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# Logistics Distribution Optimization of Hazardous Chemicals and Construction of Cloud Service Platform Based on Genetic Algorithm

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As a cloud computing-based, service-oriented new logistics service model, cloud logistics service (CLS) has gradually become one of the main directions for logistics development. In view of the efficient integration and optimization problem of massive task requirements and massive resources under the CLS platform, this paper constructs a cooperative logistics distribution model of hazardous chemicals based on the information sharing of CLS platform and the predictability of distribution planning. The genetic algorithm (GA) was used to solve the model. Besides, the results of the cooperative distribution model of hazardous chemicals were compared with the traditional independent distribution model. The comparison results show that the cooperative model constructed for the distribution of hazardous chemicals in this paper is effective and feasible, and the total cost of the optimization algorithm is reduced by 30% than that of traditional distribution model. This enables the logistics enterprises to meet the logistics service demand of hazardous chemicals with low cost, high efficiency and high safety logistics transportation and distribution.

## 1. Introduction

Following the wide application of visualization and big data technologies, and the logistics service models such as logistics alliances and supply chains etc., more logistics enterprises have attempted to build a cloud logistics service (CLS) model oriented for logistics tasks and services in order to ensure achieving the goals of resource allocation optimization, high quality and low-cost operation etc. during the logistics distribution of hazardous chemicals (Zhang et al., 2018; Zhang et al., 2016). At present, in terms of logistics distribution, many scholars and experts at home and abroad have achieved relevant results. Based on the status of domestic e-commerce logistics, He Shiming constructed the intensive logistics distribution system (Zhang et al., 2012; Subramanian and Abdulrahman, 2017; Kong et al., 2015; Zhong et al., 2016). Through comparative analysis for the traditional and emergency logistics, based on the model construction, Ding Wei used the genetic algorithm and proposed the solution to the vehicle routing problem of the emergency logistics in the model. Now, the problem of CLS platform has attracted much attention, but in actual application, there still exist many shortcomings, e.g., as far as logistics is concerned, supply and demand integration cannot be fully realized in most cases, and the supply side cannot make full use of advantages, while the demand side's personalized service needs cannot be satisfied (Pankratz, 2005; Fernández and González, 2000; Davidson and Anderton, 2000). For this, based on the development trend of cloud computing technology, this paper applies the cooperative distribution model through the use of modern software, hardware, computer technology and management methods etc. to distribute relatively high-risk chemicals.

## 2. Hazardous chemical logistics distribution under the cloud service platform

In the logistics service supply chain, the distribution activities of hazardous chemicals is often in the charge of the enterprises that ultimately supply services (Shu et al., 2013; Daugherty et al., 1998; Bharat et al., 2012). However, based on the logistics service platform, the accumulation of hazardous chemicals logistics tasks in certain areas frequently causes the fluctuation of distribution costs (Maltz et al., 2002; Barrozo et al., 2018;

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Ribeiro et al., 2018). Therefore, the paper focuses on the following aspects, namely how to integrate the characteristics of cloud logistics and logistics distribution of hazardous chemicals based on logistics platform in order to optimize distribution costs.

### 2.1 Analysis of hazardous chemicals logistics distribution

Along with the rapid development of the chemical industry, many logistics tasks of hazardous chemical have also arisen. In certain regions, there may be a chance that logistics enterprise will reduce the cost of some logistics distribution activities. Therefore, the paper summarizes the new model of cooperative distribution for logistics enterprises. This model is based on the CLS platform, to realize the information release between logistics enterprises, and thus effectively implement the communication of information resources; it also analyses the distribution demand points, make communications about the distribution activities, and charges or pays the relevant economic returns. For this model, this paper mainly discusses about whether the enterprise needs to make cooperation, design cooperation mode, and whether the logistics cost can be reduced. Figure 1 shows its cooperative distribution process.

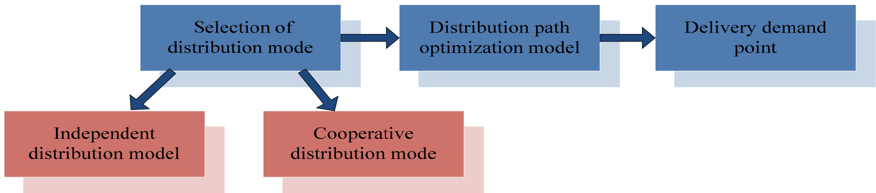


*Figure 1: The logistics distribution process*

(1) As far as the CLS platform is concerned, the logistics enterprise on demand side gradually sends the distribution information of hazardous chemicals to the platform, specifically, the information such as the delivery vehicle and location etc.
(2) The distribution enterprise on the supply size submits the delivery vehicle, service information, etc. to the platform based on the actual distribution demand, thereby achieving cooperative delivery.
(3) Each logistics enterprise should clarify whether the order is acceptable by analysing the demand information of the enterprise.
(4) The information sharing feature based on the logistics platform, through the use of GIS, GPS and other technologies, can ensure to monitor the distribution of vehicles throughout the process, and in real time to track the specific conditions of hazardous chemicals, the actual location of the vehicle and other information.
(5) Mutual evaluation can be carried out between cooperative distribution enterprises.

### 2.2 Construction of cooperative distribution model under cloud service platform

#### 2.2.1 Problem description

For the supply side of logistics resource, the distribution task should be planned before the specific delivery, and the vehicle vacancy situation should also be considered when the distribution activity is carried out. If the price slightly exceeds the cost price, the distribution information and types etc. of hazardous chemicals should be received from the platform. For other supply sides, after mastering the platform information and reading it, the enterprises with lower distribution prices than theirs are found, so as to select the competent enterprises according to specific needs and then carry out cooperative distribution. As the cooperation demand has been formed between the logistics enterprises, then the enterprises A and B become the logistics service demand side and the logistics resource supply side respectively. At this point, the logistics enterprise may have different identities, the demand side, or the supply side. Figure 2 shows the distribution path planning for this model. In view of the logistics cooperation distribution problem based on the CLS platform, firstly, the logistics distribution demand point should be judged, to clarify whether there is a transhipment demand. To be specific, for the distribution demand point, if the distribution cost is significantly higher than other enterprises, or when the hazardous chemicals are distributed, its own distribution ability cannot meet the demand. At this time, transhipment is demanded. In addition, if the transhipment of demand point is clarified, the logistics distribution path can be planned. Figure 3 shows the specific process.

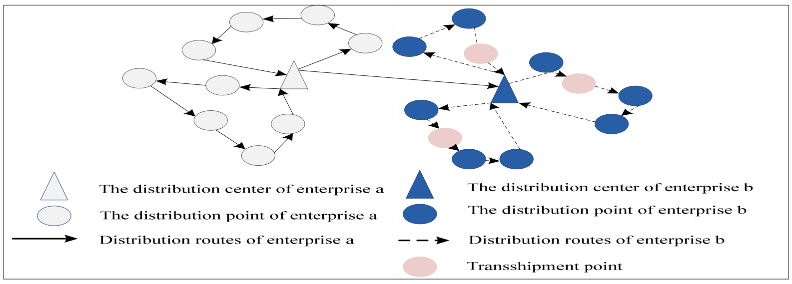


*Figure 2: The planning pattern of the cooperative distribution path*

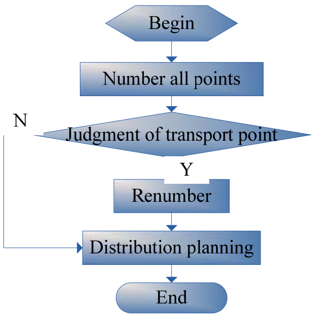


*Figure 3 Execution process of cooperative distribution mode*

### 2.2.2 Construction of logistics cooperative distribution model

(1) Model assumptions

Based on features of the relevant problems, the following related assumptions were assumed in this paper:

a) For the distribution of hazardous chemicals, it is within the time window;

b) When there is a surplus of distribution capacity, it can cooperate to distribute hazardous chemicals;

c) If transhipment is assumed, it is not necessary to consider the management costs incurred by the platform.

(2) Variable definition

Tab.1 shows the list of variables:

*Table 1: The list of variables*

| Variate | Description | Type |
|---|---|---|
| $f$ | Objective function | unknown |
| $pq$ | Logistics company | known |
| $c_{pi}$ | The unit cost of logistics company p to logistics task j | known |
| $d_{pi}$ | Distance from logistics company p to logistics task j | known |
| $y_{ip}$ | Is logistics company p responsible for logistics task j | O-1variable |
| $d_{mn}$ | Distance from m to n | known |
| $c_{mn}$ | Unit cost of transport from m to n | known |
| $X^k{}_{mn}$ | Is the vehicle in the logistics task delivery from the distribution point m to the distribution point n | O-1variable |
| $q_i$ | Distribution demand of logistics distribution task j | known |
| $Q$ | The max imumcarrying capacity of the distribution vehicle is Q | known |

(3) Model construction

a) The mathematical model of relevant judgments below:

Objective function:

$$\max f = \sum_{p=1}^{G} c_{pj} d_{pj} - \sum_{q=1}^{G}\sum_{p=1}^{G} c_{pq} d_{pq} - \sum_{q=1}^{G} C_j^q \qquad j=(1,2,\ldots,N) \tag{1}$$

Constraint condition:

$$c_{pq} = 0, p = q \tag{2}$$

$$\sum_{p=1}^{G} y_{jp} = 1 \tag{3}$$

$$\sum_{j=1}^{M} q_j y_{jp} \le Q \tag{4}$$

$$y_{jp} = \begin{cases} 1 & \text{j is completed by p} \\ 0 & \text{others} \end{cases} \tag{5}$$

For the above formula, formula (2) cannot realize the transhipment point transfer within the enterprise; formula (3) means that one enterprise is only responsible for one demand task; formula (4) means that compared with the total weight of the enterprise, the distribution weight is slightly smaller; formula (5) is an integer constraint.

## 3. Algorithm design

To solve the logistics distribution route planning model in this paper, the genetic algorithm was mainly applied. The detailed solution process is as follows:

### 3.1 Encoding

For the problem of vehicle path planning, the paper applies the natural number coding method. If the number of distribution points reaches m and the number of service vehicles is k, then the chromosome results are expressed as (0-$m_{11}$-$m_{12}$-…-$m_{1s}$-0-$m_{21}$-$m_{22}$-…-$m_{2s}$-0-…$m_{k1}$-$m_{k2}$…-$m_{ks}$-0), where, $m_{ks}$ indicates that the kth car serves the sth customer. 0 corresponds to the distribution centre, i.e., all vehicles start from here and need to return to 0.

### 3.2 Determining the number of vehicles

In terms of the specific planning path, it is necessary to select the appropriate number of distribution vehicles at this time. It' determined mainly by the following formula:

$$k = \left\lfloor \frac{\sum_{j=1}^{M} q_j}{Q} \right\rfloor + 1 \tag{6}$$

In formula 6, $\lfloor \; \rfloor$ means round down.

### 3.3 Fitness function

The size of this function can be reflected in the performance of the individual. By appropriately converting the formula (6), the value is calculated as:

$$F(x) = \frac{1}{f(x)} \tag{7}$$

## 4. Instance simulation and comparative analysis

For the traditional cooperative distribution schemes, the costs of the best distribution route for hazardous chemicals were compared and analysed, in order to verify the validity and feasibility of the research on the cooperative distribution of hazardous chemicals based on the cloud logistics service platform.

(1) Problem description of traditional scheme (Li, 2018).

A distribution centre can use a number of vehicles to distribute hazardous chemicals to different customers. With all customers' demand and location determined, for each distribution, it must be within the rated load capacity of the loader. In order to complete the transportation task, it is necessary to send out multiple vehicles. Each vehicle departs from the distribution centre, proceeds along a path with multiple customers, and finally returns to the distribution centre. All distribution paths include one or more loops. The vehicle route needs to be properly arranged to form the shortest overall transport path. In the model, the design of the driving path is used as an objective function to ensure minimum transportation costs.

(2) Problem description of the proposed scheme in this paper

On the supply side of the logistics resource, it is necessary to complete the planning based on its own tasks and the needs of distribution before the actual distribution work. In addition, it is also necessary to consider the vacant situation during the distribution of the vehicle; if the price slightly exceeds the cost price, the information, type, and the like of the hazardous chemicals from the platform can be received. For other supply sides, after mastering the platform information and reading it, the enterprises with lower distribution prices are found, and the competent enterprises are selected according to specific needs, in order to carry out cooperative distribution work. When the cooperation demand has been formed between the logistics enterprises, then the enterprises A and B become the logistics service demand side and the logistics resource supply side respectively. And the goal is set to the lowest distribution cost in order to plan the path.

(3) Algorithm parameters

The genetic algorithm was applied to solve this. Below are the algorithm parameters:

The population size popSize=300, the maximum number of iterations maxGen=200, the crossover probability Pc=0.8, and the mutation probability Pm=0.1. Substituting the specific data in the traditional scheme model, the distribution scheme was finally obtained:

The figure below shows the simulation results, in which p is the minimum cost of distribution, i.e., 589.95 yuan, and the distribution vehicle reaches 5 vehicles. The best solution for distribution is as follows:

Distribution path of No.1 vehicle: $0-L_{25}^{p}-L_{7}^{p}-L_{17}^{p}-L_{3}^{p}-L_{18}^{p}-L_{4}^{p}-0$

Distribution path of No.2 vehicle: $0-L_{12}^{p}-L_{27}^{p}-L_{2}^{p}-L_{10}^{p}-L_{15}^{p}-0$

Distribution path of No.3 vehicle: $0-L_{6}^{p}-L_{21}^{p}-L_{5}^{p}-L_{24}^{p}-L_{9}^{p}-L_{20}^{p}-L_{22}^{p}-0$

Distribution path of No.4 vehicle: $0-L_{13}^{p}-L_{29}^{p}-L_{30}^{p}-L_{14}^{p}-L_{8}^{p}-L_{11}^{p}-0$

Distribution path of No.5 vehicle: $0-L_{1}^{p}-L_{28}^{p}-L_{19}^{p}-L_{16}^{p}-L_{23}^{p}-L_{26}^{p}-0$

Q is the minimum cost of delivery, which is 265.28 yuan, and the delivery vehicle reaches 3 vehicles. The best solution for distribution is as follows:

Distribution path of No.1 vehicle: $0-L_{5}^{q}-L_{8}^{q}-L_{6}^{q}-L_{7}^{q}-L_{3}^{q}-0$

Distribution path of No.2 vehicle: $0-L_{9}^{q}-L_{4}^{q}-L_{11}^{q}-L_{10}^{q}-L_{1}^{q}-0$

Distribution path of No.3 vehicle: $0-L_{12}^{q}-L_{2}^{q}-0$

From the simulation results, it can be seen that, based on the cloud logistics service platform, the total cost for cooperative distribution of hazardous chemicals is 658.8 yuan; while the traditional transportation cost is 855.8 yuan, indicating that the total cost of the former is reduced by 30%. Figure 5 shows the corresponding simulation convergence.

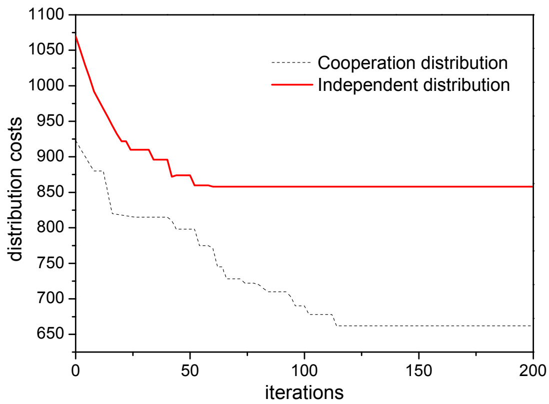


*Figure 5: The convergent effect diagram of objective function*

The comparative analysis indicates that the cooperative distribution model based on CLS platform proposed in this paper has significant effectiveness in reducing the logistics cost of hazardous chemicals.

## 5. Conclusions

(1) In view of the efficient integration problem of resources under the CLS platform, this paper constructs a cooperative logistics distribution model of hazardous chemicals.

(2) Based on the characteristics of CLS platform, the paper discusses the cooperative distribution problem of the proposed logistics platform, and uses genetic algorithm to verify the credibility of the model.
(3) By comparing the results of the cooperative hazardous chemicals distribution model with the traditional independent distribution model, the total cost is reduced by 30% compared with the traditional distribution, indicating that the cooperation model based on the improved algorithm is effective and feasible.

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