Location and Path Planning of Cross-Border E-Commerce Logistics Distribution Center in Cloud Computing Environment

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Abstract. In order to solve the problem of high transportation cost in the range of transportation distance from 3.5 km to 7.5 km, this paper proposes a method of location and path planning for cross-border e-commerce logistics distribution center in cloud computing environment. Cross-border e-commerce logistics distribution center location model is established under the cloud computing environment to achieve cross-border e-commerce logistics distribution center location. Cross-border e-commerce logistics path planning is realized by constructing cross-border e-commerce logistics path planning model in cloud computing environment. The logistic path planning model of cross-border e-commerce includes time and event sequence sub-model, state variable quantum model, external information sub-model, state transfer sub-model, objective function and optimal strategy sub-model. In order to prove that the transportation cost of this method is lower in the range of 3.5 km to 7.5 km, two original methods are compared with this method. The experimental results show that the transportation cost of this method is much lower than that of the other two methods, and the cost is reduced successfully.

Keywords: Cloud computing environment · Cross-border E-commerce · Logistics distribution · Distribution center location · Path planning

1 Introduction

Cross-border e-commerce logistics distribution center location and path planning method can help cross-border e-commerce reasonable, scientific planning of the distribution center address and distribution path. In recent years, the rapid development of cross-border e-commerce has changed from an economic phenomenon to an advanced business model, and will become the mainstream business model in the future international trade. At present, the Central Government is focusing on promoting the development strategy of "going global" of Chinese enterprises, encouraging enterprises to actively participate in the competition in the international market, and striving to become world-class cross-border e-commerce enterprises [1, 2]. In order to simplify the processing of cross-border e-commerce orders, shorten the time of logistics transportation and improve the efficiency of logistics transportation, the research on the location and path planning of cross-border e-commerce logistics distribution center has been carried out for a long time. In 2012, M.M. Nassar proposed a new distribution

S. Liu and L. Xia (Eds.): ADHIP 2020, LNICST 347, pp. 30–40, 2021.
https://doi.org/10.1007/978-3-030-67871-5_4

model based on maximum likelihood method and moment method, namely beta logistics distribution model. The model is a parameter estimation model. At the same time, N. Balakrishnan put forward the delivery model of order recurrence relation based on it. The scholar Hsiaw-Chan Yeh puts forward a method of location and path planning of cross-border E-commerce logistics distribution center based on order recursive relation distribution model. However, the research in China is relatively late. Some scholars put forward a method of location and path planning of cross-border E-commerce logistics distribution center based on fuzzy decision analysis, mainly through fuzzy decision analysis of cross-border E-commerce logistics to achieve its location and path planning [3]. In view of the fact that the location and path planning of cross-border e-commerce logistics distribution centers by using the above methods are unable to be transferred due to the difficulties in cross-border logistics control, and the transportation cost is high within the range of transportation distance from 3.5 km to 7.5 km, a method for location and path planning of cross-border e-commerce logistics distribution centers under cloud computing environment is proposed.

2 Location of Cross Border E-Commerce Logistics Distribution Center in Cloud Computing Environment

2.1 Location of Cross Border E-Commerce Logistics Distribution Center

Cross-border e-commerce logistics distribution center site selection is realized by building a cross-border e-commerce logistics distribution center location model under the cloud computing environment [4].

2.1.1 Model Assumptions and Analysis

First of all, the model assumptions need to be made as follows: all the macro-factors and meso-factors of the alternative addresses of cross-border e-commerce logistics distribution centers are the same, so only the impact of micro-factors on the location of logistics distribution centers is taken into account; and the construction costs of each logistics distribution center are fixed within a certain period [5].

According to the operation mode of cross-border e-commerce logistics distribution, this paper analyzes the factors of cross-border e-commerce logistics distribution center location, and constructs cross-border e-commerce logistics center location model. The factors for the location of cross-border e-commerce logistics distribution centers analyzed are as follows:

Cross-border e-commerce logistics and distribution center costs include transportation costs, warehousing costs, warehousing costs, reverse logistics (costs of returning and exchanging goods), costs of handling unmarketable goods, warehousing insurance costs, total customs duties and [6].

The transportation cost is the sum of the transportation cost from domestic seller to domestic port city, from port city to logistics distribution center, and from logistics distribution center to overseas buyer.

Each transport cost shall be the product of transport distance, transport volume and unit freight.

The warehousing cost of a logistics distribution center shall be the product of the storage volume (total transportation volume), storage time and unit storage fee.

Build a position cost to give total cost directly can.

The reverse logistics cost is the product of the rate of return and exchange, transportation distance, total transportation volume, and unit freight.

The total tariff is the product of the total value of the goods multiplied by the tariff rate of the importing country.

Customer satisfaction is the ratio of the quantity of goods delivered through a logistics distribution center to the total quantity of goods delivered within the standard time for customer satisfaction [7].

2.1.2 Establishing the Location Model of Cross-Border E-Commerce Logistics Distribution Center

The location model of the cross-border e-commerce logistics distribution center shall be established as follows:

Formula (1) is an overseas warehouse cost model;

$$\min Z_1 | Z_1 = L_{sr} V_m C_{sr} + \sum_{w=1}^{k} D_{rw} L_{rw} Q C_{rw} \tag{1}$$

Type (2) is a satisfaction model using overseas warehouses;

$$\min Z_2 | Z_2 = -\sum_{w=1}^{k} H_{bw} \frac{V_{wb}}{Q} \tag{2}$$

Type (3) means that the traffic volume of overseas warehouses to overseas buyers is less than the total traffic volume;

$$\begin{cases} \sum\limits_{w=1}^{k} \sum\limits_{b=1}^{n} X_{wb} Q_{wb} \leq Q \\ w \in \{1, 2, \ldots, k\} \\ b \in \{1, 2, \ldots, n\} \end{cases} \tag{3}$$

Formula (4) indicates that the first trip freight is composed of the transportation cost of the goods from the domestic seller to the domestic port city and the transportation cost of the goods from the domestic port city to the overseas warehouse;

$$F = L_{sr} V_m C_{sr} + \sum_{w=1}^{k} D_{rw} L_{rw} Q C_{rw} \tag{4}$$

Formula (5) indicates that the total tariff of the importing country consists of the product of the total value of the goods and the tariff rate;

$$R = P\theta \tag{5}$$

Formula (6) indicates the selection scope of customer satisfaction.

$$\begin{cases} H_{bw} = \begin{cases} 1, \frac{T_{wb}}{G_{wb}} \leq 1 \\ 0, \text{else} \end{cases} \\ w \in \{1, 2, \ldots, k\} \\ b \in \{1, 2, \ldots, n\} \end{cases} \tag{6}$$

Where, s represents the domestic seller; b represents the overseas buyer; n represents the number of overseas buyers; r represents the domestic port city; w represents the logistics distribution center; k represents the number of overseas warehouses; v represents the total transportation volume of domestic sellers to the logistics distribution center; V_{wb} represents the transportation volume from the logistics distribution center to the buyer; V_w represents the warehouse capacity of the logistics distribution center; L_{sr} represents the distance from the domestic seller to the domestic port city r;L_{rw} represents the distance from the domestic port city to the logistics distribution center; L_{wb} represents the distance from the logistics distribution center to the overseas buyer; C_{sr} is the freight for the domestic seller to deliver each ton of goods to the domestic port city; C_{rw} is the freight for the domestic port city to deliver each ton of goods to the logistics distribution center; C_{wb} is the freight of each unit of goods delivered by the logistics distribution center to overseas buyers; C_{wt} is the storage fee of each unit of goods stored in the logistics distribution center every day; C_w is the annual warehouse building cost of the logistics distribution center; T_{sw} is the time for domestic sellers to store goods in the logistics distribution center; G_{wb} and T_{wb} are the standard time and actual time for domestic sellers to send goods from the logistics distribution center to overseas buyers; a is the insurance cost of the logistics distribution center; θ is the import tariff rate of the country where the logistics distribution center is located; F is the first route transportation; P is the total value of the goods; R is the total tariff of the country where the goods are imported [8].

In the cross-border e-commerce logistics distribution center location model, it is composed of transportation cost, storage cost, warehouse building cost, reverse logistics (return and exchange cost), processing cost, insurance cost and total tariff; the dual objective problem of the cross-border e-commerce logistics distribution center location model is transformed into a single objective problem to solve the model, so as to achieve the location of cross-border e-commerce logistics distribution center.

2.2 Cross-Border E-Commerce Logistics Path Planning in Cloud Computing Environment

Cross-border e-commerce logistics path planning is realized by constructing cross-border e-commerce logistics path planning model in cloud computing environment. Cross-border e-commerce logistics path planning model consists of time and event sequence sub-model, state variable quantum model, external information sub-model, state migration sub-model, objective function and optimal strategy sub-model [9, 10].

2.2.1 Time and Event Sequence

The time and event sequencing submodels are modeled as shown in Fig. 1.

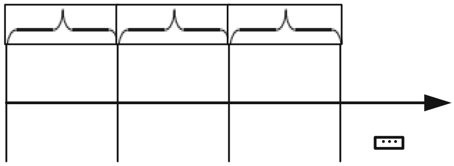

Fig. 1. Time vs. event sequencing submodel

In the time and event sequence sub model, the identifier on the timeline represents the time point, and the interval between the identifiers represents the time period. The part between time $t-1$ and time t is called time period t state S and action A are known at time t, so it is also called decision time. External information W arrives in time period t. In cross-border e-commerce logistics path planning, decision-making is triggered when one or more vehicles arrive at customers or distribution centers at the same time. The sequence of events from t to $t+1$ is as follows:

(1) When the system arrives at decision-making time t, it senses state S_t and obtains the real demand information W_t of all customers who have just arrived;
(2) Select action A_t according to current state S_t and random information W_t;
(3) Serve all newly arrived customers;
(4) Perform actions;
(5) The decision-making time of $t+1$ is triggered by an arrival event, and the vehicle is transferred to state S_{t+1} to obtain the real demand information W_{t+1} of all customers who have just arrived.

2.2.2 State Variable

When planning cross-border e-commerce logistics path, the state variables need to provide enough information for decision-making, so the state variable sub model is usually composed of vehicle state and customer state.

Set vehicle set as M, quantity as m, customer set as Z and quantity as z. For any vehicle $i \in M$, its status can be expressed as:

$$F = (l_i, q_i, k_i) \tag{7}$$

Where $l_i \in Z$ represents the current location (before service) or the next destination (after service) of vehicle i; $q_i \in [0, Q]$ refers to the current remaining on-board cargo volume of vehicle i; $k_i \in [0, L]$ refers to the time when the vehicle arrives at the next destination; L refers to the service period limit. Let $(l, q, k) = (l_i, q_i, k_i)_{i \in M}$ indicate the status of the vehicle.

For any customer $j \in N/\{0\}$, its demand status can be expressed as $\left(d_j, x_j\right)$, where d_j represents the unmet demand of customer j; x_j represents the real value of the observed customer j demand.

2.2.3 External Information

Because there is only one kind of external stochastic information, namely customer demand, for the multi vehicle routing problem with stochastic demand, the external information sub model is expressed as follows:

$$W_t = \{\hat{x}_{l_i}; i \notin M\} \tag{8}$$

Where, W_t represents external random information; $\hat{x}_{l_i}$ represents the real needs of the target customer l_i of vehicle i. When external information W_t is triggered at decision time t, the system will know immediately when it reaches state S_t.

2.2.4 State Migration

The state migration function can be expressed as:

$$S_{t+1} = S^M(S_t, A, W_{t+1}) \tag{9}$$

The superscript M refers to the model, and the independent variables of the function are state S_t, action A and external information W_{t+1}.

State transition is divided into two steps: the deterministic transition to the post decision state and the stochastic transition to the pre decision state. When action A is executed in state S_t, the state will definitely migrate to post decision state S_t^A.

2.2.5 Objective Function and Optimal Strategy

In the cross-border e-commerce logistics path planning with stochastic demand and service period, the goal is to maximize the customer demand, that is, the objective function is $\max \sum_{t-0}^{T} \rho(S_t, a)$. $\pi \in \Pi$ strategy a defines a mapping from state space to action space: $\pi : S \mapsto A(S)$. Let the value function of the state under strategy π be the long-term cumulative reward, and the evaluation standard of the strategy be the value function $V^{\pi}(S_0)$ of the initial state S_0,Then find the optimal strategy π^*, so that $V^{\pi^*}(S_0) \geq V^{\pi}(S_0), \forall \pi \in \Pi$, cross-border e-commerce logistics path planning [11, 12].

3 Experimental Test

3.1 Experimental Case

The design of cross-border e-commerce logistics distribution center location and path planning method in cloud computing environment was tested. The experimental case is as follows: Enterprise B is a third party logistics enterprise of cross-border e-commerce logistics and distribution. With the rise of export cross-border e-commerce in recent years, enterprise B's cross-border e-commerce business customers are mainly located in Quanzhou of Fujian Province, Hangzhou of Zhejiang Province, Hefei of Anhui Province, Kunming of Yunnan Province and Suzhou of Jiangsu Province. The overseas buyers of cross-border e-commerce enterprises are mainly located in France, Germany, Italy, the Netherlands and other European countries. With the increasing of business volume, B enterprises consider to add some logistics distribution centers and make path planning for them. The operating model of enterprise B is shown in Fig. 2.

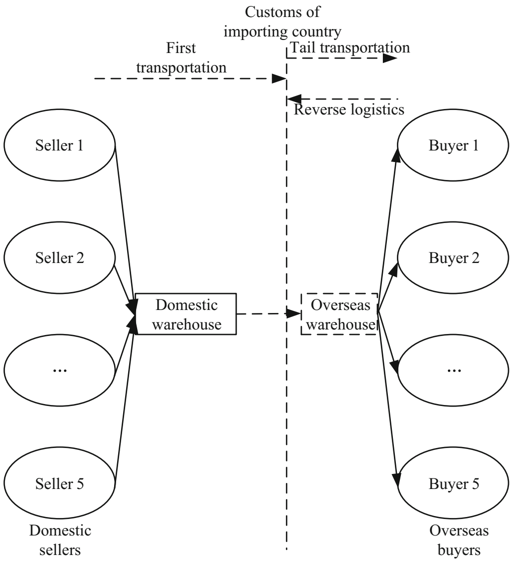

Fig. 2. B Business model

As shown in Fig. 2, enterprise B first selects a domestic port city to build a warehouse, assembles the goods of five cross-border e-commerce sellers, and then transports them by sea to the port city where the overseas warehouse is located. Finally, when the foreign buyer places an order on the cross-border e-commerce platform, the goods are directly delivered to the buyer through the overseas warehouse.

B enterprise has 5 domestic sellers concentration points, 7 overseas buyers concentration points, selected 4 domestic port cities as the warehouse selection points, 7 overseas warehouse selection points, the entire logistics network of a total of 23 nodes.

In this paper, the location and path planning of cross-border e-commerce logistics distribution center in B enterprise are tested by using the method of cloud computing. The transportation cost data in the range of 3.5 km to 7.5 km is used as the experimental data. In order to avoid the unitary experimental results, the two methods are used as comparative experimental methods, including cross-border e-commerce logistics distribution center location and path planning based on order-recursive distribution model and cross-border e-commerce logistics distribution center location and path planning based on fuzzy decision analysis. Similarly, the two methods are used to choose the location and path planning of B enterprise's cross-border E-commerce logistics distribution center, and the transportation cost data are used as the comparative experimental data. The experimental data of several experimental methods were compared.

3.2 Analysis of Experimental Results

Within the range of transportation distance from 3.5 km to 5.5 km, the comparison results of transportation cost experimental data between cross-border e-commerce logistics distribution center location and path planning under cloud computing environment and distribution model based on order recurrence relation and cross-border e-commerce logistics distribution center location and path planning based on fuzzy decision analysis are as shown in Table 1.

Table 1. Comparison of transport cost experimental data

Transport distance	Transport costs (yuan)		
	Approaches in a cloud computing environment	Method of distribution model based on order recurrence relation	Method based on fuzzy decision analysis
3.5 km	5163.32	6112.25	6932.65
3.6 km	5233.25	6115.29	7124.20
3.7 km	5263.32	6154.25	7132.36
3.8 km	5361.02	6235.55	7102.03
3.9 km	5401.02	6220.02	7004.09
4.0 km	5431.08	6323.05	7102.29
4.1 km	5441.01	6302.02	6932.30
4.2 km	5533.14	6324.25	7221.58
4.3 km	5563.32	6321.25	6962.32
4.4 km	5624.07	6421.01	7248.01
4.5 km	5713.20	6551.20	7120.06
4.6 km	5763.21	6513.20	7335.04
4.7 km	5801.02	6596.36	7469.68
4.8 km	5860.27	6563.24	7442.21
4.9 km	5820.20	6631.20	7541.20
5.0 km	5810.07	6632.04	7521.02
5.1 km	5863.20	6630.01	7620.1
5.2 km	5912.08	6725.36	7720.25
5.3 km	5934.20	6765.32	7712.23
5.4 km	5932.04	6831.20	7820.27
5.5 km	5978.25	6923.32	7921.30

According to the comparison of transportation cost experimental data in the range of transportation distance from 3.5 km to 5.5 km in Table 1, it can be concluded that the cost of cross-border e-commerce logistics distribution center location and path planning method in cloud computing environment is much lower than that in cross-border e-commerce logistics distribution center location and path planning method based on order recurrence relationship distribution model and fuzzy decision analysis.

Within the range of transportation distance from 5.5 km to 7.5 km, the comparison results of transportation cost experimental data between cross-border e-commerce logistics distribution center location and path planning under cloud computing environment and distribution model based on order recurrence relation and cross-border e-commerce logistics distribution center location and path planning based on fuzzy decision analysis are as shown in Table 2.

Table 2. Comparison of transport cost experimental data

Transport distance	Transport costs (yuan)		
	Approaches in a cloud computing environment	Method of distribution model based on order recurrence relation	Method based on fuzzy decision analysis
5.6 km	5123.36	6132.20	6759.36
5.7 km	5123.25	6132.20	6785.20
5.8 km	5163.20	6113.32	6798.62
5.9 km	5120.04	6223.21	6798.98
6.0 km	5263.32	6112.20	6895.32
6.1 km	5287.62	6298.96	6912.03
6.2 km	5221.20	6324.20	6943.21
6.3 km	5232.04	6321.20	6987.25
6.4 km	5363.24	6452.30	7021.20
6.5 km	5362.30	6425.30	7046.32
6.6 km	5462.32	6521.03	7059.32
6.7 km	5414.02	6564.20	7084.32
6.8 km	5420.21	6578.96	7125.32
6.9 km	5563.32	6584.21	7201.32
7.0 km	5524.21	6632.01	7698.32
7.1 km	5623.20	6698.32	7712.03
7.2 km	5652.32	6712.05	7785.20
7.3 km	5721.02	6789.32	7798.32
7.4 km	5813.20	6875.30	7821.02
7.5 km	5820.32	6897.21	7962.30

According to the transportation cost experimental data in the range of 5.6 km to 7.5 km in Table 2, the results show that the cost of cross-border E-commerce logistics distribution center location and path planning method in cloud computing environment is much lower than that in cross-border E-commerce logistics distribution center location and path planning method based on order recurrence relationship distribution model and fuzzy decision analysis. The cost and capacity constraints of e-commerce logistics distribution center are shown in Table 3.

Table 3. Cost and capacity constraints of e-commerce logistics distribution center

Distribution center candidate	Construction cost of candidate distribution center/ten thousand	Unit product operation cost/ten thousand	Capacity limitation/ten thousand
1	60	85	800
2	60	85	800
3	70	85	850
4	70	90	860
5	75	90	880
6	75	95	900
7	80	100	920

It can be seen from Fig. 2 that the location problem of e-commerce logistics distribution center involves not only the cost of construction, operation and distribution, but also the cost and capacity constraints. Therefore, it has practical application value to construct an optimization model of e-commerce logistics distribution center location, which comprehensively considers the factors of cost, time window constraint, cargo damage rate, objective function and optimal strategy [13, 14].

In conclusion, the transportation cost of location and route planning of cross-border e-commerce logistics distribution center in cloud computing environment is lower than the other two methods, which provides an important reference for practical application.

4 Conclusions

At present, the construction level of China's cross-border logistics and transportation system is far lower than that of developed countries in Europe and America, and the distribution service level cannot meet the needs of the rapid development of the market. We should actively promote the layout and construction of logistics hubs to promote and improve the quality and efficiency of national economic operation. Major cross-border logistics solutions all have some problems that cannot be solved by themselves, which are the main factors affecting the further development of cross-border e-commerce. Therefore, the site selection and path planning of cross-border e-commerce logistics distribution center must be carried out through the method of site selection and path planning.

The location and path planning of cross-border e-commerce logistics distribution centers under cloud computing environment can reduce transportation costs, but this method only considers the influence of micro factors. The two original methods are compared with this method, which has lower transportation costs within the range of 3.5 to 7.5 km. The experimental results show that the transportation cost of this method is much lower than the other two methods, and the cost is reduced successfully.

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