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Design of Intelligent Transportation Control System Based on Blockchain Technology

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Abstract
Transportation allocation requires information such as storage location and order information. In order to guarantee the safe transmission and real-time sharing of information in all links, an intelligent transportation control system based on blockchain technology is designed. Firstly, the technical architecture of intelligent transportation information traceability blockchain and the overall architecture of intelligent transportation control system were designed. Secondly, the transportation management demand module and storage demand management module were designed, and the control process of each module was given. Then, the type of intelligent transportation vehicle was defined, the objective function of intelligent transportation control was designed, and the objective function of intelligent transportation control was constructed. Finally, the intelligent transportation control was realized by genetic algorithm. It was found that when the transportation order volume was 50×103, and the CPU occupancy of the designed system was only 11.8%. The reliability attenuation of the code deletion scheme was lower, indicating better performance of the designed system.

Keywords
Blockchain Technology, Genetic Algorithm, Objective Function, Transportation Control

1. Introduction

In recent years, the overall scale of China's transportation industry has expanded, and the informatization of transportation management has developed rapidly. According to the national statistics of transportation industry data in 2019, the total transportation cost in China was nearly 15 trillion yuan, with a year-on-year increase of 7.3%, accounting for 14.7% of the gross domestic product (GDP). Compared with the developed western countries with low proportion of transportation cost, China has a great potential to improve the proportion of transportation cost [1]. At the policy level, the state proposes a series of positive measures in the transportation industry in terms of cost, transportation structure and hub construction, so as to reduce logistics expenditure cost, improve transportation turnover performance, advocate the network construction of transportation hub, and promote the large-scale development of transportation system [2]. Transportation business involves various links, including transportation and distribution of commodities from production place to consumption place, transportation procurement in supply chain and storage, packaging and processing in production process [3]. Modern transportation enterprises are responsible for many business activities, including warehousing and supply integration,

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vehicle transportation, truckload express, third-party logistics, cold chain, etc. By building an information system architecture and combining Internet technology, enterprises can realize rapid transmission of information in all links of the transportation system and share information in a real time manner, so as to improve the efficiency, timeliness and accuracy of transportation circulation, and truly realize the comprehensive utilization of the information driving the flow of transportation capital [4]. However, due to the complexity of transportation activities, it is difficult for the superiors of transportation companies to accurately know the bottom level information or effectively formulate short- and long-term development policies, leading to bullwhip effect [5]. In particular, there are obvious shortcomings in the source tracking of the transportation chain. For example, some activity information is not included in the information system of the transportation system, making the information data not participate in all channels; moreover, the transaction activities are opaque in the whole transportation transaction process, which is difficult to realize the effective tracking of source information, and fail to provide efficient transportation services for participating customers [6].

In addition, the high complexity of the handling process of transportation activities leads to the low coordination ability between operations. The diversified requirements of activity information storage affect the efficiency of query data [7]. Relevant scholars have studied this issue. Li and Zhu [8] put forward the traffic control strategy of logistics sorting system based on automatic guided vehicles (AGV). Based on the centralized control strategy of central controller, the label correcting algorithm was used for dynamic path planning of AGV, and the traffic control of AGV in the system was based on the "no stop at intersection" strategy. However, this method could not reduce the high occupancy rate of the system.

To this end, an intelligent transportation control system based on blockchain technology is proposed in this paper. This paper introduces blockchain technology to encryption, storage and writing of a large number of intelligent transportation data. On this basis, taking the vehicle parking and running time as the premise and the vehicle transportation cost as the constraint, the objective function was constructed and solved by genetic algorithm, which realized the allocation and scheduling of traffic vehicles with small traffic volume. To avoid the large amount of calculation caused by encryption operation and the long output time, the genetic algorithm was introduced so solve the objective function, which greatly reduced the amount of calculation during the solution and eliminated long delay in the output of the final result.

2. Blockchain Technology Model

2.1 System Architecture Design

The system architecture consists of C/S (client/server) architecture and B/S (browser/server) architecture. Considering the convenience in system development, maintenance and upgrading, B/S architecture is adopted to design the logistics transportation system architecture based on blockchain technology. As shown in Fig. 1, the whole system architecture consists of three layers, including data layer, control layer, and application layer.

2.2 Storage Demand Management Module

The warehouse management module has a major influence on the operation of the system. Since most logistics companies conduct business activities in multiple regions, each region will be equipped with large and small warehouses responsible for the delivery, warehousing, stock transfer, inventory counting, inventory query, etc. The main purpose of warehouse management is to analyze improve warehouse utilization, reduce inventory cost, and ensure the smooth progress of intelligent transportation tools logistics process. Fig. 2 shows warehouse management diagram.

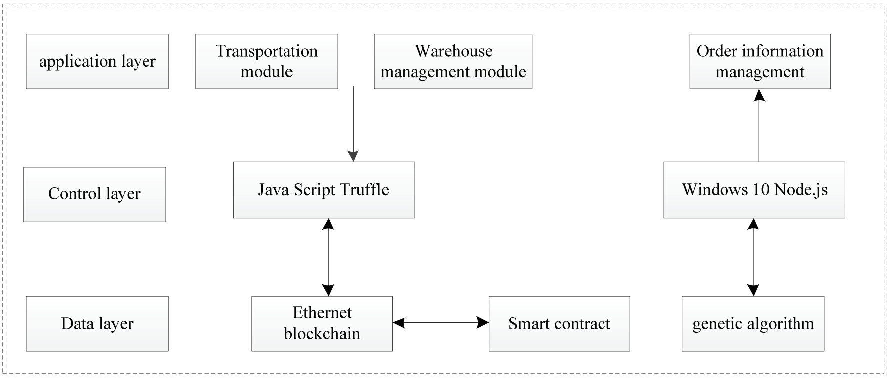

Fig. 1. Overall system architecture.

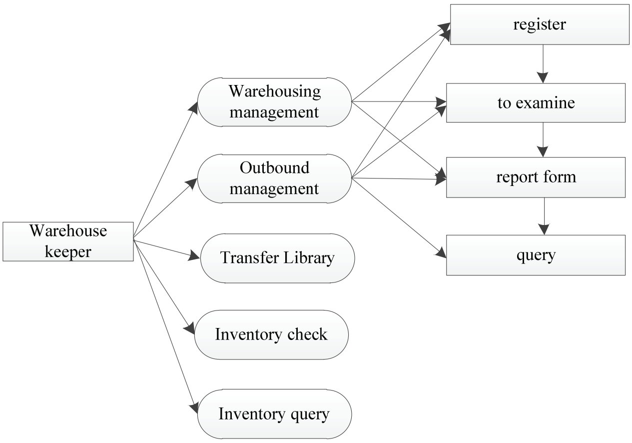

Fig. 2. Warehouse management diagram.

3. Intelligent Transportation Control Method Based on Blockchain Technology

3.1 Behavior Analysis of Intelligent Transportation Vehicles

In the above-mentioned blockchain model, it is necessary to analyze the application of intelligent transportation tools in transportation management, and analyze the behaviors of intelligent transportation tools in transportation, parking and other states. The parking time of intelligent transportation vehicles can be described as a double gamma distribution. Let t_p represent the parking time of intelligent transportation vehicles. t_a represents the time when the intelligent transportation vehicle arrives at the parking place. Therefore, the first-order density function of t_p is given by the following formula.

$$h(t_p,t_a)=\frac{D_{t_a}^s}{\Gamma(\aleph_{t_a}^s)(\varepsilon_{t_a}^s)^{\aleph_{t_a}^s}}t_p^{\aleph_{t_a}^s-1}e^{-\frac{t_p}{\varepsilon_{t_a}^s}}+\frac{D_{t_a}^l}{\Gamma(\aleph_{t_a}^l)(\varepsilon_{t_a}^l)^{\aleph_{t_a}^l}}t_p^{\aleph_{t_a}^l-1}e^{-\frac{t_p}{\varepsilon_{t_a}^l}} \tag{1}$$

where, $t_p > 0, t_a = \{0,1,2,\ldots,23\}$. $\aleph_{t_a}^s$ and $\varepsilon_{t_a}^s$ are shape and proportion parameters that determine the short-term parking behavior of intelligent transportation vehicles, while $\aleph_{t_a}^l$ and $\varepsilon_{t_a}^l$ are shape and proportion parameters that determining the long-term parking behavior of intelligent transportation vehicles.

$D_{t_a}^s$ and $D_{t_a}^l$ represent the proportions of the two gamma functions, respectively, $D_{t_a}^s + D_{t_a}^l = 1$. $\Gamma(\cdot)$is the gamma function. From the first-order density function, the probability distribution function can be obtained as follows:

$$H(t_p,t_a)=D_{t_a}^s\times\frac{\gamma(\aleph_{t_a}^s,\frac{t_p}{\varepsilon_{t_a}^s})}{\Gamma(\aleph_{t_a}^s)}+D_{t_a}^l\times\frac{\gamma(\aleph_{t_a}^l,\frac{t_p}{\varepsilon_{t_a}^l})}{\Gamma(\aleph_{t_a}^l)} \tag{2}$$

The proposed blockchain network operates on the basis of time slots, and the time axis is divided into equal non-overlapping time slots (hours) of a day. Let t represent the time slot whose value is an integer, $t_i^p, i \in \{1,2,\ldots,M\}$ represents the parking time of intelligent transportation vehicles, so the arrival time of parking vehicles can be expressed as $t_i^a(t) = t - t_i^p$. When the transportation vehicle stops at t_i^p, the probability of the vehicle stopping for another period of time h can be expressed as:

$$\begin{aligned}P_i^s(t)&=P[t>t_i^p+\tau|t>t_i^p]\\&=\frac{H_{t_i^a}^s\gamma\left(\aleph_{t_i^a}^s,\frac{t_i^p+\tau}{\varepsilon_{t_i^a}^s}\right)\Gamma(\aleph_{t_i^a}^s)+H_{t_i^a}^l\gamma\left(\aleph_{t_i^a}^l,\frac{t_i^p+\tau}{\varepsilon_{t_i^a}^l}\right)\Gamma(\aleph_{t_i^a}^l)-\Gamma(\aleph_{t_i^a}^l)\Gamma(\aleph_{t_i^a}^s)}{H_{t_i^a}^s\gamma\left(\aleph_{t_i^a}^s,\frac{t_i^p}{\varepsilon_{t_i^a}^s}\right)\Gamma(\aleph_{t_i^a}^s)+H_{t_i^a}^l\gamma\left(\aleph_{t_i^a}^l,\frac{t_i^p}{\varepsilon_{t_i^a}^l}\right)\Gamma(\aleph_{t_i^a}^l)-\Gamma(\aleph_{t_i^a}^l)\Gamma(\aleph_{t_i^a}^s)}\end{aligned} \tag{3}$$

3.2 Construction of Intelligent Transportation Vehicle Transportation Model

To realize the goal of minimizing the total transportation cost, the sum of fixed cost, transportation cost and penalty cost should be minimized, which can be expressed as Eq. (4):

$$MinZ = C_1 + C_2 + C_3 \tag{4}$$

4. Experiment

First, the platform development environment was set up. The system uses Ethereum blockchain technology as the underlying architecture. In addition to realizing the function of application layer, the system focuses on the development and design of smart contracts. Truffle is specially selected as the development framework, Ethereum blockchain (EVM) is used as the execution environment of smart contracts, and the contract editing is completed by using the solid language function. The interface of front-end application layer is developed by using the widely used Windows system. This series of activities will use the Java language to complete source code editing. Through the development of the setting system and the blockchain, the deployment and application of smart contracts can be facilitated. Considering the stability and scalability of the system, the main development environment and configuration of the system are shown in Table 1.

Table 1. List of system development environment

Development environment	Tools and versions
Development language	Java
Operating environment	Windows 10
Java Script Operating environment	Node.js v8.9.4
Solidity development environment	Truffle v5.0.6
Database	MySQL v5.7
Processor	E5-2620 CPU @2.0 GHZ
Client	Bootstrap v3.3.7
Template engine	Handlebars

4.1 Simulation Environment

Simulations were conducted based on docker technology to validate the feasibility and efficiency of the block compression storage scheme based on LT coding and the block jump verification algorithm proposed in this paper. The test hardware parameters are shown in Table 2.

Table 2. Hardware environment

Number of CPU cores	Dominant frequency	Framework	Memory	Hard disk
20	3,100 MHz	x86	64 GB	8 T

The construction of simulation environment using docker technology can promote utilization of the computing resources of hardware. As the container of docker is lighter than the traditional virtualization technology, more node containers can be created for simulation in a single machine environment. In the simulation, docker container nodes can be categorized into RSU node and OBU node, where RSU node undertakes more tasks than OBU node, and OBU node is only responsible for verifying the accepted blocks. In addition, a container node is used as the master node to coordinate and monitor the global nodes. The network node types are shown in Table 3.

Table 3. Network node types

Node name	Node function	Number of nodes
Main	Block generation and node monitoring	1
RSU	Block coding and block storage	Multiple
OBU	Block verification	Multiple

4.2 Experimental Results

4.2.1 CPU occupancy rate of intelligent transportation system

The CPU occupancy rates of the designed intelligent transportation control system, the system in [8] and [9] were comparatively analyzed.

Table 4. System CPU occupancy

Transportation quantity ($\times 10^3$)	System CPU utilization (%)		
	Jin and Liu [9]	Li and Zhu [8]	Proposed designed system
10	68.2	49.6	8.6
20	69.6	50.3	9.2
30	78.2	56.2	10.2
40	79.6	62.8	11.3
50	80.9	66.8	11.8
60	85.3	70.2	12.9

According to Table 4, when the transportation quantity was 10×103, the CPU occupancy rate of the system in [9] reached 68.2%, that of the system in [8] reached 49.6%, and the that of the designed system was only 8.6%; When the transportation quantity was 50×103, the CPU occupancy rate of the system in [9], the system in [8] and the designed system was 80.9%, 66.8%, and 11.8%, respectively. The CPU utilization of the designed method is much lower than that of other methods.

5. Conclusion

This paper designs an intelligent transportation control system based on blockchain technology. First, the technical architecture of intelligent transportation information traceability blockchain and the overall architecture of intelligent transportation control system are constructed. Then, the objective function of intelligent transportation control is designed, and intelligent transportation control is realized through genetic algorithm. The experimental results show that when the transportation quantity is 50×103, and the CPU occupancy rate of the designed system is only 11.8%, indicating higher efficiency. The code deletion scheme has lower reliability attenuation and higher reliability when the node reaches a certain scale, which shows that the designed system is of high reliability in blockchain block storage.

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