

Heuristic algorithm and its application in logistics

¹Yan-yan Liu ,²Jie-shuang Dong ,³Wei-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 location routing problem (LRP) appears as a combination of two difficult problems: the facility location problem (FLP) and the vehicle routing problem (VRP). In this work ,we take inventory costs into account ,structure a LRP model and use the way of heuristic algorithm to solve it. Inventory costs is an important part of the construction of logistics facilities, adding it into the LRP model makes the model closer to reality. Moreover, this paper uses heuristic algorithm to solute the model and gives its steps. We make the routing and location costs minimize as the goal. By using Heuristic algorithm , we get the facilities location cost, transportation cost and inventory cost , proof that the method does reduce the cost in logistics, meanwhile optimize the layout of logistics facilities and the distribution paths, and verify the practicality of the model.

Keywords –Vehicle routing problem; Heuristic algorithm; Location routing problem; Inventory costs.

1. Introduction

Many scholars have done a lot of research on the location allocation problem (LAP) and vehicle routing problem (VRP) [1] about the logistics decision-making. Considering the relationship between the position of logistics facilities and cargo distribution, the purpose of the LAP is to make a decision of the number and the position of facilities aiming at the cost minimum. In reviewing the criteria modeled in the articles reviewed of LAP, John Current found that it could be classified into one of four general categories: cost minimization, demand oriented, profit maximization, environmental concern. The classical location allocation problem (LAP) can be seen in figure 1, as it is assumed that the transport

routes of the facilities to the customers is radial, neglecting vehicle tour itinerary, so it may lead to costs growth [2]. In the VRP problems, there is no analysis of the facilities location problem, this will make the whole logistics cost can't meet the minimum. The location routing problem (LRP) appears as a combination of two difficult problems: the facility location problem (FLP) and the vehicle routing problem (VRP). Through the establishment of the LRP model, it can simultaneously determine the optimal number of the facilities, location, capacity and optimal transportation plan, route arrangements between the overall problem, so as to further reduce the cost of logistics system, and improve the efficiency of product distribution, the LRP can be seen in figure 2.

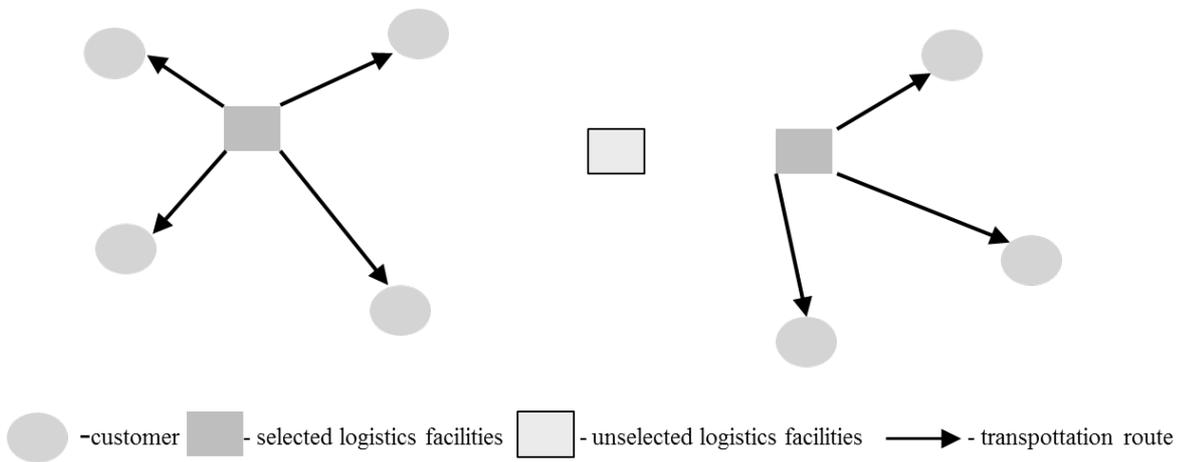


Figure1. Schematic of LAP

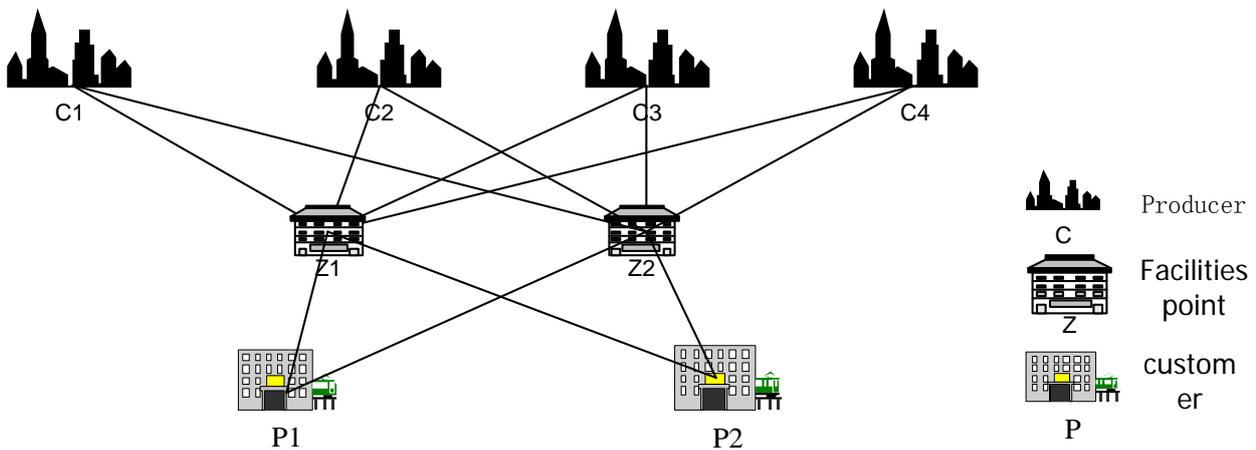


Figure2. The delivery mode of LRP

2. The way of solving LRP model

The way of solving LRP can be divided into exact algorithms and heuristic algorithms. Exact algorithm can be divided into four, directly tree search method, dynamic programming, integer programming and nonlinear programming, only limited to small-scale.

There have already many related foreign literatures explains its precision of the algorithm to solve the LRP, Heuristic method seems to be the only feasible method of solving large-scale LRP. LIU ,SC[3] used two-phase heuristic algorithm that first solving VRP and then optimizing LAP, to solve LRP, Wu[4] solved the multi-model and the amount given of the LRP with two stage simulated annealing heuristic algorithm.

Solving exactly a LRP is a difficult task. By analysing the strategy of the tree encoding of the genetic algorithms, immune genetic algorithm and genetic algorithm, Zhang chang xing constructed the LRP modified genetic algorithm. Because of the complexity of the LRP problems, all kinds of solving methods have certain limitations, so exploring the multi-factor and new effective algorithm for LRP is necessary.

3 Take Inventory cost into LRP

Facility location, routing and inventory policy is mutual influence and restrict ,any party's decision will affect the other two. You can see the relationship between the Inventory and transportation costs in figure3.

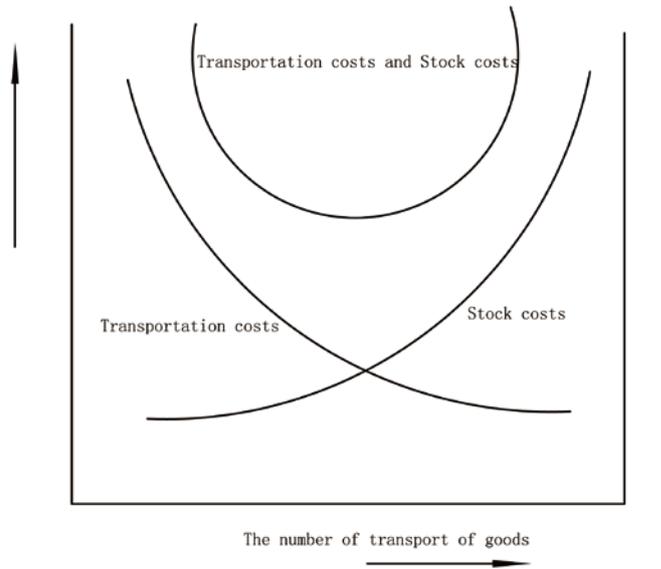


Figure 3. Diagram of the Inventory and transportation costs

To simplify the presentation, we have the following assumptions:

- (1) The research object for single product, many sites location route problem
- (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 and each route start and end in the same site
- (3) All vehicles have the same capacity.

3.1 The LRP model considering inventory costs

This paper establishes the localization routing and Inventor combinatorial optimization mathematical model of problem are as follows. The purpose of the objective function is to make the sum cost of construction , transportation and inventory minimum .

$$M \text{ in } F = \sum_{r \in R} G_r y_r + \sum_{k \in V} \sum_{i \in S} \sum_{j \in S} (c + cm + Dis_k) \times \frac{D_k}{EOQ_k} + \sum_{k \in V} \sum_{i \in S} \sum_{j \in S} ((\frac{EOQ_k}{2} + R_k - UL_k) \times h^+ + \frac{D_k}{EOQ_k} \times A + hs \times B(R_k) \times \frac{D_k}{EOQ_k}) \times X_{ijk}$$

S.T.

$$EOQ_k \leq Q_k, k \in V \tag{3.1}$$

$$D_k \leq MaxSup, k \in V \tag{3.2}$$

$$\sum_{k \in V} \sum_{i \in S} x_{ijk} = 1, j \in J \tag{3.3}$$

$$\sum_{i \in S} x_{ipk} - \sum_{j \in S} x_{pjk} = 0, k \in V, p \in S \tag{3.4}$$

$$\sum_{r \in R} \sum_{j \in J} x_{rjk} \leq 1 \tag{3.5}$$

$$\sum_{j \in S} (x_{rlk} + x_{ijk}) \leq 1 + z_{rj}, r \in R, j \in J, k \in K \tag{3.6}$$

$$U_{lk} - U_{jk} + Nx_{ijk} \leq N - 1, l, j \in J, k \in V \tag{3.7}$$

$$x_{ijk} = 0, 1, i, j \in S, k \in V, i \neq j \tag{3.8}$$

$$y_r = 0, 1, r \in R \tag{3.9}$$

$$z_{ij} = 0, 1, i \in R, j \in J \tag{3.10}$$

$$U_{lk} \geq 0, l \in J, k \in V \tag{3.11}$$

Each letter significance as follows :R is for facilities point set position, J is the customer’s point set, V is for the set of vehicles, S is for customer point and potential facilities point set, N is for the number of customers, QK is for Vehicle k capacity, Max Sup is for each vehicle maximum service ability, Gr is for facilities’ construction and operation of the fixed cost, C is for fixed fee for each use of the vehicle ,cm is for unit distance transportation cost, Cijis for the distance between two points, h+ is for the storage cost of unit product unit time, hs is for the cost out of stock in unit product ,A is for ordering cost, ulk shows the average customer needs on line k during the period of order , B(Rk)shows the average quantity of stock out in one week, and the others are decision variables .The objective of the function is to make the sum cost of construction , transportation and inventory minimum . The constraint conditions of the target function are the formula 3.1to the formula 3.11.Fourmula 3.1 is the transport vehicle capacity constraint condition, 3.2 is the vehicle's service restrict ,to make sure the aggregate demand not more than the vehicle's capacity, 3.3 ensures that every customer only serviced by a transport vehicle, 3.4 guarantees route continuous,3.5 ensures that each transport route only from a facility to put off, 3.6 is to make sure that customers only serviced by the selected facilities, 3.7~3.11 are the variable constraints of zero or one, 3.11 is for auxiliary variable constraint.

3.2 The improvement steps of heuristic algorithm

Steps 1: Generating an initial solution. Make k = 1, r = 1. All customers put into the customers collection of J. Some sites into a site collection R.

Steps 2: Initialize the first routes. Randomly select a customer from J, and put it into the route V_k, then deletes the customer from J.

Steps 3: Selecting customers w as a candidate customer from a J in accordance with the principle of minimum marginal cost customers as a candidate for the customer.

Steps 4: judge whether the sum of demand of the customers on the route V_k and candidate customers w exceed maxsup. If so, make k = k +1, increase a vehicle, put candidate customers w into the route V_k, delete customers w from J. If not, put the candidate customers w into route V_k ,then delete w from J .

Steps 5: Judge whether there are customers in customer collection J. If yes, go to Step 3, or else go to step 6.

Steps 6: Calculate center of gravity coordinates (Xt, Yt) of the customers on each route Vt (1≤t≤k).

Steps 7: Select the site that provides services to customers on each route. Select a site m which is nearest to the center of customer gravity on the distance routes Vr from site collection R, Put m into the collection Vr, site m service customers on the route, then delete site m from R.

Steps 8: Judge if r is bigger than k, and if so, go to step9, if not, go to step7.

Steps9: Calculate the evaluation value of the initial solution, make the current solution as the best solution.

4 Application example

Given the complexity of the problem, this article with only small-scale data checking computations. Assume that there are three facilities point (D1, D2 and D3) and four customers (C1 and C2 and C3 and C4). Make C=25, cm=1, h+=0.5, A=20, hs=2, the car capacity is 150, MaxSup =1000, facilities point and customer's detailed data table1 and table 2.

Table 1. Alternative facility point data sheet

Optional facilities point	coordinates	Construction cost
D1	(38,133)	209
D2	(22,76)	467
D3	(174,193)	143

Table 2. Customer data information table

Customer	coordinates	Demands	Ordering lead time demand (uniform distribution)
C1	(155,98)	474	U[0,3]
C2	(178,191)	365	U[0,8]

C3	(78,88)	522	U[0,6]
C4	(50,65)	200	U[0,7]

In this paper the design of two stage heuristic algorithm for the optimization solution of the problem to see table3.

Table3. Heuristic algorithm to calculate the results

Selected facilities point	route	Construction cost	Transportation cost	Inventory cost	Sum cost
D1	D1 - C3 - C4 - D1				
D3	D3 - C1 - C2 - D3	352	2159.5	288.84	2800.34

Table4. Location routing problems and inventory independent calculation results

Selected facilities point	route	Construction cost	Transportation cost	Inventory cost	Sum cost
D2	V1 : D2 - C4 - C3 - D2				
D3	V2 : D3 - C1 - D3	610	1719.81	546.97	2876.78
	V3 : D3 - C2 - D3				

By the contrast of table3 and table 4, we can conclusion that:

(1) Stock cost is an important part of the total cost of the logistics system, different stocks strategies have greater impact on stock costs and overall costs.

(2) Consider the cost of inventory facilities in location route and distribution of the total cost is relatively low, there is great practical significance and economic significance to reduce the logistics cost.

5. Conclusion

This paper presents a model considering stock costs in localization routing problem and proposes heuristic algorithm in solving steps. this model is closer to the actual situation, to further reduce the cost of logistics transportation, stock and the total cost of logistics overall. This method makes contributes to the solution of location allocation problems of Integrated Logistics, with a heuristic algorithm to solve the LA problem of integrated logistics, providing research-based for further settlement of location Routing Problem (LRP). Through the case analysis, it verifies that validity of the location routing problem model considering the stocks factors, optimizes the layout of logistics facilities and distribution paths, and reduces transportation costs and stock costs, thereby reducing the overall logistics costs. In summary, it can promote the integration management and development of modern logistics.

References

[1] Qian-Gao Zhang. Integrated logistics location Routing Problem (LRP) the optimization algorithm Comment [J]. Northeastern University (Natural Science), 2003,24 (1): 31 - 34.
 [2] Shou-yang Wang, Qiu-hong Zhao. Positioning-transport routes

arrangements by integrated logistics management system[J]. Management Science, 2000, 3(2):69-75.

[3] LIU S C, LEE S B. A two-phase heuristic method for the multi-facility location routing problem taking inventory control decisions into consideration[J]. The International Journal of Advanced Manufacturing Technology, 2003, 22: 941-950.

[4] WU -Taihis, LOW Chinyao, BAI Jiunnwei. Heuristic solution to multi facility location routing problems [J]. Computers & Operations Research, 2002, 29: 1393-1415.

[5] ZHANG Qian, Li-qun GAO, Xue-me LIU. A two-phase heuristic approach to the location routing problem[J]. Control and Decision, 2004, 19(7): 773-777.

[6] ZHANG Changxing, DANG Yanzhong. A novel genetic algorithm for location routing problem [J]. Computer Engineering and Application, 2004, 12: 65-68.

[7] Rajesh Srivastava, W.C. Benton. The location-routing problem: considerations in physical distribution system design[J]. Computers & Operations Research, 1990, 17: 427-435.

[8] Von Boventer. The relation between transportation costs and location rent in transportation problems[J]. Journal of Regional Science. 1961, 3(2): 27-40.

[9] Dilek Tuzun, Laura I. Burke. A two-phase tabu search approach to the location routing problem[J]. European Journal of Operational Research, 116(1999)87-99.

[10] Da-wei Hu. Facility location and vehicle route problem model and heuristic Algorithm research [D]. Chang'an University, 2008, 95-101.