keep a complete copy of the blockchain, and keep the data consistent through mutual communication and consensus algorithm.

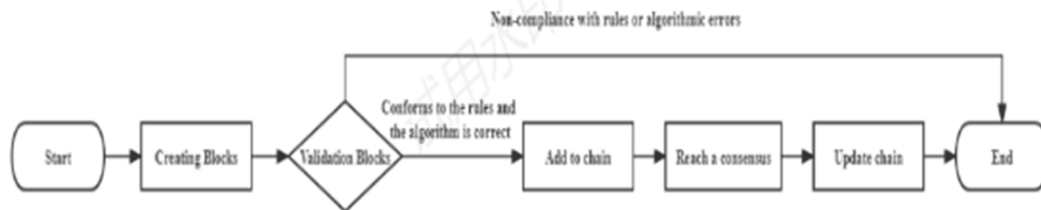


Fig 2. Blockchain workflow chart

Blockchain technology ensures the security and credibility of data through decentralized database technology and distributed consensus algorithm, and has the characteristics of high transparency, traceability, and anti-attack ability.

3. The Role and Value of Blockchain Technology in Smart Logistics

Blockchain technology, as a distributed account book technology, provides innovative solutions for the logistics industry with the characteristics of decentralization, data tamper ability, high transparency, safety, and reliability.

(1) In supply chain management

Blockchain can provide a transparent and tamper-proof data link, so that every transaction can be clearly checked. It helps to improve the transparency and efficiency of the supply chain, reduce fraud, and ensure the authenticity and quality of products. Through blockchain, all supply chain participants can access common data in real time, thus strengthening cooperation and optimizing inventory management and logistics planning.[4]

(2) In Smart Logistics

Blockchain technology can be used to ensure the security of digital identity and digital assets. For platforms that need to process a large amount of data and transactions, such as e-commerce and logistics service platforms, blockchain can provide a security framework to protect user information and transaction records from unauthorized access or tampering.

(3) In the financial sector

Blockchain technology can be closely integrated with the logistics industry, and automated payment and settlement processes can be realized through intelligent contracts and other tools. It not only reduces the errors of manual processing, but also reduces the cost of financial transactions.

(4) In improving the trust of the logistics industry and solving the contract execution

Through blockchain technology, contract terms can be programmed into automatically executed intelligent contracts to ensure that all parties to the contract fulfill their commitments and reduce the risk of default. In dealing with accounts receivable, transfer and financing, the application of blockchain can simplify the process, reduce disputes, and improve the efficiency of capital circulation.

4. The Architecture Design of Smart Logistics System based on Blockchain Technology

The intelligent logistics system based on blockchain technology breaks many problems in the traditional logistics industry and injects new vitality into the logistics industry. This system is the development direction of our logistics industry in the future. The design and implementation of intelligent logistics system based on blockchain technology needs to comprehensively consider technical architecture, business model, user experience and other aspects, which breaks the limitations of traditional logistics industry and significantly improves operational efficiency.[5] The intelligent logistics system architecture based on blockchain technology includes the following levels.

(1) Data Awareness Layer

It includes various sensors and identification devices, such as RFID tags, GPS trackers, temperature, and humidity sensors, etc., which are used to collect real-time data in the logistics process. The data collected by these devices are encrypted and uploaded to the blockchain network to ensure the authenticity and non-tampering of the data.

(2) Blockchain Network Layer

This is the core of blockchain technology, which consists of multiple blockchain nodes, each of which stores complete transaction records. Blockchain network is responsible for verifying transactions, recording events, and processing intelligent contracts. Each participant is a node in the network and has access to data and audit rights.

(3) Data Processing and Analysis Layer

This includes big data analysis and artificial intelligence algorithms, which are used to process and analyze data on blockchain. Through these technologies, logistics activities can be monitored and predicted in real time, inventory management can be optimized, transportation route planning and so on.[9]

(4) Application Services Layer

This layer provides an interface for intelligent logistics system to interact with users, including various applications and services, such as order management system, inventory

management system, transportation management system and so on. These applications and services interact with blockchain networks through intelligent contracts to ensure the safe and automated execution of transactions.

(5) Security and Privacy Layer

Ensure the security of the system, including encryption technology, access control and privacy protection mechanism. By using the private key and public key system of blockchain, the safe transmission and storage of data can be ensured. Protect data from unauthorized access, and ensure the security of the system and the privacy of users.[8]

(6) Regulations and Compliance Layer

Ensure that the operation of the system meets the requirements of relevant laws and regulations. Through the transparency of smart contracts and blockchain, the compliance inspection and audit process can be simplified. Ensure that all logistics activities comply with relevant laws and regulations, and simplify the audit process.

The goal of the whole system architecture design is to realize the automation, intelligence, and transparency of logistics activities, improve logistics efficiency, reduce costs, and enhance the reliability and trust of the supply chain. Through blockchain technology, smart logistics system can provide a decentralized trust mechanism to ensure that all participants can share information and services in a safe, fair, and transparent environment.

5. Smart Logistics Business Scenario Application based on Blockchain Technology

(1) Logistics Information Sharing and Collaborative Operation

In the traditional logistics system, the low efficiency and poor accuracy of information transmission have always been the pain points of the industry. The lack of mutual trust among participants makes it difficult to realize effective information sharing and collaborative operation, forming information islands, resulting in waste of resources, delay and contradiction between costs and benefits.

The emergence of blockchain technology provides an effective solution to the above problems. The core of blockchain technology is decentralization, which allows participants to exchange information directly on an open and transparent platform, eliminating the problems of intermediate links and information asymmetry. This not only improves the speed of information transmission, but also ensures the consistency and accuracy of data. For example, through blockchain technology, all parties in the supply chain can view the status, location, and delivery time of goods in real time, to predict and solve possible problems in advance. At the same time, all participants can communicate and cooperate in real time on the platform, complete logistics tasks together, and improve the efficiency and response speed of collaborative operations. In addition, the introduction of intelligent contract further simplifies the transaction process and improves the efficiency of collaborative operation.

(2) Logistics Tracking and Tracing

Today, with increasing emphasis on product quality and source, tracking and tracing goods has become the basic demand of the industry. Blockchain technology provides a solution to this demand. As shown in Figure 5-1, blockchain logistics tracking and traceability flow chart. Using the immutability of blockchain, we can create a unique digital identity for each piece of goods and record every link from production to consumption. In this way, both consumers and enterprises can trace the source, production date, transportation route and delivery process of goods by scanning QR codes or using specific applications to ensure that goods arrive at their destinations safely and on time. In addition, the regulatory authorities are introduced to monitor the whole supply chain in real time, issue regulatory information reports, access third-party testing institutions, and provide scientific and reliable third-party testing reports to further improve the security and transparency of the supply chain. This transparency not only enhances consumer confidence and reduces the risk of fake and shoddy products, but also helps enterprises identify problems in the supply chain, improve operational efficiency and reduce the risk of fraud.

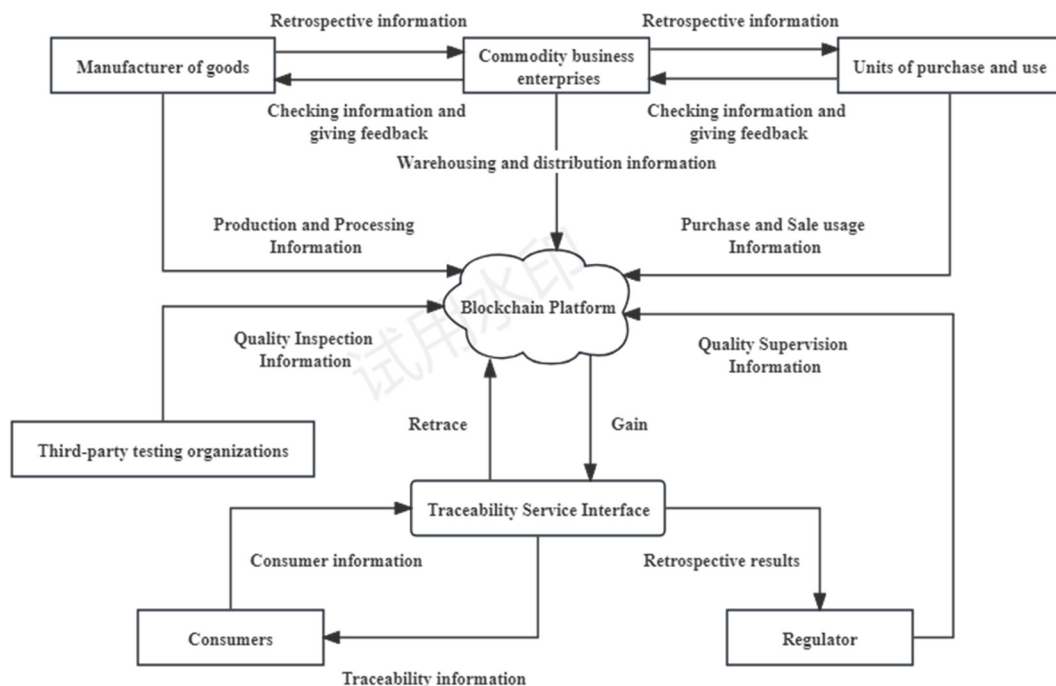


Fig 3. Blockchain Logistics Tracking and Traceability Flow Chart

(3) Logistics Safety and Integrity System

Logistics security has always been the focus of the industry, which involves not only goods security, but also personnel security, information security and payment security.[6] The multi-level encryption and distributed storage mechanism of blockchain technology provides strong support for logistics security and credit system, which can effectively solve the problems mentioned above. Logistics enterprises can ensure the privacy and integrity of data through encryption technology; Distributed storage enhances the recoverability and fault tolerance of data. Blockchain technology can record the behavior and transaction data of each participant, and provide reliable data for the establishment of credit evaluation system. At the same time, the regulatory authorities can monitor and manage the logistics industry in real time. The intelligent contract function based on blockchain can also create predetermined rules and conditions, automatically execute certain transactions or operations, reduce human intervention and potential fraud risks, and build "double insurance" for logistics security and credit system.

(4) Cross-border logistics application scenarios

With the acceleration of globalization, the demand for cross-border logistics is increasing. However, cross-border logistics involves many countries and regions and currencies, and the process is complex, time-consuming and there are many risks. This increases the complexity and risk of cross-border logistics. Blockchain technology brings many advantages to cross-border logistics by providing decentralized, traceable, and safe transaction records. From payment and settlement to tariff settlement, all links can be managed efficiently and transparently through blockchain technology. This can not only reduce the risks and costs of cross-border transactions, but also improve the efficiency and convenience of customs supervision. The complexity of cross-border transactions is greatly simplified, and the operation cost and time cost are reduced. Through intelligent contract, scheduled payment and delivery conditions can be automatically executed to ensure the balance of interests of all parties. In addition, due to the transparency of blockchain, the risk of cross-border fraud and counterfeiting can be greatly reduced. For example, by verifying the authenticity and origin of products, the authenticity and compliance of imported goods can be ensured.

6. Conclusion

Intelligent logistics system based on blockchain technology is an important part of digital transformation of logistics industry. By integrating advanced technologies such as blockchain, Internet of Things, big data, and artificial intelligence, it provides a safer, more transparent, more efficient, and intelligent operating environment for the logistics industry. The design and implementation of this system can not only improve logistics efficiency, reduce operating costs, but also enhance the reliability and trust of the supply chain, laying a solid foundation for the future

development of the logistics industry.

With the continuous progress of technology and the deepening of application, it is expected that the intelligent logistics system will further promote the innovation and transformation of the logistics industry in the future. From supply chain management to financial services, from real-time tracking to intelligent contracts, blockchain technology will play an increasingly important role in intelligent logistics. Enterprises and organizations need to pay close attention to the development trend of these technologies and actively explore and practice the application of intelligent logistics systems in their respective businesses to maintain their leading position in the increasingly competitive market.

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