Research on Electronic Bill of Lading of Container Shipping Based on Blockchain Technology

Hankun Shi¹, Xuelin Wang*²
¹China Waterborne Transport Research Institute Beijing, China  
²China Waterborne Transport Research Institute Beijing, China  
¹shihankun@wti.ac.cn  
²wangxuelin@wti.ac.cn

Abstract. This paper analyzes the electronic bill of lading technology of container shipping, and solves the key problems such as the loss of bill of lading during the circulation of paper bill of lading. Based on the optimization of the basic structure and core technology of electronic bill of lading, this study incorporates the blockchain technology, analyzes the fit between blockchain technology and electronic bill of lading, and constructs a new model of electronic bill of lading for container shipping based on blockchain technology, which improves the safety and stability of shipping transaction information and provides more effective solutions for the future practice of electronic bill of lading for container terminals.

1. Introduction

In the process of container logistics goods trade, the rapid development of modern shipping technology puts forward higher requirements for the retention time and work efficiency of ship handling port. The emergence of electronic bill of lading has solved the problems of cumbersome circulation procedures in the operation of traditional paper bill of lading. The advantages of simple, convenient, safe and efficient electronic bill of lading make it gradually become an important tool in port logistics, and it has been widely applied and developed in the international community.

2. Technical analysis of electronic bill of lading for container shipping

Shipping has the characteristics of long distance, large volume, slow speed and wide waterway[1]. With the progress of shipping technology, especially the wide application of containers, the on-way time of goods is greatly reduced. However, in international trade, each business needs to go through inspection, customs declaration, settlement, mailing, redemption, insurance, negotiation, settlement, tax rebate, and delivery[2-3]. It involves multiple agencies such as shipping companies, customs, commodity inspection, banks, insurance, taxation. When the time of goods transportation is greatly reduced, if the circulation speed of bill of lading is not accelerated, the consignee cannot normally carry goods through the bill of lading. Electronic bill of lading can shorten the circulation time of documents. The traditional port logistics bill of lading is usually sent by the shipper to the consignee through express delivery. The arrival of the ship before the document will directly lead to the delay cost of goods and storage management costs. If the ship is transporting perishable goods, it may lead to the loss of the whole batch of goods. Therefore, the application of electronic bill of lading can greatly shorten the time of issuance and circulation of documents, save costs and improve work efficiency so that the consignee can successfully complete the delivery task.
Electronic bills of lading can reduce transaction costs. The use of electronic bills of lading has significantly reduced demand for bonds, and electronic bills of lading have significantly reduced the cost of trade as a whole[6-7]. Electronic bill of lading carries out the circulation and storage function of data and information through the network, which reduces the large amount of manpower and material cost consumed in the circulation of paper bill of lading. Electronic bill of lading is always stored in electronic form and recorded in the system. Electronic bill of lading avoids the loss of bill of lading caused by the transfer of bill of lading through paper transmission, and greatly reduces the possibility of forging bill of lading. The characteristics of e-commerce such as security, scalability and integration determine that the degree of freedom of electronic bill of lading circulation has reached an unprecedented level in time and space. Traditional paper bill of lading is poor in terms of the security of bill of lading circulation and the efficiency of bill of lading operation. Therefore, from the perspective of the future development of trade in goods, it has become the general trend that electronic bill of lading replaces traditional paper bill of lading.

3. blockchain technology

Blockchain is a chain data structure composed of data blocks in chronological order. Blockchain is a non-tamperable and unforgeable distributed account guaranteed by cryptography. Instead of accessing data by ordinary key value access, blockchain adopts chain structure and checks block data by calculation, generates blocks and loads new blocks through consensus and voting mechanism[8]. Blockchain technology uses encryption algorithm to improve the reliability of information transmission. Since there is no fixed central node in blockchain, participants in the system exchange data based on address rather than personal identity, so all parties can complete all kinds of transactions and cooperation without mutual trust, and the recorded information is difficult to be tampered with. The blockchain system is formed by the combination of countless nodes in the computer network, so the system does not need to rely on the interference and supervision of central third-party organizations [9]. The data exchange between nodes is carried out according to the established rules of the system itself, and other institutions cannot interfere. Blockchain technology ensures the safety of data exchange between system nodes. Any node is independent, and a small part of the block is not qualified for the operation of the whole blockchain system.

Blockchain is a solution of multiple technology sets. The core technologies in its technical architecture include consensus mechanism, encryption algorithm, intelligent contract and so on.

3.1. Hash function

Hash algorithm is suitable for many research fields. It converts values of any length to binary values and maps them to shorter binary values of a fixed length. This result is called the hash value of the original data. Hash algorithm is unidirectional, no matter how long the input data is, the hash value of the same length is generated, reflecting a fixed length. When the input data has only one bit difference, the hash value will be different, which reflects the randomness of the hash algorithm.

3.2. Peer-to-Peer Networking (P2P)

Peer-to-Peer Networking is a spring-centered service node, which regards all network participants as peers and assigns tasks and workloads among them. P2P network is a network structure that relies on the common maintenance of the user group, with strong reliability. Any single or small number of node failures will not affect the normal operation of the entire network. The network capacity of P2P network has no upper limit, because with the increase of the number of nodes, the resources of the whole network are also increasing synchronously. Compared with the centralized network model, in the peer-to-peer network model, there is no centralized server, and the status of thousands of computer nodes connected to each other in the network is equal. The data in the network are jointly maintained, produced and shared by all nodes.
3.3. Cryptographic algorithm
In the case of identity uncertainty and information asymmetry, the establishment of ‘trust’ mechanism to ensure the normal development of economic activities is the key problem of blockchain. Encryption algorithm can ensure the free exchange of data between network nodes and ensure the safety and reliability of data. The encryption algorithm solves this core problem, and the most widely used encryption algorithms are hash algorithm and asymmetric encryption algorithm.

3.4. Smart contract
Blockchain technology can be integrated into many fields, and the application of intelligent contracts is indispensable. Intelligent contract is a computer program that automatically executes when certain conditions are met. An intelligent contract based on blockchain needs to include transaction processing mechanism, data storage mechanism and complete state machine for receiving and processing various conditions. The logic of smart contracts running in blockchain is shown in Figure 1.

![Smart contract operation logic](image)

3.5. Consensus mechanism
Consensus mechanism is a consensus understanding of all nodes in the network how to record, verify the results of accounting and maintenance. To modify transaction information in a block, you must modify the information in the block and all blocks behind it. The consensus algorithm of blockchain system is mainly divided into workload proof, voucher consensus algorithm, BFT algorithm, and consensus algorithm combined with trusted execution environment.

3.6. Time stamp
Time stamp refers to adding time verification to the information production on each block in the blockchain, tracing the source of each data input, arranging, verifying and ensuring the authenticity of the data according to the time sequence, and not allowing the data to be tampered with to prove the originality of the data and the ownership of the right. Based on the above characteristics of blockchain, the technology has three advantages: one is authoritative and credible. To establish the trust needed by unifying the constraints and supervision of the collective. Two is to decentralize, there is no third party intervention and interference, by encrypting the device to ensure that any transaction is not regulated by third parties. And it also can completely reproduce the links and procedures experienced before and after any commodity transaction.

4. Analysis of Fit between Blockchain Technology and Electronic Bill of Lading
At present, the electronic bill of lading for container shipping mainly adopts the EDI data exchange method, while the blockchain is a distributed shared database technology. Each node stores a complete account, and different nodes backup each other. The data update and maintenance are completed by multiple nodes. The comparative analysis of blockchain technology and electronic bill of lading technology is shown in Table 1. Container shipping electronic bill of lading involves the co-operation of shippers, consignees and ports to achieve information sharing. In information sharing, it relies on network exchange, transfer and storage of data. Therefore, blockchain technology and electronic bill of lading data exchange are consistent in this mechanism. Blockchain realizes data interaction through trust.
Blockchain technology improves the trust relationship, so that information can be exchanged accurately and quickly. Therefore, blockchain technology and electronic bill of lading are consistent in the trust mechanism. Blockchain has a strong security guarantee for information, and the data of electronic bill of lading has a high demand for security, especially the security of transaction information and user information. The security mechanism of blockchain can effectively solve the security problems in multimodal transport, so blockchain technology and electronic bill of lading are compatible in security mechanism. Intelligent contracts embedded in blocks in blockchain technology are automatically executed when they are triggered after compilation. If the electronic bill of lading uses intelligent contracts, its automatic execution characteristics can avoid artificial malicious interference and improve the execution efficiency. Therefore, the two are consistent in the contract mechanism.

Table 1 Comparative analysis of EDI technology and blockchain technology

| Dimension | EDI technology | Blockchain technology |
|-----------|----------------|-----------------------|
| Informatization | Centralization, low level of information sharing | Decentralization, high degree of information sharing |
| Safety | It is prone to tampering when querying and monitoring information, and network failures will cause irreversible information | Transaction information cannot be tampered with and can be traced back |
| Efficiency | Information needs to be analyzed by EDI, and the transmission efficiency is low | Real-time data sharing, high transmission efficiency |
| Credibility | Low credibility | High credibility and de-trust |

5. Research on Shipping Electronic Bill of Lading Based on Blockchain Technology

In the practice of port logistics e-commerce, the operation procedure of electronic bill of lading is shown in Figure 2. The carrier transmits the telecommunication information and password to the shipper. The carrier begins to enjoy the right to dispose of the consignment upon confirmation by the shipper that it has received the consignment. After the shipper completes its settlement in accordance with the rules, it notifies the carrier by sending a telegram, at which time the consignment of the consignment is transferred from the carrier to the bank and the carrier provides the bank with a new password while withdrawing the old password. After the consignee successfully pays the goods to the bank, the consignee finally obtains the right to control the goods. The carrier communicates to the carrier by sending a telecommunication that it has controlled the goods. The carrier also informs the consignee about the goods. Finally, the consignee obtains the bill of lading at the port by means of the telecommunication of the notice of arrival and its identity certificate. It can be seen from the operation process of electronic bill of lading that the practical operation of electronic bill of lading is extremely complex. In the process of realizing the same function as traditional paper bill of lading, it must rely on the intervention of the third party system to register the issuance, circulation and cancellation of electronic bill of lading, so as to ensure the safe and single circulation of electronic bill of lading.
This study uses blockchain technology, consensus algorithm and intelligent contract to construct container shipping scenarios based on blockchain electronic bill of lading system, which provides a new direction for the development of electronic bill of lading. The electronic bill of lading mode of container is shown in Figure 3.

The electronic bill of lading mode of container shipping based on blockchain technology is as follows:

1) The shipper prepares a list of goods to be sent to the carrier through the electronic bill of lading system. The carrier accepts the shipment application and the system will generate the electronic bill of lading on the basis of mutual consensus and send it to both the shipper and the carrier. Both parties have the right to access the relevant information of the electronic bill of lading, and no one has the right to modify it alone. The shipper sends the cargo transportation content and rules to the carrier through the electronic bill of lading circulation platform to apply for shipment.

2) The carrier node of the system automatically processes the application submitted by the shipper, and checks the legitimacy and security of the application. If the application conditions are met, the carrier node will automatically generate an electronic bill of lading and send it to the carrier, which will be confirmed by the shipper and notify the cargo transportation scheduling. After the goods are loaded, the carrier will sign an electronic receipt, and then the carrier will send the electronic bill of lading and updated communication keys to the shipper. After confirmation, the shipper will have the right to control...
the goods, and the electronic bill of lading is issued. The carrier node sends information to the consignee node to confirm that the consignee obtains the goods, and sends electronic bill of lading and updated communication keys, which are confirmed by the consignee node.

3) The shipper conducts forecast inspection to the customs and other regulatory authorities. After passing, the system sends the information certificate to the shipper and the carrier, and the information certificate will be systematically recorded. The shipper and the carrier sign the intelligent contract through the system, setting the trigger conditions, the carrier receives and loads the goods, and authorizes the electronic signature to the shipper. After confirming the authorized electronic signature, the shipper authenticates and records the shipper as the owner of the electronic bill of lading, and gives the shipper the relevant access and use rights.

4) If the shipper applies to the financial institution for pledge, the shipper and the financial institution need to sign an intelligent contract through the system and set trigger conditions, at this time, the financial institution obtains the ownership of the electronic bill of lading, and the shipper retains only the access to the electronic bill of lading. When the consignee pays a ransom to the financial institution, the smart contract triggers the consignee to obtain ownership of the electronic bill of lading. The shipper sends electronic invoices, electronic insurance policies and electronic bills of lading to the terminal of financial institutions, and completes the settlement of money after confirmation. The shipper sends information to the carrier, and the right of cargo control is transferred to the financial institutions. Then the carrier destroys the communication key with the shipper, and confirms and provides new transaction keys to the financial institutions. Financial institutions become the pledge holders of electronic bill of lading.

5) The intelligent contract between the shipper and the carrier is triggered. The system sends the arrival information to the consignee, and the consignee takes the goods from the carrier by the ownership certificate of the electronic bill of lading. The consignee sends a key to the carrier’s agent and returns the delivery time and place after confirmation. After the pick-up is completed and the two parties confirm, the system automatically settles the completed intelligent contract and terminates the relevant permissions granted.

With the continuous expansion of the application of blockchain, its credit is also accumulating. This mutual proof mechanism within the blockchain system ensures the true reliability of electronic bill of lading transaction information. The transaction data transferred to a certain account will not appear repeatedly in other accounts, ensuring the uniqueness of the transaction data, realizing point-to-point transactions, and avoiding the problem of double payment. Blockchain technology solves the problem of the most needed credit source of electronic bill of lading, and fundamentally solves the problem of insufficient transferability of electronic bill of lading. Blockchain bill of lading is not like CMI bill of lading and Bolero bill of lading, in the transportation contract relationship to create an additional third party to ensure the smooth progress of the contract, but let all users in the blockchain system as a neutral third party to exercise the function of supervision. The issuance of blockchain bills of lading is automatically generated through the system running special instructions. The issuance of blockchain bills of lading is more neutral and closer to the issuance mode of traditional paper bills of lading. In the course of the transfer, the participation of the carrier or the registration authority is not required, nor is the carrier given more responsibility and risk. The database technology used in block chain bill of lading is to record data messages in the whole network through distributed recording. Each change of bill of lading information will be authenticated and supervised by the whole network. The possibility of tampering with the information recorded in this way is extremely low, and the transaction information recorded on the blockchain bill of lading has higher security.

6. Future trend analysis
Blockchain technology brings both opportunities and risks to the shipping industry. At present, there is no unified standard for block chain technology in the field of container shipping. While exploring the application of block chain technology, it is necessary to actively discuss and formulate extensive industrial standards and technical agreements. At the same time, it is necessary to grasp the focus of
supervision, study the implementation of policies and laws and regulations in depth, strengthen market supervision, shipping needs innovation, and innovation also needs to improve supervision. In order to circulate smoothly and stably under the international trade system, a sound and reliable legal system is essential. A complete set of legal system can provide corresponding legal norms under the premise of ensuring transaction safety and safeguarding the legitimate rights and interests of all parties, ensure the stability and predictability of relevant evidence of all parties, so that the parties can have laws to abide by when disputes occur on blockchain bills of lading, and maintain the stability of blockchain bills of lading.

7. Conclusion
In order to solve the problems of mutual trust and transaction security in the process of container shipping electronic bill of lading circulation, this study applies block chain technology to the field of electronic bill of lading, and designs a research scheme of container shipping electronic bill of lading based on block chain technology. By analyzing and referring to the characteristics of blockchain time stamp, consensus mechanism and intelligent contract, and recording each transaction of electronic bill of lading in chronological order with time stamp, the P2P network is used to package the information of electronic bill of lading transactions into blocks for the whole network broadcasting. All nodes in the whole network can verify the legitimacy and effectiveness of each cargo transportation transaction corresponding to the electronic bill of lading. Finally, consensus mechanism is used to reach a consensus, and relevant blocks are added to the blockchain. The information of electronic bill of lading transactions throughout the whole process cannot be tampered with. The electronic bill of lading for container shipping based on block chain technology can not only ensure the safety and fairness of the circulation of electronic bill of lading, but also provide more effective solutions for the practice of electronic bill of lading, and help to improve the operation efficiency and service quality of multimodal transport of goods.

References
[1] Sun Tao. The container ship shipping market presents five major characteristics [J]. China Ship Inspection, 2007(6): 39-39.
[2] Zhang Weixin, Wang Qianfeng. On the operation of electronic bills of lading in international cargo transportation [J]. Foreign Economic and Trade Practice, 2004, 000(002): 20-22.
[3] Zhang Qianqian. Prospects of electronic bills of lading [J]. Times Economics and Trade (Academic Edition), 2006.
[4] Liu Zhao. Research on Legal Issues of Electronic Bill of Lading Circulation Mode[D]. Dalian Maritime University, 2011.
[5] Hu Lijun. Circulation Mode and Application Analysis of Electronic Bill of Lading[J]. Modern Trade Industry, 2008, 20(010):344-345.
[6] Li Qiujuan. On the Application of Electronic Bill of Lading in International Trade[J]. Foreign Economic Relations and Trade Practice, 2008, 12(12):62-62.
[7] Wang Huaqun. Cryptography in Blockchain[J]. Journal of Nanjing University of Posts and Telecommunications (Natural Science Edition), 2017, 37(6):61-67.
[8] Yuan Yong, N I Xiao-Chun, Shuai Zeng, et al. Development status and prospects of blockchain consensus algorithm[J]. Zidonghua Xuebao/Acta Automatica Sinica, 2018, 44(11):2011-2022.
[9] Dong Peng, Xie Fengbo.The impact of blockchain on the development of shipping industry [ J ].Traffic and transportation, 2018, v.34. No.197 ( 03 ) : 26-28.