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Research on Cold Chain Pharmaceutical Logistics System based on Blockchain Technology

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Abstract

At present, Chinese medicine cold chain logistics industry is still in the early stage of development. The medical cold chain logistics lacks a sound mechanism and a standardized dynamic full-chain monitoring system. The industry information level is low, and no unified information management platform has been formed in drug manufacturing, transportation, storage, distribution and other links. Blockchain technology has many advantages, such as distributed ledger, tamper-free environment, consensus driven, etc., and can provide technical support for pharmaceutical anti-counterfeiting traceability, real-time monitoring, and regulatory coordination. This paper analyzes the current situation of Chinese pharmaceutical industry and the problems existing in the development of logistics, expounds the technical advantages of blockchain technology applied to pharmaceutical cold chain logistics industry, and finally builds a pharmaceutical supply chain model based on blockchain.

Keywords

Blockchain; Logistics System.

1. Introduction

With the rise of e-commerce and the Internet, the logistics industry develops rapidly, but there are many problems in the process of logistics development that need to be solved urgently: logistics cooperation difficulties and food safety problems caused by information asymmetry; The incessant problem of fake and inferior quality in society; Logistics enterprises have the risk problems of delayed payment and bad debts in the transaction; Supply chain small and medium-sized enterprises financing difficult, expensive and other problems.

Since Satoshi Nakamoto put forward the blockchain in 2008, the research on this concept has been hot every year. Blockchain technology has been applied to many areas of society, but it is not widely applied in the field of logistics. The characteristics of blockchain, such as decentralization, information sharing and unalterability, make it of high application value in the field of logistics. Therefore, applying blockchain technology to logistics will help solve some pain points in the current logistics industry.

2. Key Features and Advantages of Blockchain

2.1 Distributed Ledger

A distributed ledger is essentially a database of assets that can be shared across a network of sites, geographies, or organizations. Participants in a network can obtain a single, authentic copy of the ledger. Any change in the ledger will be reflected in all the copies, and the response time will be within minutes or even seconds. Records in the ledger can be updated by one, some, or all participants, depending on the rules agreed upon in the network.

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2.2 Tamper-free Environment

Blockchain provides the best security features for transactions with extremely high transparency and accuracy, with all data embedded in the system network and publicly available in the most transparent financial processing method. Changing the block data on the blockchain requires a large amount of computing power and computing costs. Therefore, the blockchain system is transparent, secure, and corruption-free, and linking data through nodes in a single-link network does not provide any weak links for tampering with the supply chain system.

2.3 Non-modifiable

Once a transaction is agreed upon and recorded by the system, it cannot be changed. The original record is saved as a transparent history that allows changes. For trust verification, blockchain technology independently verifies each block through a consensus model, which is immutable.

2.4 Consensus Driven

Consensus is the process by which a group of peers (or nodes) on a network determine which blockchain transactions are valid and which are not. The consensus mechanism is the method used to reach this agreement. It is these rule sets that help protect the network from malicious acts and hackers. There are many different types of consensus mechanisms based on blockchain and its applications. Although they differ in terms of energy use, security, and scalability, they all share a common goal: to ensure truthful and honest records. The following is an overview of some of the most well-known types of consensus mechanisms used by distributed systems to reach consensus.

3. Application Analysis of Blockchain Technology in the Field of Pharmaceutical Cold Chain Logistics

The pharmaceutical cold chain is a systematic project, involving the maintenance of a prescribed low temperature environment in every link from production, storage, transportation to distribution, so as to ensure the effectiveness of drugs to meet people's needs in disease prevention, diagnosis and treatment. China's pharmaceutical cold chain logistics industry is growing in scale, with sales reaching 390.34 billion yuan in 2020, up 14.97 percent year on year, according to data provided by the Pharmaceutical Logistics Branch of China Federation of Materials. At the same time, since 2018, the scale of pharmaceutical cold chain logistics cost has increased year by year, reaching 17.317 billion yuan in 2020, with a year-on-year growth of 25.81%. In addition, China's medical cold chain infrastructure investment continues to expand, the medical cold chain logistics network system is gradually strengthened, and new technologies and intelligent equipment are also emerging. With the batch launch of COVID-19 vaccines and the rapid expansion of the pharmaceutical e-commerce market, China's pharmaceutical cold chain logistics industry is bound to face more innovation and reform.

4. Pharmaceutical Cold Chain Logistics Node

4.1 Drug Production Link

Drug production involves raw material supply, drug research and development, drug testing and mass production. The data involved in this link includes raw material information provided by raw material suppliers and electronic procurement contracts, drug research and development parameters provided by drug research and development centers, qualified drug testing reports from drug testing centers, and various production information recorded by manufacturers. After the data is uploaded by different institutions, the platform stores and updates the data in the blockchain distributed ledger by successively authenticating the signature of the institutions, analyzing the original data, generating encryption keys and other processes.

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4.2 Cold Chain Logistics Link

Relevant enterprises undertaking warehousing, transportation and distribution business are important links of the whole pharmaceutical cold chain. The whole link should input the detailed information of logistics enterprises such as warehousing, transportation and distribution, logistics order information, temperature information collected by sensor equipment, positioning information collected by GPS and relevant information of each responsible person in the circulation process. After the information collection is complete, the authentication authority first signs the information, and then encrypts and stores the related data. The platform realizes the identification and verification of the user's identity through asymmetric encryption technology, and those who pass the verification can timely grasp the real-time and historical status of drugs and equipment through the blockchain platform. Relevant entities sign smart contracts using private keys. When the temperature exceeds the standard or the device is abnormal, the platform sends early warning information to different entities based on different permission Settings, which facilitates timely handling of abnormal events.

4.3 Traceability of Cold Chain Supervision

The platform verifies the authenticity of the identity by checking the subject's digital certificate, so as to carry out different authorization. Among them, cold chain traceability mainly includes pharmaceutical manufacturers' traceability of raw materials, consumers' anti-counterfeiting traceability of pharmaceuticals, and regulatory authorities' traceability of problem pharmaceuticals. Manufacturers can trace the information of planting, processing, testing, and logistics distribution of pharmaceutical raw materials or medicinal materials. Consumers can inquire the authenticity of drugs and the information of drugs in production, storage, transportation, distribution and other links through the retrospective source code. When a medical safety accident occurs, relevant regulatory departments can obtain the information of the overall process from production to consumption of drugs through blockchain, so as to efficiently and accurately locate the problem link, find the root cause of the problem and recall the problem drugs.

4.4 The Challenge of Block Supply Chain

The logistics link of pharmaceutical supply chain is determined, and then some problems and functions of supply chain are summarized. Table 1 summarizes the key challenges and how they can be addressed through blockchain. Seven major areas were identified and strategies in blockchain technology were discussed.

Table 1. Supply chain challenges and blockchain characteristics

		Blockchain capability			
		Distributed ledger	Tamper-free environment	non-modifiable	Consensus driven
Challenges	Large number of vendor (LNV)	Raw materials will be inspected and certified by multiple authorities within the organization so that each supplier and their respective raw material quality can be looked at	Once specific data and relevant information about suppliers and raw materials are added, it is impossible to change its originality.	Once the authorities will authenticate the data, they can determine where it is and what happens throughout the process and life cycle.	Since each block will be validated independently, there are certain rules for verifying quality.
	Multiple manufacturing facilities (MMF)	All blocks of each facility can be combined into one blockchain, which can be easily accessed due to decentralization.	Data from each facility will be more accurate and reliable	Each e facility and each individual blockchain has a person in charge, making it easy to access and modify.	You can check that one person only uses one access point to authenticate each block in each facility

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	Complex and unequipped distribution Network(CUDN)	Inventory as well as finished products (temperature, handling and visibility) can be easily tracked by adding a distribution network to a separate blockchain.	As the product/inventory will be continuously visible, there will be less chance of losing quality control due to temperature control etc.	Most third party cold chain logistics providers participate in the distribution network, so they cannot use the data that organizations have verified	If the third-party logistics provider validates any block, there is at least one responsible person.
	Procurement (P)	Each department can control raw material and batch failures through continuous quality checks and place information in relevant blocks so that all information is accessible through one source.	Problems with the quality and availability of raw materials have spiraled over the past few years, leading to production failures, quality delays and shortages throughout the plant	When we obtain data on each step of each process, it is easy to determine which step has fallen in quality, or where poor quality raw materials are coming from.	Once the problem is identified, you can easily access the people involved in the data in the validated block.
	Manufacturing (M)	Unexpected delays, plant closures, huge amounts of unused raw materials.	In this case, a consensus-driven characteristic or consensus model would be most effective.	Every process that enters the blockchain will be verified once these parameters are met.	
	Reverse Logistics (RL)		All products will appear on the blockchain, so whenever the product will be moved back, it can be kept in any warehouse or related venue		
	No visibility of Inventory (NVI)	Blockchain is the best solution to this challenge, because once inventory data is entered into the blockchain.			

Table 1 summarizes supply chain system characteristics and challenges, and considers all major factors in the pharmaceutical industry blockchain evaluation model.

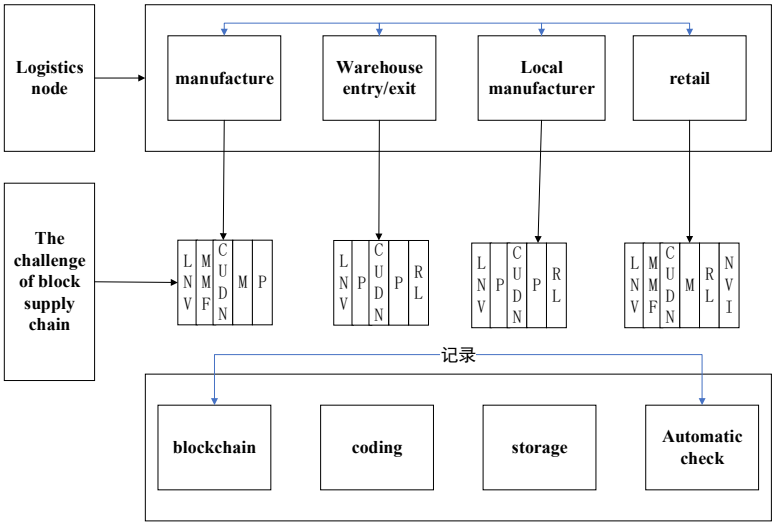

Figure 1. Supply chain network model of blockchain application

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Figure 1 integrates blockchain technology to illustrate the various links and challenges in the supply chain management system. Supply chain challenges such as LNV, MMF, CUDN, P, M, NVI, etc., are all solved in blockchain technology. All permissions and records are accessed through blockchain technology, making the system worry-free, secure, convenient and transparent.

5. Conclusion

With the rapid development of pharmaceutical e-commerce, pharmaceutical cold chain market demand continues to improve, pharmaceutical cold chain market has a huge prospect for development, pharmaceutical logistics industry has a long way to go. With the continuous innovation and application of blockchain technology and the continuous improvement of blockchain market policies and industry regulation, the blockchain industry has ushered in a wide range of application scenarios. The application of blockchain in the construction of pharmaceutical cold chain logistics can not only ensure logistics efficiency but also reduce logistics costs, realize the real-time sharing of cold chain information in all links, realize the whole-chain tracking of pharmaceuticals, and form a safe and efficient cold chain system. Taking blockchain as the underlying technology, the construction of digital platform of pharmaceutical cold chain has enlightenment significance for the informatization construction of the industry.

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