

# Construction of Multimodal Transport one-hilt coverage mechanism Information Platform Based on Blockchain Technology

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**Abstract:** In recent years, due to the lack of information exchange and sharing platforms in China's transportation industry, the development of multimodal transport still faces problems such as low efficiency and insufficient sharing. This article proposes the construction of multimodal transport one-hilt coverage mechanism based on blockchain technology. The overall architecture scheme includes the basic layer, blockchain core layer, application service layer, application interface, and business layer. The use of blockchain technology helps optimize the operation process of multimodal transport systems, enhance collaboration efficiency, and promote the construction of multimodal transport one-hilt coverage mechanism.

**Keywords:** Multimodal transport, one-hilt coverage mechanism, information platform, blockchain technology.

## 1. Background Analysis

In recent years, with the continuous development of global trade and the complexity of supply chains, logistics activities between different countries and regions have become increasingly frequent, and traditional single transportation methods are no longer able to meet the rapidly growing global logistics demand. Multimodal transport one-hilt coverage mechanism is an innovative logistics transportation model that covers the entire transportation of goods from the starting point to the destination through a single transport document (including multiple modes of transportation such as road, railway, sea or air), achieving efficient services of "one commission, one payment, one order to the end". The "one unit system" of multimodal transport can fully utilize the advantages of various transportation modes, improve the efficiency and quality of logistics transportation, and meet complex supply chain needs. According to statistics, multimodal transportation can improve transportation efficiency by about 30%, reduce cargo damage and difference by about 10%, and lower transportation costs by about 20% compared to a single mode of transportation.

In order to promote the development of information technology in multimodal transport, the General Office of the State Council issued the "Work Plan for Promoting the Development, Optimization and Adjustment of Transport Structure in Multimodal Transport (2021-2025)" in 2022. This plan emphasizes the need to significantly improve the development level of multimodal transport by 2025, promote the "one document system" for multimodal transport, promote the electronicization of documents, and increase the sharing of information resources. These measures aim to promote closer connections between all parties involved in multimodal transport, improve the overall efficiency and service quality of multimodal transport through the application of information technology, and meet the growing logistics demand.[1]

## 2. Problems in Multimodal Transport One-hilt Coverage Mechanism

The implementation of multimodal transport one-hilt coverage mechanism involves multiple entities such as

shippers, receivers, financial institutions, customs, as well as logistics carriers such as railway, water, road, and air transport. The information transmission and sharing among these entities face the following problems:

### 2.1. Difficulty in information exchange

A unified information platform is a necessary condition for implementing the "one-stop system" for multimodal transportation. However, multimodal transportation involves numerous entities, and at present, stable business standard processes have been formed at each node. Each entity has established one or even multiple management information systems based on its own business characteristics. However, due to significant differences in business architecture, operation processes, database structures, and data standards between the systems, their operation and operation are independent of each other, making it difficult to achieve information exchange and sharing. This has led to low efficiency in freight transportation and difficulty in truly realizing the "one-hilt coverage".

### 2.2. High Information Security Risks

The implementation of multimodal transport one-hilt coverage mechanism requires sufficient information sharing in logistics services such as orders, contracts, transportation, warehousing, monitoring, tracking, settlement, and delivery. However, information sharing involves confidential information such as the flow of funds, goods, and contracts of enterprises. In the traditional multimodal transport mode, the information systems between enterprises are incompatible, and information sharing cannot guarantee privacy and security, resulting in low enthusiasm for sharing information among enterprises and difficulties in implementing the "one-hilt coverage" for multimodal transport.

### 2.3. Information asymmetry is widespread

There are many enterprises involved in the process of multimodal transportation, and the information processing capabilities and precision requirements of different enterprises vary greatly. For example, experienced logistics service providers only need basic information to complete cargo transportation services, while some companies require more

detailed information to ensure the smooth completion of cargo transportation. This information asymmetry makes it difficult to share information at various stages of the multimodal transport supply chain.

#### **2.4. Inaccurate information integration**

The various entities in the multimodal transport supply chain often use their own developed information systems, and there are certain differences in the standards and formats of important information such as transportation plans and order contracts. These pieces of information need to be translated and converted during information sharing, and the inconsistency of information standards makes it difficult to accurately connect the information, increasing the difficulty of implementing multimodal transport one-hilt coverage mechanism.

### **3. The Necessity of Applying Blockchain Technology**

Blockchain is a distributed database technology characterized by decentralization, immutability, and transparency. It consists of a series of data blocks arranged in chronological order, each containing a series of information transactions within a certain period of time, and ensures the authenticity and immutability of these transaction information through cryptographic methods. The application of blockchain technology to share transportation documents and business data in multimodal transport can optimize the operation process of multimodal transport, accelerate the flow of logistics information, speed up logistics business coordination, accelerate logistics transportation efficiency, and lay a solid foundation for realizing multimodal transport one-hilt coverage mechanism.[2] Specifically, the following problems can be solved.

#### **3.1. Solving the problem of information silos**

Blockchain technology has distributed characteristics and can record every transportation process of goods, encrypting and storing relevant data in blocks. In this way, throughout the entire multimodal transportation process, the location and status of the goods can be accurately tracked, and any party can view and verify the transportation status, location, and other information of the goods in real time, without the need for traditional centralized institutions to query. At the same time, the immutability of blockchain can also achieve the traceability of goods, tracking the behavior and responsibility of each participant, thus breaking the information island.

#### **3.2. Addressing Information Security Risks**

Based on technologies such as blockchain distributed ledger and digital identity multi-party signature, it forms transparent, trustworthy, and tamper proof properties, enabling multi-party sharing and cross verification of real data sources for multimodal transportation, and constructing trustworthy data packets. Using blockchain technology to connect data from all parties involved in multimodal transportation, achieving an end-to-end logistics ecosystem alliance network. Utilizing blockchain technology to provide digital identities for related enterprises, institutions, and departments on the chain, achieving true data sharing under privacy and security, ensuring the authenticity and reliability of information, and effectively protecting information from tampering and leakage.

#### **3.3. Solving the problem of information asymmetry**

Blockchain technology can solve the problem of information asymmetry in multimodal transportation through the application of smart contracts. Smart contract is an automatically executed contract that manages multimodal transport transactions and agreements based on preset rules and conditions. Through smart contracts, participants in multimodal transport can develop and execute various contracts and agreements on the blockchain, such as delivery time, quality standards, prices, etc., thereby achieving automation and transparency in multimodal transport transactions. In this way, multimodal transport participants no longer rely on manual judgment and communication, but use smart contracts to ensure the fairness and credibility of transactions, thereby eliminating the problem of information asymmetry.

#### **3.4. Addressing the Issue of Inconsistent Information Standards**

Blockchain technology can achieve standardization and normalization of data. When building a blockchain network, a unified data format and standard can be established to ensure that the information provided by all parties can be correctly parsed and used. In this way, even if different parties use different information systems or data formats, unified data exchange and sharing can be achieved through the blockchain network.

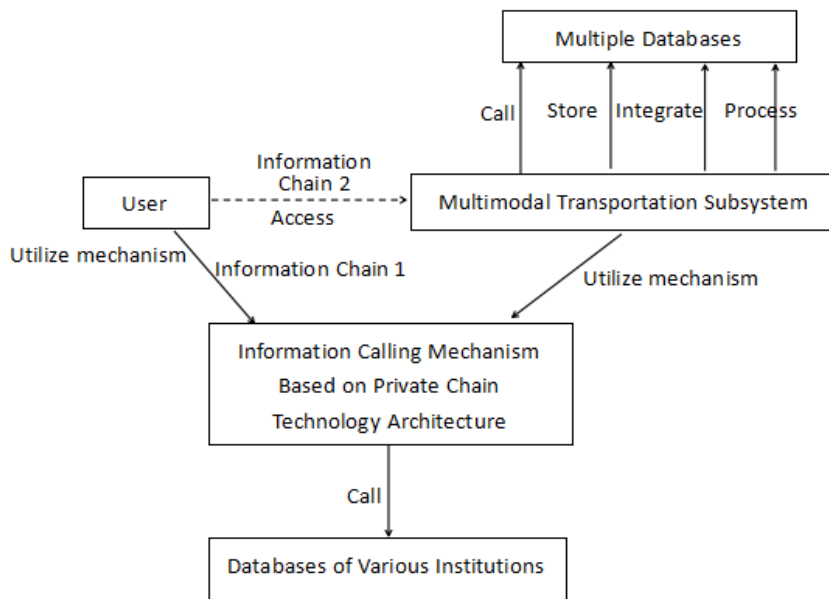
### **4. Construction of Multimodal Transport one-hilt coverage mechanism Information Platform Based on Blockchain Technology**

#### **4.1. Overall Architecture**

The use of blockchain technology to build multimodal transport one-hilt coverage mechanism information platform is the application of information technology to establish a multimodal transport information platform at various nodes of multimodal transport (such as ports, railways, customs, freight forwarding companies, shipping companies, etc.), in order to establish service modes such as "one-stop commission", "one-stop delivery", and "one-time collection" throughout the process, achieve information sharing and interconnection among multimodal transport related entities, realize unified data standards, real-time information collection and exchange, and secure data flow. The multimodal transport one-hilt coverage mechanism information platform for multimodal transport is an information sharing mechanism based on private chain technology architecture, with two main information chains running through it. One information chain is used by users to call the information data of multimodal transport related entities through the calling mechanism, and the other information chain is used by users to access the multimodal transport subsystem. The subsystem uses the calling mechanism to call the information in the databases of various institutions, and then processes, integrates, stores, and calls the data according to the functions of their respective subsystems. Among them, the subsystem is connected by the platform through various business processes of multimodal transportation, such as business declaration, business review, cargo loading and unloading, cargo ticketing, real-time tracking of cargo inspection, etc. A multi database is a database that retrieves, stores, integrates, and processes data related to the multimodal transportation subsystem, and stores

the corresponding data of the subsystem. The databases of various institutions are the proprietary databases of external departments and enterprises, and any data calling process is completed through this calling mechanism. The overall

architecture design of information sharing for multimodal transport one-hilt coverage mechanism information platform is shown in Figure 1.

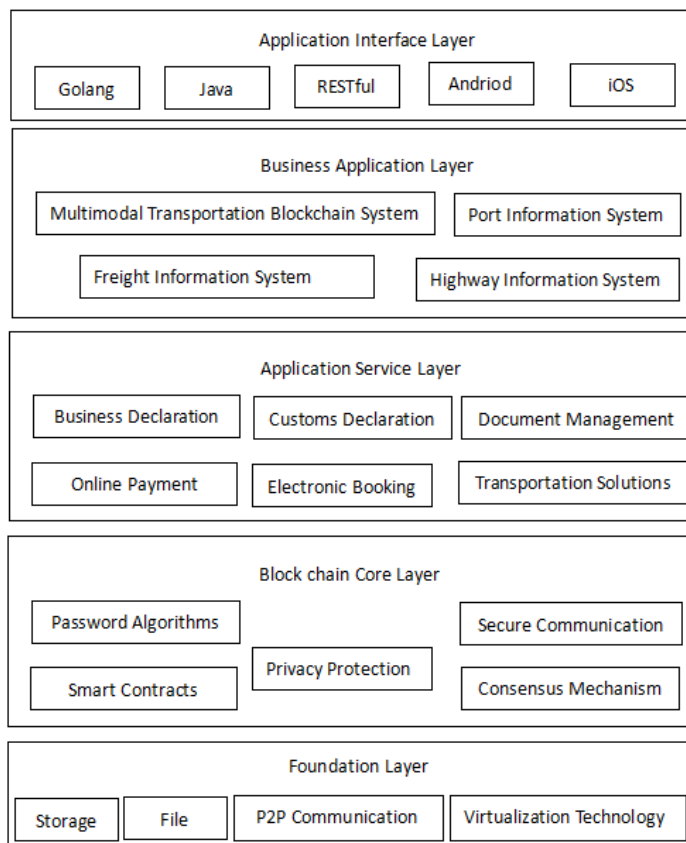


**Figure 1.** The overall architecture design of information sharing for multimodal transport one-hilt coverage mechanism information platform

#### 4.2. Technical Architecture

The technical architecture of multimodal transport one-hilt coverage mechanism information platform based on

blockchain technology mainly consists of a basic layer, a blockchain core layer, an application service layer, an application interface layer, and a business application layer. The schematic diagram is shown in Figure 2.



**Figure 2.** The technical architecture of multimodal transport one-hilt coverage mechanism information platform

#### 4.2.1. Foundation layer

The foundational layer is located at the bottom level of the architecture, providing database storage, file storage, P2P communication protocols, and virtualization technology required for node and network operation in blockchain. The database storage includes blockchain data storage and blockchain data caching, blockchain data storage includes the storage of relational and non relational databases, and blockchain data caching includes the storage of transaction data, block data, operational data, etc. In terms of communication protocols, blockchain platforms generally use distributed P2P protocols for network transmission, where each node can publish and broadcast information.

#### 4.2.2. Blockchain Core Layer

The core layer of blockchain provides all the functions for the operation and maintenance of the entire network, including smart contracts, consensus mechanisms, cryptographic algorithms, privacy protection, permission management and secure communication, blockchain operation and maintenance management, and other core functions.[5]

In terms of smart contracts, building a secure smart contract mechanism, including registration and publishing, contract execution, and management of contract templates. When a user submits an instruction to call multimodal transport business information to the information system and searches through keywords, if it meets the requirements set by the smart treaty, the system will automatically transfer the relevant multimodal transport information from the corresponding database to the user. The database provider coordinates the design of a comprehensive smart contract that specifies the criteria for calling data information. Due to the mechanism of automatic data retrieval that smart contracts meet, compared to traditional review mechanisms that rely on manual review to approve call requests, it is faster and more efficient.

In terms of consensus mechanism, design a reliable and efficient consensus mechanism. In order to achieve a more flexible, reliable, and efficient consensus mechanism, we provide pluggable consensus mechanisms, including distributed consensus mechanisms or two-layer consensus mechanisms based on sharding technology, to adapt to various application scenarios across systems and departments in multimodal transportation, greatly improving consensus efficiency.

Provide secure and reliable password and privacy protection mechanisms in terms of password algorithms and privacy protection. In terms of password algorithms, provide password algorithms that support national encryption algorithms and support user identity authentication for third-party trusted CAs; In terms of privacy protection, multiple privacy protection technologies are provided to ensure privacy and security under different conditions. The main privacy technologies include: privacy protection based on multi-channel, privacy protection based on trusted certificate repositories, and privacy protection tools based on cryptography, such as ring signatures, zero knowledge proofs, and hidden addresses.

In terms of secure communication, provide multiple CA access solutions for different needs. Providing a key authentication system based on national encryption algorithms can not only free the network from the limitations of CA, achieving higher performance with smaller resource usage, but also improve system compatibility by supporting multiple CA access schemes. At the same time, to ensure the transmission security of blockchain networks, a secure transmission layer

protocol based on commercial encryption algorithms can be designed to ensure the transmission security of data. Before establishing secure communication, the sender and receiver will exchange some necessary information, negotiate the password suite used for secure communication, verify the identity of the other party, encrypt the data, prevent data theft, and verify the integrity of the data. In order to facilitate the operation and maintenance of the blockchain platform, the built operation and maintenance management includes monitoring the operation status of the blockchain, configuring and deploying the blockchain, as well as setting alerts, etc; Customized permissions and user management can be achieved through a combination of attribute certificates and blockchain technology to implement an access control model based on attribute certificates. Flexible access policies can be configured and applied to various business scenarios.

#### 4.2.3. Application Service Layer

The multimodal transport one-hilt coverage mechanism information platform utilizes private chain technology architecture to call on various institutions' own database information for partial information integration, processing, utilization, and provision of derivative functions, providing users with information services, including the following aspects.

One is the customs clearance supervision service information subsystem, which provides customers with online declaration, approval, and information query services for multimodal transportation, covering business declaration, customs declaration, inspection and quarantine declaration, inspection status, fumigation treatment, billing and release, and other businesses.

The second is the logistics finance insurance service information subsystem. This subsystem provides an electronic platform for various intermodal units, banks, and insurance institutions. The shipper can use this system to consult with insurance companies, purchase insurance services, and pay premiums; Banks can evaluate, process, and guarantee financing of assets owned by related enterprises through this system.

The third is that the customer service information subsystem connects various related parties of multimodal transportation, integrating basic user information and relevant information resources during transportation for customers, and establishing a complete customer database. Including functions such as intermodal business consultation, business order acceptance, cargo status tracking and inquiry, complaints and suggestions, aiming to achieve "one-stop" customer service.

The fourth is the collaborative operation information subsystem, which provides services such as document management, intermodal transportation solutions, port loading and unloading, railway/road transportation, and station operations, achieving information sharing and interconnection at various nodes, and conducting intensive management. The platform uses a dedicated data exchange engine, supplemented by the creation of multi-source heterogeneous interfaces, to retrieve, store, verify, and summarize data from key nodes in regional multimodal transport, achieving an integrated multimodal transport collaborative operation solution.

The fifth is the comprehensive information service subsystem, which mainly provides customers with business information exchange and electronic financial settlement services, covering business information flow, online payment,

electronic booking, financial management, tax management and other businesses.

In addition, the user layer of the platform mainly includes multimodal transport related entities. Other related users can enter the platform through strict user agreements to obtain relevant information. Shipowners (consignees) can also query, track, and exchange information with relevant multimodal transport operators through the platform.

#### 4.2.4. Business Application Layer

The upper level business system includes multimodal transport blockchain system, freight information system, highway information system, and port information system. The multimodal transportation blockchain system includes waybill circulation, waybill processing, waybill updates, waybill queries, cargo location updates, and historical waybill queries. The railway freight information system, highway information system, and port information system are mainly used to collect relevant information from various nodes. For example, the railway freight information system shares railway waybill information, cargo information, waybill tracking and other information into the blockchain. Other nodes in the consortium chain can timely query the status and location information of multimodal transport waybills within their authority.

#### 4.2.5. Application Interface Layer

According to the interface of the enterprise logistics information system, the application interface layer mainly includes interfaces such as Golang, Java, RESTful, Android, iOS, etc.

### 4.3. Key Technologies

#### 4.3.1. Privacy Protection

The blockchain platform provides various privacy protection technologies to ensure privacy and security under different conditions. By utilizing multi-channel based privacy protection and cryptographic based privacy protection tools such as ring signatures, homomorphic encryption, zero knowledge proofs, etc., user privacy issues in blockchain transactions can be solved, as well as privacy distribution after authorization in the blockchain network through trusted repositories; Provide multiple privacy protection mechanisms, including mechanisms for sharing privacy data between different institutions and upper level business privacy protection functions based on password technology.

#### 4.3.2. Reliable and Efficient Consensus Mechanism

The blockchain platform provides a high-performance consensus mechanism based on the national encryption algorithm environment, ensuring the throughput of the entire network while also making the network more compliant with national password security requirements. Provide pluggable consensus mechanisms, including distributed consensus mechanisms based on Kafka and two-layer consensus mechanisms based on sharding technology, which can be applied to various application scenarios and improve consensus efficiency.

#### 4.3.3. Secure Smart Contracts

Formal verification can quickly identify security vulnerabilities in smart contracts. Provide smart contract operation review, real-time monitoring of deployed and running contracts, and prevent contract vulnerabilities from causing harm. Users define contract logic through contract language, publish it on the blockchain, and based on the contract terms logic, execute it through user signature or other events to complete transaction settlement and other contract

logic. Quickly discover the security and privacy of smart contracts through formal verification, provide a secure IDE, implement template based smart contracts, and facilitate users to quickly implement secure and usable smart contracts according to different business scenarios.

#### 4.3.4. Cross chain Protocol

In order to better achieve data sharing and interoperability between blockchains, cross chain technology is needed. Different blockchain networks provided by blockchain platforms can communicate data, providing technical implementation for cross chain blockchain network information fusion and realizing the flow of value and information resources between chains.

#### 4.3.5. Key Security

The consortium chain network relies on private keys for authentication and business operations, and the platform provides blockchain node and user key management solutions. Including multi factor key management, encryption cards, encryption machines UKEY. The key management scheme of mobile white box technology is used to adapt to the needs of different security levels and access methods.

#### 4.3.6. Multiple CA and uncertified authentication schemes

Provide multiple CA access solutions for different needs. Providing a certificate free key authentication system based on SM2 not only frees the network from CA restrictions, but also reduces the demand for network loans, achieving higher performance with smaller resource usage.

## 5. Conclusion

With the continuous development and maturity of blockchain underlying technology, blockchain technology will combine big data, artificial intelligence, cloud computing, and 5G technology to jointly promote the intelligent and digital development of multimodal transport, promote data sharing and efficient collaboration among multimodal transport and international transport entities, enhance the operational coordination ability between various transportation modes, build a full logistics information chain, and lay the foundation for realizing the "one-stop system" of multimodal transport, thereby reducing the overall logistics cost of society, promoting cost saving and consumption reduction, and improving the comprehensive economic and social benefits.

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