Based on Blockchain Technology and Genetic Algorithms Logistics and Supply Chain Optimization

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Abstract. In order to enhance the accessibility of goods and logistics information security, improve the efficiency of supply chain, and reduce transportation costs, the optimization of logistics supply chain based on blockchain technology and genetic algorithm under the background of the Internet of Things is studied. First of all, the basic technology of blockchain, supply chain optimization and genetic algorithm are introduced, and the optimization of logistics information collaborative management is analyzed. Then, the logistics supply chain network optimization model is built based on the genetic algorithm, and the optimization results are analyzed simultaneously. The optimization results show that the blockchain technology is applied to the logistics information collaborative management system, improve the overall benefit of the logistics supply chain, and reduce the logistics distribution cost. From the perspective of increasing the security and accessibility of logistics information, the research optimizes the logistics information collaborative management system in the logistics supply chain through blockchain technology and genetic algorithm, as well as the path of logistics distribution, which reflects the innovation. This paper takes Company A as an example. After introducing blockchain technology, the overall efficiency of the company increased by 26.63%. Through the use of genetic algorithm and 500 cycles, a logistics optimization plan was obtained. The example study shows that the blockchain technology and genetic algorithm to strengthen and optimize the logistics supply chain improves the work efficiency, reduces the cost, improves the management level and economic benefits of enterprises, and enhances the competitiveness of enterprises.

Keywords: Internet of Things,blockchain,genetic algorithm, logistics,supply chain, coordination management

1 Introduction

With the development of modern logistics and Internet of Things technology, customers require shorter logistics cycles and require specialized delivery[1]. This makes the Internet of Things widely used in the field of logistics supply chain. The Internet of Things technology is mainly used to strengthen the informatization of logistics supply chain and realize goods monitoring[2]. However, as the demand of logistics supply chain becomes more and more complex, the following problems may solve the shortage of data centralized storage: The transportation process is not transparent; Data storage is not transparent; Resource sharing is difficult.

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After the introduction of the concept of blockchain, the blockchain technology has been widely used in the supply chain field[3]. Blockchain technology can break the limitations of the current Internet of Things technology, which is of great significance to the development of the logistics industry[4][5]. Therefore, the use of blockchain technology in the logistics supply chain has become the development direction of the logistics field.

This paper studies the optimization of logistics information coordination management and genetic algorithm based on blockchain technology in the background of the Internet of Things, and optimizes the logistics supply chain network, so as to promote the improvement of supply chain efficiency and the reduction of cost, and improve the level of comprehensive logistics management.

2 Supply chain network modeling based on genetic algorithms

2.1 Blockchain system Architecture

Blockchain is a term in the field of information technology. Blockchain is essentially a shared database, in which the data or information stored cannot be forged, left traces throughout the whole process and kept public[6]. Blockchain system usually consists of six layers, which are introduced as follows.

(1)Application layer. The application layer encapsulates many application scenarios and cases of blockchain.

(2)Contract layer. The contract layer includes smart contracts, algorithm mechanisms, and script codes, such as Bitcoin.

(3)Excitation layer. The main practical function of the incentive layer is to give incentives and provide induction conditions for the nodes to better and deeply participate in the blockchain.

(4)Zonsensus layer. Standing in the perspective of blockchain, the consensus layer can be simply summarized as a unified rule approved by everyone.

(5)Network layer. The task of the network layer is to get through the nodes existing in the blockchain, so that they can realize information interaction smoothly.

(6)Data Layer. The data layer mainly displays the physical content of the blockchain association. The initial node of the blockchain design is defined as the “creation block”[6].

2.2 Supply chain optimization

Supply chain optimization consists of three elements, namely, the decision-making level variable, the purpose function and the specific constraints[8]. The decision variable of supply chain optimization represents the decisions that enterprises need to make, such as when they need to buy materials. The objective function refers to the purpose, such as how much profit, etc. Constraints refer to the conditions to be met, such as the ability of an enterprise to produce goods.There are many ways of supply chain optimization, but not all optimization methods have to have relevant technologies. If the optimal scheme needs to be obtained in a certain period of time, the genetic algorithm can be adopted. The computational process of the genetic

algorithm is simple and easy to implement. For optimization, the genetic algorithm can be used to obtain better solutions.

2.3 Genetic algorithm

The genetic algorithm was proposed by the Holland in the United States according to the theory of biological evolution in nature. Its computational model is a method to simulate the optimal solution in natural evolution according to the natural selection and genetic mechanisms in biological evolution. The algorithm takes a mathematical form to transform the process of solving the problem into a process of variation and crossing and similarity of genes in biological evolution[9]. In the complex optimization solution process, compared with other optimization algorithms, the genetic algorithm can generally get better optimization results very quickly[9]. Genetic algorithms have been widely used in the fields of application combination, signal processing, and machine learning. The basic process of the genetic algorithm is performed as follows.

(1)Encoding. Because the various parameters in the problem cannot be directly processed by the genetic algorithm, the coding form is used to simulate the problem into the chromosome or individual in the gene.

(2)Fitness function. Fitness in biological evolution means the ability of an individual to adapt to the environment, and also represents the ability of an individual to reproduce for their offspring. .

(3)Initial population selection. Arbitrary individuals are employed in the calculation process of the genetic algorithm. The initial population can be set in the following way.

(4)Select. Selection is the process of selecting the optimal individual in a population. Selection is used to pass the optimized individuals into new individuals or to offspring[10].

(5) Cross connection. In the field of biological evolution, the reorganization of inherited genes plays a key role.

2.4 Optimization of collaborative management of logistics information

Through the collaborative management of logistics information, it can promote the reduction of the distribution cost, and can quickly respond to and improve the comprehensive benefits. Therefore, this study applies blockchain technology to the optimization of traditional logistics information coordination management.Through the blockchain technology design and improving the order processing process, the prominent problems such as low efficiency, high cost and excessive error in the logistics supply chain can be effectively solved. Fundamentally speaking, to improve the collaborative processing capacity of the logistics supply chain is to improve its comprehensive benefits.

Through horizontal observation of the logistics coordination situation before and after the optimization, we can clearly understand that after the introduction of blockchain technology in the collaborative management system, the optimized logistics coordination is obviously beyond the traditional way in terms of data security, decentralization and process cohesion. Therefore, the logistics system is combined with the logistics information to build the

Stackelbe model, and pay attention to the realistic role of the supply chain coordination system with the blockchain as the core.

2.5 Stackelbe model construction

The seller can dynamically gain insight into the market demand through the application of information collaboration system, determine the number of products as q, deliver orders through the system, and send them to the manufacturer. Manufacturers can define the seller purchase quantity according to the size of the purchase order, and determine the unit price. The unit price is set as pl, and the unit cost of the product is set to c. For sellers, the unit price of the products sold is set at p2. Based on this, the following functions exist:

$$q = a - bp_2 + \beta \tag{1}$$

Where a, b are constant.

The revenue of manufacturers and sellers are:

$$P_1 = (p_1 - c_1)q = (p_1 - c_1)(a - bp_2 + \beta) \tag{2}$$

$$P_2 = (p_2 - p_1)q = (p_2 - p_1)(a - bp_2 + \beta) \tag{3}$$

In formula: p_1 for the selling price of the manufacturer; q for the quantity of products purchased by the seller; p_2 Seller unit product price;β is the purchase quantity fluctuation parameter; c_1Production cost per unit of the product for the manufacturer; c_2Additional inventory costs for the manufacturers;P_1 For the manufacturers' earnings; P_2 for the profit; by applying the mathematical thinking of reverse induction, we can solve the optimal parameters:

$$p_2 = \frac{a+\beta+bp_1}{2b} \tag{4}$$

$$p_1 = \frac{a+\beta+bc_1}{2b} \tag{5}$$

$$P_1 = \frac{(a+\beta-bc_1)^2}{8b} \tag{6}$$

$$P_2 = \frac{(a+\beta-bc_1)^2}{16b} \tag{7}$$

$$P_3 = \frac{3(a+\beta-bc_2)^2}{16b} \tag{8}$$

2.6 Network optimization of Internet of Things

A logistics branch delivery is based on m distribution center, and through n lines to achieve. Before optimizing the network, according to the actual distance to each distribution center, unit transportation cost, and the distribution center by the actual distance of each line, unit cost, distribution of specific business data, for the proportion of line business evaluation, so as to better grasp the distribution center distribution status, ability.The following is the associated model. The cost of setting up m distribution centers to each distribution route is f (X_{mn}), have:

$$f(X_{mn}) = \sum_m c_m X_m + \sum_m \sum_n d_{mn} x_{mn} \tag{9}$$

In formula: c_m For the distribution cost per unit volume upon arrival at m distribution centers; dmnFor the distribution cost per unit amount of each distribution line from the m center distribution.

Suppose the path chosen for transportation, in priority, set to wj;Based to the i distribution center, the transportation road passes through j roads, and the realized distribution volume is set as P_{ij}. In the relevant requirements, give Out of the distribution efficiency parameter $c_{ij}=$ wijPij. There are:

$$f(D) = max\left(\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}\right) \tag{10}$$

The optimization problem solving process is as follows.

(1)Determine the decision constraints and variables. Where, the restriction condition is1 im, 1 jm; the decision variable is Pij,wj。

(2)Establish the optimization model. The optimization model is established according to equation (9).

(3)Define the coding mode. BaseV = crthase (r, k) was used as a regional scanner to describe the interpretation and expression of chromoschromosome. Chromosomes are represented in decimal codes. An initial population was created with the function crtbp, and then k decimal Chrom matrices of length r were generated.

(4)Determine the individual measurement method (through equation (10), the value domain of the general function is positive. Taking the maximum as the optimization target, the fitness of the individual is the objective function, namely:

$$F(D) = f(D) \tag{11}$$

(5)Design of the genetic operators. The selection operator is used to select certain good individuals and enable these good individuals to be inherited in the next generation group.

The general scale operator is the selection operator. An individual that is proportional to the probability and fitness of the next generation is called a proportional selection operator. Let x be the group, y be the individual, and WjFor the individual fitness, pjsFor the probability that an individual is selected, then:

$$P_{js} = \frac{w_j}{\sum_{j=1}^{n} w_j}, j = 1,2,\dots n \tag{12}$$

Equation (12) shows that the probability of an individual being selected increases and decreases with the degree of adaptation in the group.

(6)Clear information about the relevant variables of the genetic algorithm. M is the group size, indicating the number of individuals in the population; T is the number of termination cycles; and G is the generation gap.

3 Analysis of logistics supply chain optimization results

3.1 Optimization of the logistics supply chain caused by blockchain technology

This paper uses Stackelbe model to analyze and demonstrate the optimization effect of logistics information collaboration system based on blockchain supply chain. First, choose A Company as the manufacturer and Company B as the seller. Based on the data of 2020, the specific parameters of product E ordered for A in the third and fourth quarters of the third year. In the third quarter, the unit production cost, unit inventory cost and average sales price increased by 21.1 yuan, 1.2 yuan and 28 yuan respectively. The actual average unit production cost, unit inventory cost and average sales price in the third quarter were 1 273.4 yuan, 85.8 yuan and 1624.7 yuan respectively. In the fourth quarter, the unit production cost and average sales price of the A manufacturer decreased by 121.9 yuan and 255.6 yuan respectively, and the unit inventory cost increased by 1.7 yuan. The average value of unit production cost, unit inventory cost and average sales price in the fourth quarter were 1293.9 yuan, 81.0 yuan and 1650.97 yuan respectively. In the third quarter, B dealers subscribed to 18,500 products, with an average selling price of 2,165.2 yuan, and the average selling price increased by 45.8 yuan. In the fourth quarter, B dealers subscribed to a total of 17,800 products, with an average selling price of 2,208.7 yuan, and the average selling price decreased by 234.3 yuan. According to the above data, we can find the best price of the manufacturer and the dealer, give the best order quantity parameters, and then grasp the total income under the condition of the supply chain acting on each other.

It is known that the benefit of the logistics supply chain information coordination system before optimization is 3101161.74 yuan. According to Equation (1), the specific results of the parameters a and b can be obtained, with a=27500 and b=9.8. In this assumption, the value of the interval β of fluctuation is 200. According to Equation (8), the benefit results after the introduction of blockchain are obtained, and the specific performance is 3926893.76 yuan. Horizontal comparison of the data before the optimization, it is found that the overall benefit has increased substantially, with the growth rate reaching 26.63%.

3.2 Optimization of logistics supply chain by genetic algorithm

There are 5 distribution centers with A logistics branch, and 30 distribution paths. First, the coordinates of each distribution center in reaching the terminal of each distribution path are measured. For details, please refer to Table 1. When the genetic algorithm is calculated, the number of individuals (x) is set to 90, the maximum number of cycles (T) is set to 300, the chromosome dimension is set to 30, the generation gap variable G is set to 0.9, and the most suitable individual is always passed on to the offspring.

Table 1. Coordinate values from each distribution center to each pinpoint.

The pin	Demand/ piece	Distributioncenter coordinates/km	North-south coordinates / km	East-west coordinates / km
1	19	a′(2.0,1.8）	-1.5	35.0
2	52	a′(2.0,1.8）	-23	34
3	30	a′(2.0,1.8）	24	-0.1
4	34	a′(2.0,1.8）	43	16
5	27	a′(2.0,1.8）	46	-16
6	33	a′(2.0,1.8）	23	53
7	35	a′(2.0,1.8）	13	34

8	55	b′(-1.9,-2.1）	-42	-15
9	36	b′(-1.9,-2.1）	-51	24
10	34	b′(-1.9,-2.1）	-5	0.6
11	31	b′(-1.9,-2.1）	-58	0.4
12	41	b′(-1.9,-2.1）	-30	25
13	35	b′(-1.9,-2.1）	-34	17
14	40	c′(36,-7.4）	-5.3	35
15	31	c′(36,-7.4）	-12	33
16	26	c′(36,-7.4）	-62	30
17	34	c′(36,-7.4）	-77	39
18	36	c′(36,-7.4）	-54	59
19	27	c′(36,-7.4）	-72	25
20	30	d′(7.1,23）	40	84
21	35	d′(7.1,23）	35	92
22	28	d′(7.1,23）	6.2	5.5
23	40	d′(7.1,23）	4.6	5.8
24	20	d′(7.1,23）	-24	66
25	35	d′(7.1,23）	0.6	79
26	27	d′(7.1,23）	-0.6	7.5
27	47	e′(107,112）	77	9
28	51	e′(107,112）	75	124
29	42	e′(107,112）	115	128
30	48	e′(107,112	165	113

By calculating the distance between the distribution center and each sales point, the distribution capacity and demand degree of each sales point can be evaluated. After passing through 500 genetic cycles, the logistics optimization scheme is shown in Figure 1.

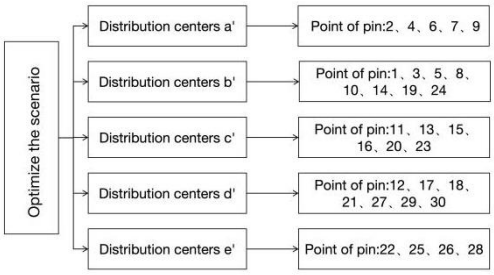

Fig. 1. Logistics optimization scheme

From the above analysis, the genetic algorithm can quickly obtain the best scheme of the logistics network.

4 Conclusion

In this paper, we optimize the logistics supply chain based on blockchain and genetic algorithm under the background of the Internet of Things, and further use the genetic algorithm to build and improve the performance of the logistics information collaborative

management system network. Through Stackelbe model analysis and demonstrating the optimization effect of logistics information coordination system based on blockchain supply chain, it is concluded that the optimization of logistics information coordination management by blockchain can improve the overall benefit of logistics supply chain. The distribution network based on logistics supply chain is improved, the basic optimization model is established, the principle of maximizing distribution efficiency is followed, and certain genetic algorithm is introduced to extract the best strategy. By improving these supply chain logistics networks, enterprise A is adopted as the research object. The research results show that the optimized system reduces the transportation cost, improves the work efficiency, promotes the management level and economic benefits of enterprise A, and comprehensively improves the comprehensive strength of the enterprise.However, there are also shortcomings in this study. The biggest difficulty in using blockchain technology in the logistics supply chain lies in how to make enterprises trust and accept the decentralized platform. This requires the realization of information resource sharing and collaboration.

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