Research on Air Passenger Baggage Tracking
Based on Consortium Chain

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Abstract. Air passenger baggage transportation has such a long time and space span that it is difficult to track. Aiming at baggage transportation process of air passenger check-in with baggage, blockchain technology was combined with baggage handling system to study whole process tracking and real-time monitoring methods. Consortium chain architecture model applied to baggage tracking system is constructed. Baggage tracking mode based on the model and connection method of data space and physical space are designed. Change of baggage in physical space can be sensed on blockchain data space. Simulation experiment verifies traceability and safety of the method, which can improve normal rate of baggage transportation.

Introduction

Improving quality of service is an inevitable requirement for high-quality development of civil aviation [1]. The recent civil aviation consumer complaints of Civil Aviation Administration of China (CAAC) show that the number of passenger baggage delay and loss in a single month accounted for 8.56% of all the complaints. Complaints lead to reputation and economic damage of airlines and airports [2]. According to the latest international passenger survey of the International Air Transport Association (IATA), 56% of passengers want real-time baggage tracking information throughout the journey [3].

Problems still exist in baggage handling system (BHS). First, Managers and passengers cannot grasp baggage information. Second, hacker attacks and software errors are inevitable. Third, ‘data silos’ [4] exists. Fourth, centralized management of data has the problem of low efficiency [5], high management and operation costs and high risk of external attacks [6]. So existing baggage transportation system urgently needs to establish a baggage transportation process record and data sharing, information update and release mechanism to achieve baggage tracking and traceability.

Baggage tracking problem has always been highly valued by the CAAC [7] and the IATA [8]. There is still no method of using blockchain solve baggage tracking problems. A reliable, traceable and instantly aware technology system has become the key to solve it. Improvement of the BHS mainly combines emerging technologies such as machine vision and the Internet of Things with it. Zhang Feng [9] proposed an airport integrated baggage handling solution based on the Internet of Things (IOT), this scheme can't solve the problem of baggage retrieval and ‘data silos’, nor can it guarantee the encryption cooperation between different departments. Jiang Wentao et al [10] completed target tracking based on machine vision, which is mainly used to solve the problem of target loss caused by occlusion. Once the baggage is out of the surveillance camera coverage, it is difficult to complete baggage tracking.

After stating that the basic R&D of blockchain should be strengthened in the Plan of National Informatization [11], Research and application of it showed explosive growth in finance [12], the IOT, medical care [13] and other aspects. The decentralized distributed structure of blockchain can avoid risk of centralized scheduling; the time series structure ensures that the data cannot be falsified, asymmetric encryption can ensure information security and credibility, and achieve error-free transmission; Trustworthiness establish point-to-point trusted value transfer between unfamiliar
nodes and breaks through 'data silos'; the traceable chain structure provides a way to track and retrieve baggage. To this end, the air passenger baggage tracking method is implemented based on the consortium chain.

**Architecture Model of Baggage Transport Blockchain**

The consensus process of consortium chain is determined by predefined authorization nodes. Other third-party access nodes can be queried through an open API, which is suitable for organizations or alliances composed of multiple entities. The consortium chain system generally consists of data layer, network layer, consensus layer, contract layer and application layer, but without incentive layer. In baggage transportation consortium chain, the node can be controlled without reward model, and each segment is responsible to ensure the normal operation of the baggage information sharing platform.

1) **Data Layer** Data layer mainly stores block structure (as shown in Fig. 1), and each data block includes a block header and a block body. The block header of block N in Fig. 1 encapsulates the previous block hash value (block N-1Hash), merkle root, and timestamp; the block body stores transaction information. In the baggage tracking consortium chain, the baggage is regarded as a trading good, the nodes of the front and back sections in the process of transportation are regarded as the transaction parties to complete digital signature, and the baggage transportation information is stored in the block as transaction data.

![Figure 1. Data layer block structure diagram.](image1)

![Figure 2. Baggage handling and transportation process model.](image2)
2) Network Layer The network layer node, that is, the baggage transport operation process node, is also the internal authorized authorization node in the consortium chain. The baggage handling operation process consists of 15 sections, which are operated by departure airports, airlines, transit airports and arrival airports.

![Segment logical connection diagram.](image)

**Figure 3. Segment logical connection diagram.**

| 01 SLT 620102199408232569 TJ 0835 SH 1020 AAA | Sa Rb |
|-----------------------------------------------|------|
| Passenger Data                                |      |
| Departure Airport                             |      |
| Arrival Airport                               |      |
| Number                                        |      |
| Send section                                  |      |
| Receive section                               |      |
| luggage category                              |      |
| Passenger ID                                  |      |
| Departure Time                                |      |
| Arrival Time                                  |      |

**Figure 4. Baggage Code.**

**Operation Mode of the Baggage Transport Consortium Chain**

The operation mode is divided into physical transport mode and information transmission mode. The physical transport mode refers to the actual transport process of the baggage passing through each section. The information transmission mode refers to the transmission process of the baggage information corresponding to physical transport mode.
The information transmission mode flow is shown in Fig. 5: ① Baggage information collection system of every section performs preliminary processing such as de-duplication and de-interference on the data acquired by RFID in section i, and then uploads it to respective management system. ② Management system of every section uploads baggage information to respective information server after parsing, filtering and completeness checking. ③ Information server of every section interacts with its web server, and stores baggage information distributed in the node server. ④ Internal designated all sections of baggage handling operations involved in the transport process as authorized nodes, all authorized nodes generate new blocks according to the PBFT consensus, and new blocks are added on the blockchain.

The operation mode of the baggage tracking system is shown in Fig. 5. When the system runs, the root hash of the block and its API are publicly disclosed. Passengers, carriers and supervisors, as third-party access nodes, can use the open API to query and subscribe to relevant information using wireless PDA or operation control platform. The system can also personally push relevant information. Push all kinds of real-time updated baggage statistics to airport. The total number of baggage delivered to airlines. Daily, monthly and annual luggage consignment volume and percentage of error-free luggage are pushed to supervisors.

**Simulation Experiment of Luggage Tracking Process**

Experimental development environment is on a PC with i5-650 3.2GHz. Each node is ubuntu16.04.3 system using Oracle VirtualBox. The consortium chain project is built by the open source platform Quorum. All models are programmed by GO 1.10.4 language, using multi-threading techniques to simulate multiple verification nodes.

The system links data space and physical space. Data structure function \( F(i) \) represents the transmission of information in data space, and position function \( p(i) \) indicates position change of the baggage in physical space. They corresponding to each other. As the baggage moves in physical space, data space changes instantly.

Definition 1. \( f(i) \) represents the baggage data generated by the baggage in section \( i \) in the physical transport mode. \( f(i) \) stores the baggage electronic code as shown in Fig.3. The data structure function \( F(i) \) denotes the baggage data generated when the baggage arrives at section \( i \) in the physical transport mode, \( F(0) = 0 \), then:
\[ F(i) = f(i)F(i-1) \quad \{[i | i \in \mathbb{N}, \text{and } i \in [1, N]], \mathbb{N}\} \text{be a set of positive integers.} \]

(1)

Definition 2. Baggage position function \( p(i) \):

\[ p(i) = \begin{cases} 
1 & \text{Buggage arrived at Section } i \\
-1 & \text{Buggage didn't arrived at Section } i 
\end{cases} \]

(2)

When \( p(i) \neq 1 \), baggage abnormality alarm message will be uploaded.

Definition 3. Baggage transfer function \( L(i), \ L(0) = 0 \), then:

\[ L(i) = \sum_{j=1}^{i} p(j) \quad \{[i | i \in \mathbb{N}, \text{and } i \in [1, N]], \{j | j \in \mathbb{N}, j \leq i\}\} \]

(3)

\[ \Delta L(i) = L(i) - L(i-1) \]

(4)

Simulation experiment shows relationship between \( F(i) \) and \( p(i) \). The perceptual image is shown in Fig. 6. The quantized result of the storage space occupied by \( f(i) \) by \( G[f(i)] \) is set to constant 2. \( G[F(i)] \) is the same. The experimental simulated baggage fails at section 13 (Fig. 6). It can be seen that in the physical space, the \( p(i) \) output at section 13 is no longer 1, but is directly output -1, which shows that the baggage transportation is abnormal in this section. At the same time, in the data space, \( F(i) \) no longer increases \( f(i) \), that is, the blockchain has stopped updating.

![Figure 6. Comparisons of Baggage Section and Block Data Consistency.](image)

Fig. 7 shows the relationship between baggage position function \( p(i) \), baggage transfer function \( L(i) \) and section number \( i \). The baggage fails at the section 13, where the \( p(i) \) output -1 shows the transport situation. At section 13, \( \Delta L(i) \) is no longer 1, and the abnormal section number is indicated by \(|\Delta L(i)|\), and \( L(i) \) decreases sharply due to the accumulation of the abnormal section number.
The simulation experiment shows that the system can record baggage information in each section. The web server updates baggage record in real time according to content of the consortium chain, and perceives the physical space through the data space. The structural characteristics of the blockchain meet the current needs of the BHS, the baggage tracking scheme based on the consortium chain can effectively solve the problem of baggage loss and recovery and realize baggage tracking.

Conclusion

Baggages checked by air passengers has great span in time and space, so it is difficult to track and retrieve lost baggage. The method of air passenger baggage tracking based on consortium chain is studied, which corresponds baggage transfer section to the block of consortium chain, and realizes the whole process tracking and real-time monitoring of baggage transport in data space. The system has the characteristics of decentralization, traceability and strong encryption, which can open data silos, avoid the risk of centralized scheduling, and ensure that the information cannot be tampered with.

However, industrial practice of consortium chain is still in its infancy. After the air passenger baggage tracking system is mature, consortium chain can be applied to aircraft tracking, flight information sharing, and airport real-time scheduling.

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