

# Logistics Management System Based on Permissioned Blockchains and RFID Technology

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**Abstract.** In the traditional logistics management system, it usually involves the integration of information flow, transportation, warehousing and security. However, in the actual process, it is not easy to verify and track the goods in transit while responding to emergencies. In addition, due to the lack of transparency, the accident caused by the whole process is extremely difficult. Radio Frequency Identification (RFID) technology can better solve the problems of visual tracking and complicated operation in logistics management. Blockchain (BC) technology can make organizations more transparent, democratic, distributed, more effective and safer. The use of BC technology can build a traceable and identifiable system for the logistics industry from production, warehousing to distribution, and protect logistics security in a complex supply chain system for cross-regional logistics. In this paper, we design and develop a logistics management system based on permissioned BCs and RFID technology. This system uses RFID chip, smart contract and permissioned BCs technology to improve the transparency of logistics management and automation of information collection and reduce the risk of logistics security. Finally, the validity of the design scheme is proved by combining specific application scenarios with an actual case.

**Keywords:** Logistics management system, permissioned blockchains, RFID, smart contract.

## 1. Introduction

Due to the continuous development of e-commerce platforms, logistics needs are becoming more and more extensive, logistics management is becoming more and more important, and logistics management is developing towards information technology. The logistics management system mainly includes three parts: order processing, inventory management and distribution management [1]. The order processing is mainly for the customer to submit the order through the platform, and the system will remind the warehouse to carry out the goods after the system has been reviewed. Customers can also track the logistics status of goods through the platform; inventory management mainly includes four modules: information collection, storage management, library management and outbound management [2]. The information collection includes writing, reading and information entry operations. Inbound management includes cargo inspection, inbound inspection, and inbound operations. The warehouse management includes cargo inventory, cargo inquiry and location inquiry operations. The outbound management includes outbound query, outbound information entry and outbound operations; distribution management is mainly used for cargo tracking and monitoring, to optimize the transportation route and the security of the distribution process. Guarantees are also divided into vehicle source information management, line information management, order information management and system management.

However, with the explosive development of logistics industry in recent years, the existing problems have become increasingly prominent, which has become one of the most prominent contradictory industries in the new consumption era, such as goods damaged, lost, long-term stay,

wrong single-lead, information leakage, logistics business chain long lead to the underutilization of resources and so on [3].

Traditional bar code recognition technology is susceptible to contamination, and can only scan one at a time, with low efficiency, harsh conditions, small capacity, and inability to reuse. Moreover, it is difficult to trace the product information, and it is difficult to prove and trace when a dispute arises. RFID technology is a kind of wireless radio frequency identification technology, which consists of reader and electronic tag [4]. It is a kind of automatic identification technology using radio. It has high confidentiality, large information capacity, and cannot affect the loss of information in harsh environment. It is easy to operate, can carry out high data integration, has good security protection capability, low operating cost, and can carry out long-distance operation. RFID technology with identification, multi-label identification and convenient packaging is not easy to damage [5].

Traditional business model is difficult to monitor the execution of cross-agency transactions in a mutual trust network. Each participant has its own ledger and changes it when the transaction occurs, additional work and intermediary costs caused by collaboration with all parties. Due to business conditions, contract duplication is scattered among the participants, resulting in the ineffectiveness of the overall business process. The information is not transparent and unified, which results in the complex collaboration of commodity production, logistics, warehousing, sales and other links, consuming time and high cost.

Blockchain (BC) is a distributed, multi-node, cooperated database [6]. Detailed information of each link in logistics industry, such as seller, buyer, price, contract terms and any related details, is verified by signatures of both parties and many parties, and uploaded to the whole network to achieve information sharing and absolute security of information. Thus, information interaction is achieved, which determines the scale and efficiency of logistics. In this way, everyone in the system can keep accounts. This not only ensures the great security of the whole system, but also guarantees the openness and transparency of accounting records, removes the flow of manual information and paper information, greatly reduces costs and improves efficiency[7].

Using BC technology, the transportation process of goods can be clearly recorded. The whole process of loading, transportation and taking parts can be clearly seen, which can optimize the utilization of resources, compress the intermediate links and improve the overall efficiency. The BC records all the steps of the goods from sending to receiving, which ensures the traceability of information, thus avoiding the occurrence of packet loss and false claim. For express mail signature and receipt, just check the BC, which eliminates the problem that couriers faked signatures to collect parcels, and also promotes the implementation of real-name logistics system. Moreover, enterprises can also grasp the logistics direction of products through BCs to prevent cargo channeling, which is conducive to cracking down on fake goods and guaranteeing the interests of dealers at all levels offline.

The content of this paper is organized as follows: Section 2 introduces the related technical background; Section 3 presents a logistics management system based on permissioned BCs and RFID technology; Section 4 analyzes actual case; Section 5 is the summary and the future works.

## **2. Background**

### **2.1 RFID Technology.**

Radio Frequency Identification (RFID) is a wireless communication technology, which can identify specific targets and read and write related data through radio signals, without establishing mechanical or optical contact between recognition system and specific targets [8]. RFID is similar to barcode scanning. For barcode technology, it attaches coded barcodes to the target and uses special scanning reader to transmit information from barcode magnet to scanning reader by optical signal. For RFID, special RFID reader and special tag can be attached to the target are used to transmit information from the RFID tag to the RFID reader by frequency signal.

The RFID system consists of tag, central information processing system and RFID reader [9]. RFID tags mainly consist of chips and coupled antennas, while the uniqueness of RFID tags is due to the EPC unique electronic code of tags, which mainly attaches to the objects and objects to be marked; RFID reader can erase and read the information data of the identified objects or objects, and it can borrow external antennas to receive and transmit radio frequency signals. Central information system, also known as database, is mainly composed of information processing system, database and intermediate parts. Its main function is to process the information read by readers.

## **2.2 Permissioned BC.**

The method and algorithm proposed in this paper are based on permissioned BC. Bitcoin network is a public BC technology, which runs on P2P network [10]. Every computer on the Internet can participate in computing and validation activities. In the practical application process, there are some shortcomings such as low efficiency and low efficiency. Block and transaction latency are special applications that are not allowed in some cases.

Permissioned BC refers to the BC managed by several organizations. Each organization runs one or more nodes. Only the licensed nodes can participate in voting, accounting and building blocks. Each node in the chain usually has a corresponding entity or organization; participants join the network by authorization and form a stakeholder alliance to jointly maintain the operation of the BC. The data only allows different organizations in the system to read, write and send transactions, and jointly record transaction data. It has the advantages of fast transaction speed, no need for mining, low transaction cost, fast transaction speed, and favorable support for supervision.

The permissioned BC nodes operate at high levels, the network speed is fast, the transmission rate is fast, the transaction speed is faster, and the security is higher. In the allowed BCs, the node has certain security guarantees, such as authorization. These features ensure the permissioned BC technology. It can be used for large-scale transaction processing. The permissioned BC can use Concurrent Byzantine Fault Tolerance (CBFT), which is a four communications: block determination, pre-prepare, prepare and commit. An important advantage of CBFT is concurrency. Each block can vote and build blocks concurrently with other blocks, thus greatly improving the speed of consensus. Another important feature of CBFT is that it can detect damaged nodes in the submission phase and broadcast messages to identify traitor nodes in the final phase. In the face of hacker attacks, it can guarantee the untouchable modification of data and ensure the security of data.

## **2.3 Smart Contract.**

Smart Contract, first proposed by computer scientist encryption master Nick Saab in 1994, is a computerized program that automatically enforces contract terms, a pre-programmed program code that identifies data from external sources. When the conditions set by the program are met, the trigger system automatically executes the corresponding contract terms and conditions, thus, the contract terms can be automatically executed. Complete transactions and transfer of intellectual assets. It is a code contract and algorithm contract, which will become the basic technology of the future digital society. It uses protocol and user interface to complete all the steps of the contract process.

Blockchain-based smart contracts, including transactional preservation and state processing, are all done on the blockchain. The transaction mainly contains the data that needs to be sent, and the time is the description of the data. When the transaction and event information is passed into the smart contract, the resource status in the contract resource set is updated, which in turn triggers the smart contract for state machine judgment. If the event action satisfies the trigger condition, the state machine selects the contract action automatically and correctly according to the participant's preset information.

### 3. Logistics Management System Based on Permissioned BC and RFID Technology

#### 3.1 System Architecture.

Logistics management system based on the permissioned BC and RFID technology has a four-layer structure, including application layer, BC layer, data processing layer and data collection layer. The detailed technical framework is shown in Fig. 1.

The application layer is responsible for all UI, including the interaction experience of administrators and users on the system. Provide the use of all software functions, including user management, inventory management, and order processing and distribution management.

The BC layer provides data standard format for the whole logistics management system to store and record all kinds of logistics transaction data, and provides application interface. BC layer use permissioned BC, only the licensed node can participate, and all the organizations on the chain jointly record data. Logistics transaction contracts are realized through smart contracts, which are deployed on the BC. Participants prepare the contract content and trigger mechanism in advance, and embed the system in the form of code. Once the trigger condition is met, the contract is automatically executed and the outside world cannot interfere.

The data processing layer is responsible for data acquisition, processing, transmission, verification of the collected data, to filter out the information should be read, the redundant data removing duplicate electronic codes, to initialize the data processing performed according to the standard format set The data is processed and then transferred to the BC layer .

The data collection layer uses RFID radio frequency identification technology as the underlying hardware technology to realize information collection during the process of goods entering and leaving the warehouse, inventory and distribution. In order to ensure the versatility of the system, RFID electronic tags use Electronic Product Code(EPC) encoding , which mainly includes manufacturers, products, embedded information, classification, batch product coding and carrier information.

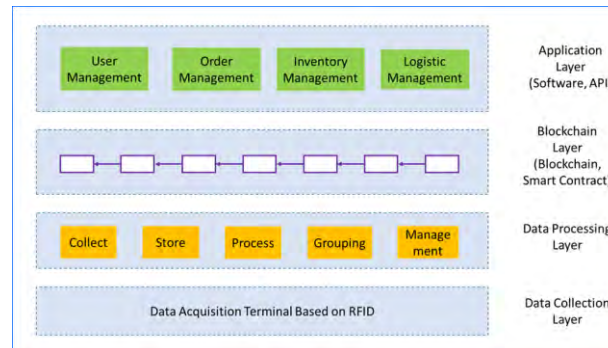


Fig. 1 System Architecture

#### 3.2 Permissioned BC Architecture.

Permissioned BC is generally divided into storage layer, core layer, service layer, interface layer and application layer, as shown in Fig. 2. The storage layer is responsible for the persistent storage of various cache data stores and blockchain data [11][12]. Support a variety of mainstream databases, such as cache database Redis, relational database MySQL, non-relational database HBase, file storage LevelDB. The blockchain core layer is responsible for the core functions of the blockchain such as consensus mechanism, reputation mechanism, user data, transaction data, smart contract, encryption and decryption, signature verification, authentication management, and node management. The permissioned blockchain consensus algorithm uses CBFT [13]. The CBFT consensus algorithm is mainly to let the blockchain nodes reach a consensus on the creation, verification and storage of the block, and to ensure the consistency of BC replicas in the system [14]. The service layer consists of the account BC (ABC) and the transaction BC(TBC) [15]. ABC is responsible for maintaining account information, TBC is responsible for executing transactions and maintaining transaction history, and ABC is storing account information. Smart contracts provide contract deployment, contract execution, contract triggering, and contract testing [16]. The interface layer is responsible for

providing the blockchain platform service interface to the application layer, and provides the blockchain service for the application layer through the blockchain unified interface Open Blockchain Connector (OBCC).

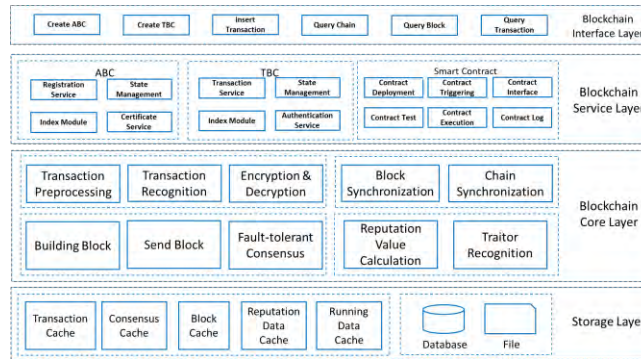


Fig. 2 BC Architecture

### 3.3 Workflow

#### 3.3.1 Product Manufacturing.

The information of product production includes the manufacturer, product code and name, product model, number of accessories, time and place of inventory, etc. The manufacturer uses this information to include it in the unique electronic label. The RFID reader recognizes the content of the RFID tag and carries out real-time scanning and tracking management. The RFID reader to read the contents uploaded to the system, the data processing module of the acquired data verification, data initialization processing, according to the standard format for the data required for processing, then the transaction is stored in the form of BCs. The order production plan of the manufacturing company, according to this plan, the procurement of raw materials, as well as the scanning of the inbound and outbound warehouses, and transmission to the blockchain layer. When the inventory quantity of the product is lower than the warning value, the system can feedback the production plans manager, and save the resource cost while ensuring the production plan of the accessory is reasonable.

#### 3.3.2 Product Inventory.

The inventory manager puts the product out of the library and sends a read command when the RFID tag enters the reader recognition range. The RFID reader identifies the contents of the RFID tag and uploads the read contents to the system, such as product number, product name, product quantity, time of entry and exit, warehouse location, etc. The data processing module verifies the collected data, initializes the data, and calls the smart contract through the form of transaction, and stores it in the blockchain. Inventory manager can view the relevant information of various inventory products through the application, can see the use of various models in the system, can carry out statistical analysis of products, and feedback information to inventory managers.

#### 3.3.3 Logistics Management.

Logistics links such as goods outbound, transportation, and entry store warehouses are quickly and automatically scanned using RFID technology. The information of the transported goods mainly contains static basic attributes (goods name, cargo number, production time, etc.) and dynamic status information. The application of RFID in distribution management is to store the fixed attributes of the goods in the electronic label, and the position and status of the goods are constantly changing as they are transported. The RFID reader recognizes the contents of the RFID tag and uploads the read contents to the system, thereby real-time tracking of the cargo transportation. The data processing module verifies the collected data, initializes the data, automatically stores relevant information by calling the smart contract, and stores it in the blockchain.

#### 3.3.4 Store Management.

Rapid data acquisition can be achieved through the application of RFID technology in commodity delivery, shelving, display, sales record, inventory information and anti-theft management. The relevant information is automatically stored by calling the smart contract and stored in the blockchain.

#### 4. Case Analysis

Take clothing logistics management as an example.

When producing a finished clothing, the corresponding RFID tag information written to their associated properties, and by the RFID scanner and a control terminal connected to the management PC, the product information storage system, after handling system, the information of the product is released by the manufacturer in the form of transaction through the way of calling the smart contract, and thus the chain of data related to the production of this commodity has been realized.

In warehousing, logistics, store sales, commodity returns and exchanges, through the use of smart contracts, commodity information can be stored in the chain, so as to facilitate cooperation among manufacturers to reduce costs, as well as follow-up traceability and anti-counterfeiting of commodities. Users can use mobile APP to scan garment two-dimensional code, and can query the garment related production, raw materials, origin, process, logistics, sellers and other information data.

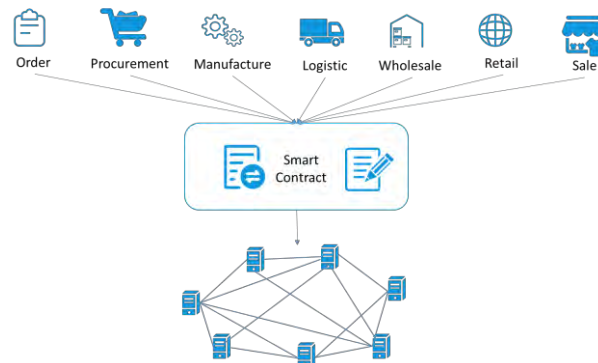


Fig. 3 Clothing Logistics Management

#### 5. Summary and Future Works

This paper proposes a logistics management system based on permissioned BC and RFID technology. The automated collection of logistics is realized by using RFID technology. The data generated by logistics are stored in BC, which can guarantee the traceability and irreversible modification of logistics information, and realize the automation of logistics transaction process by using smart contracts. BC technology makes every logistics link and circulation link transparent, improves logistics information sharing ability and reduces inventory risk. In the future work, we will integrate the specific production environment, continue to improve the system functions, and conduct large-scale testing for the system.

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