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Simulated Annealing algorithm and its application in logistics park location

[1]Yan-yan Liu , [2]Jie-shuang Dong , [3]Wei-wei Liu

[1]School of Management, University of Shanghai for Science and Technology, Shanghai, China
[2]School of Management, University of Shanghai for Science and Technology, Shanghai, China
[3]School of Management, University of Shanghai for Science and Technology, Shanghai, China

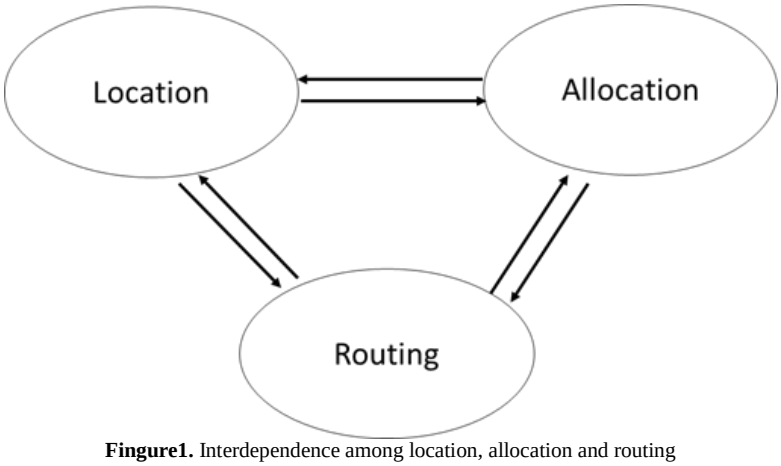
Email:13733931592liuyan@163.com

Abstract-The logistics costs include the cost of transportation, warehousing, information management, land costs and environmental protection. It is an important influence factor of the logistics facilities location. The location of logistics park and vehicle routing arrangement directly determine the logistics cost. Compared with the conventional location allocation model, the location routing model is closer to reality. Based on the traditional the facility location model and the transport vehicle routing model, this paper establishes the location routing model making the generalized cost minimum as the goal . Moreover, this paper uses simulated annealing algorithm to solve the model and gives its steps. By using the simulated annealing algorithm, we get the facilities location and the vehicle routing, optimize the location of the logistics facilities and the distribution paths, and verify the practicality of the model.

Keywords –Simulated annealing algorithm; Facility location problem(FLP); Facility location-allocation problem; Logistics park location model

1. Introduction

Facility location problem and vehicle routing problem are affected and constrained, any part of them will affect each other in the decision-making. Many scholars have done a lot of research on the facility allocation problem (FAP) and vehicle routing problem (VRP)[1]about the logistics decision-making. The vehicle routing problem (VRP) refers to determine the driving route of the individual customer under the premise of the facilities location known, aiming at the transportation route shortest or the transportation costs lowest . Considering the characteristics of the vehicle tour of each customer, it improves the transport efficiency and is consistent with the actual situation, but ignoring the facility location analysis, this will make the whole logistics costs can not meet the minimum. The FAP issues bases on considering the relationship between the positioning of logistics facilities and goods distribution, aimed at determining the number of facilities and its position, so that the cost of facility location and the vehicles routing lowest. With the continuous development of modern logistics industry and the needs to reduce the cost of logistics and integrated logistics management, a group of scholars from abroad carry out a comprehensive study on the facility location-routing problems (FLP). The main difference between the facility location-routing problem(FRP)and the classical location-allocation problem is that ,once the facility is located, the former requires a vistitation of customers/suppliers through tours, whereas the latter assumers the straight line or radial trip from the facility to the customers/suppliers. Therefore ,the classical location allocation problem ignores tours when locating facilities and subsequently may lead to increased distribution cost. In practice, due to the high investment costs and long recovery cycle of the logistics park, therefore it is very important to optimize the location and vehicle line of the logistics park. At the same time, optimizing the vehicle route can improve the efficiency of logistics operations. Therefore, the study of the system optimization has important theoretical value[3]. the relationship between location ,allocation and routing problem can be seen in figure 1.



Fingure1. Interdependence among location, allocation and routing

2. The research of facility location on the generalized cost minimum

Logistics network planning takes full account of both space and time factors. The study of facility locating problems has a long and extensive history, as this area of research has evolved, and many scholars have made a lot of contributions, and established a number of different types of models.

But with the development of the supply chain structure and the continuous improvement of the customer's demand, how to build the model reflecting the actual needs of the logistics is particularly important.Lazaros G.papageorgiou[3] mainly studied several model used to determine the optimal position of logistics facilities and optimal scale in the book of "Logistics of Facility Location and Allocation ". Yoshiaki Shimizu andTakeshi Wada[4] proposed to solve the problem of logistics site optimization and route selection optimization by hybrid tabu search method under the capacity constraints.Xu li-ming[12] advocated the use of dynamic programming method and MATLAB to solve the optimal site layout program in the period of planning time.

3.The location model of logistics park based on the generalized cost minimum

To simplify the presentation, we have the following assumptions:

(1) The number of the factory ,the factory location and supply are known.

(2) Every customer serviced by a car and each route correspond to one vehicles. Each line of aggregate demand not more than the vehicle's maximum service ability

(3) The location, storage capacity of the alternative logistics park are known.

(4)The number, location and demand of the customers are known.

3.1.The FRP model of the logistics park location based on generalized cost minimum

This paper establishes the facilities localization routing mode as follows. The purpose of the objective function is to make the sum cost of location、construction and transportation minimum.

$$\min F = \sum_{i=1}^{m}\sum_{k=1}^{q} C_{ik} X_{ik} \delta_{ik} + \sum_{k=1}^{q}\sum_{j=1}^{n} C_{kj} X_{kj} \delta_{kj} + \sum_{i=1}^{m}\sum_{k=1}^{n} C_{ij} X_{ij} \delta_{ij} + \sum_{k=1}^{q} F_k W_k$$

S.T.

$$X_{kj} = B_j \delta_{kj} \tag{3.1}$$

$$\sum_{j=1}^{n} X_{kj} \delta_{kj} \le M_k W_k \tag{3.2}$$

$$X_{ij} = B_j \delta_{ij} \tag{3.3}$$

$$\sum_{k=1}^{q} X_{ik} \delta_{ik} W_k + \sum_{j=1}^{n} B_j \delta_{ij} \le A_i \tag{3.4}$$

$$\sum_{i=1}^{m} X_{ik}\delta_{ik}W_k = \sum_{j=1}^{n} B_j\delta_{kj} \quad (3.5)$$

$$\sum_{i=1}^{m} B_j\delta_{ij} + \sum_{k=1}^{q} B_j\delta_{kj} = \sum_{j=1}^{n} B_j \quad (3.6)$$

$$X_{ik} \le W_k \quad (3.7)$$

$$\delta_{ik} = 0,1, i \in I, k \in K \quad (3.8)$$

$$\delta_{kj} = 0,1,, k \in K, j \in J \quad (3.9)$$

$$\delta_{ij} = 0,1,, i \in I, j \in J \quad (3.10)$$

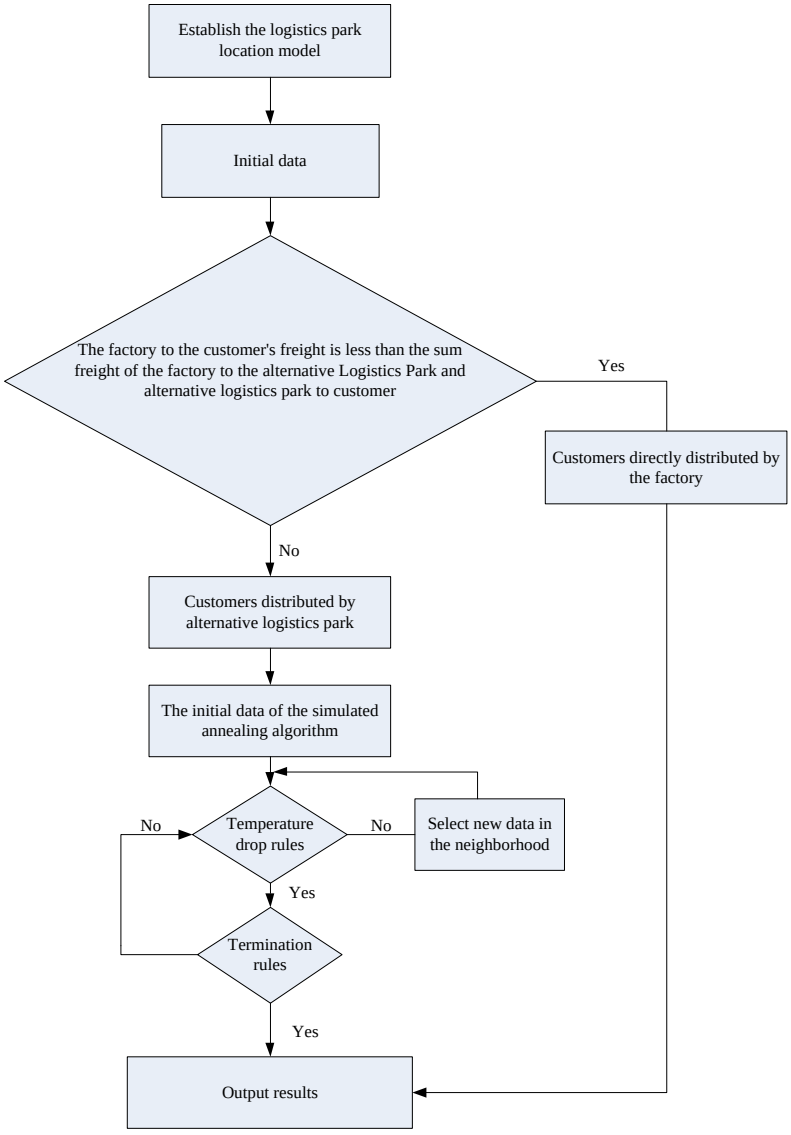
$$W_k = 0,1,, k \in K \quad (3.11)$$

$$i = 1,2,\cdots\cdots,m; \quad k = 1,2,\cdots\cdots,q; \quad j = 1,2,\cdots\cdots,n \quad (3.12)$$

Each letter significance as follows : J is the customer's point set, I is for the the set of supply place (factories, etc.), K is for the collection of alternative logistics parks, m is for the number of the supply place, q is for the number of production plants, n is for the number of customers, Cik is for the units restocking fee of the alternative Logistics Park K from factory I, Xik is for the goods quantity of the Logistics Park K from factory I, F_k represents the infrastructure investment costs of the logistics park, Mk represens the capacity of Logistics Park K, AI represens the production of I, Bj represens the demand of customer j, the others are decision variables .The objective of the function is to make the sum cost of construction and transportation minimum . The constraint conditions of the target function are the formula 3.1to the formula 3.12. Fourmula 3.1shows that the distribution amount of the Logistics park equals to the demand of the customers, 3.2 shows the distribution amount of the logistics park to all the customer does not exceed its own capacity.3.3 is the limit of the factory transporting goods ,to make sure aggregate demand not more than the produce capacity.3.4~3.6 are the supply meets the demand restrict.3.7 ensures that every customer only serviced by the selected logistics park, 3.8~3.11 are the variable constraints of zero or one, 3.12 is the number 3.11 is the range scope of i,j,k.

3.2. The way and the process to solute the model

The FRP problem belongs to NP-hard problem of combinatorial optimization problems, this paper introduces the modern heuristic algorithm, decomposes this model into multiple sub-problems, and the solves it by heuristic algorithm or exact algorithm. Heuristic algorithm is divided into these algorithms, including tabu search, simulated annealing algorithms, genetic algorithms, artificial neural networks. we apply the simulated annealing algorithms to solve it . The solving flowchart of Logistics Park location can be seen in figure 2.



Fingure2. The solving flowchart of Logistics Park location

3.3. The improvement steps of simulated annealing algorithm

Steps 1: Optionally choose an initial solution x_0, Make $x_i = x_0$, $k = 0$, $t_0 = Tmax$ (initial temperature).

Steps 2: If the temperature reaches the internal circulation stop condition, then go to Step3. Otherwise, randomly selected x_j from the neighborhood N (x_i), calculated Δf_{ij} according to 3.13, if $\Delta f_{ij} \le 0$,make $x_{i=}x_j$.If not ,judge wehter it meet the conditions of 3.14,if yes , make $x_{i=}x_j$,and then repeat step2.

$$\Delta f_{ij} = f(x_j) - f(x_i) \tag{3.13}$$

$$\exp(-\Delta f_{ij} / t_k) > random(0,1) \tag{3.14}$$

Steps3: judge whether it satisfies the determination condition of 3.15, yes, terminate the calculation, Otherwise, return to Step2.

$$t_{k+1} = d(t_k), k = k+1 \tag{3.15}$$

4. Application example

Given the complexity of the problem, this article with only small-scale data checking computations. Assume that there are three optional logistics facilities point (K1, K2 and K3) and six customers (J1 ~J6). The objective is to make the whole cost of distribution system minimum.The production of the factory can be seen in table 1 and the information data of logistics park can be seen in table 2,including the capacity、unit transportation cost and the construction cost. The data table of the users can be seen in table 3,including the demands and the unit cost of transportation. In this paper we use the simulated annealing algorithm for the optimization solution of the problem and find the reasonable position from the alternative logistics parks ,the result can be seen in table4.

Table 1. The production data of the supply places

Supply place	I1	I2
Production of I	50	40

Table 2. The information of logistics park's data

optional logistics facilities	K1	K2	K3
The capacity of Logistics park M_k	40	40	40
Construction cost F_K	80	110	60
The unit transportation cost from I1to Logistics Park C_{1k}	7	12	8
The unit transportation cost from I2to Logistics Park C_{2k}	9	7	14

Table3. The data table of the users

customer	J_1	J_2	J_3	J_4	J_5	J_6
Demand of B_j	9	13	18	9	7	12
The unit transportation cost from the factory of I1 to the user C_{1j}	5	25	30	35	28	30
The unit transportation cost from the factory of I2 to the user C_{2j}	8	15	18	22	25	28
The unit transportation cost from Logistics Park of K1 to the user C_{1j}	5	14	10	15	9	9
The unit transportation cost from Logistics Park of K2 to the user C_{2j}	11	16	5	7	7	5
The unit transportation cost from Logistics Park of K3 to the user C_{3j}	4	9	3	6	13	11

Table4. The sheet of selected facility and the clients serviced by facilities

	The customer serviced by Logistics park service
The selected logistics parkK2	J_3,J_4,J_5,J_6
FactoryI_1	J_1
FactoryI_2	J_2

5. Conclusion

Logistics park is an important node and plays a connecting role in the entire modern logistics system. If the location of the logistics park is appropriate, it can greatly improve the operating efficiency of the logistics system, save the logistics cost and play a role in promoting social logistics and economic development. Based on the analysis of location allocation problem (LAP) and vehicle routing problem (VRP), this paper presents a model for the Logistics Park location considering cost factor ,and proposes the steps of the simulated annealing algorithm to solve the model. This model considers two transportation paths, the factory directly transport to the customer and the factory to the customer transiting by logistics park ,makes it closer to the actual situation.This papes uses simulated annealing algorithm of heuristic algorithms to solve the model , and applies a simple example to analyze and verify the validity of the model in the area of logistics park location.finally we optimize the layout of logistics facilities and distribution paths.In summary, it can promote the integration management and development of modern logistics.

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