Research on the optimization of vehicle distribution routes in logistics enterprises

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Abstract. With the rapid development of modern logistics, the vehicle routing problem has become one of the urgent problems in the logistics industry. The rationality of distribution route planning directly affects the efficiency and quality of logistics distribution. This paper first introduces the definition of logistics distribution and the three methods of optimizing the distribution routes, and then analyzes the current vehicle distribution route by using a representative example, finally puts forward the optimization schemes of logistics distribution route.

1. Introduction

In the context of the rapid development in today's logistics industry, the level of logistics industry has become one of the important criteria to measure the development of a country's economy. Logistics distribution is an important part of logistics activities to be directly connected with consumers, its cost accounts for a great proportion of the total cost [1]. However, there are still a considerable number of logistics enterprises to design its distribution route in an unreasonable state, relying solely on their own experience, which resulted in high distribution costs and low distribution efficiency of this phenomenon, greatly restricting logistics industry development and growth. Therefore, the logistics vehicle routing optimization problem has become an important issue in the current logistics research.

2. The definition of relevant theories and methods

2.1. The definition of relevant theories

The vehicle routing problem (VRP) [2] was first proposed by Dantzig and Ramser in 1959, which means that the enterprise has a certain number of customers, each with a different number of cargo needs, the distribution center to provide customers with goods by a team responsible for the distribution of goods, and organize the appropriate driving routes. The goal is to make the customer's needs are met, and can be in a certain constraint to achieve such as the shortest route, the minimum cost, the least time consuming and so on.

2.2. The definition of related methods

The Saving Algorithm is used to solve the vehicle routing problem in the uncertain state of the number of transport vehicles. It is the most famous heuristic algorithm to solve the Vehicle Routing Problem [3].

The Value-inserting Method [4], originally proposed by Mole and Jameson in 1976, was used to solve the vehicle routing problem. Under the guidance of the shortest distance and the least costly
concept, it inserts the customer point into the route in order to design the distribution route. Its characteristic is to find the insertion position while completing the element movement.

The Sweep Algorithm [5], first proposed by Gillett and Miller in 1974, was used to solve the vehicle routing problem, which belonged to the way of grouping and rearranging routes. The method uses polar coordinates to represent the location of each demand point, and then take a demand point as the starting point, set its angle to zero, in clockwise or reverse clock direction, the car capacity for the constraints of the service area of the division, after And then use the Lin and Kernighan's exchange method to sort the demand point to build the vehicle routing route.

2.3. The significance of vehicle routing optimization

For enterprises and society, it is very necessary to optimize the distribution route of vehicles [6].

1) This can minimize the delivery time while reducing the mileage of the delivery distance, so that enterprises can get the most cost-effective economic benefits.

2) This will shorten the time of delivery of goods and improve customer satisfaction.

3) This can be more reasonable and professional arrangements for the various processes, improving the efficiency of operations enhancing the competitiveness of enterprises.

3. Overview of logistics enterprise D and its distribution routes

This paper chooses the logistics enterprise D with typical characteristics as the research object, and analyzes its distribution route, aiming at seeking the corresponding route optimization scheme for this kind of enterprise similar to D logistics enterprise.

The following figures and tables show the basic situation of this enterprise: the relative position distribution of each customer point shown in figure 1, the demand and distance of each customer point as shown in table 1, and distribution information as shown in table 2.

Table 1. The demand and distance of each customer point

| Customer Point | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|----------------|---|---|---|---|---|---|---|---|---|
| Demand(boxes/a day) | 180 | 120 | 120 | 60 | 80 | 220 | 70 | 90 | 200 |
| Distribution distance(km) | 7.59 | 8.92 | 18.67 | 17.03 | 5.7 | 15.38 | 8.7 | 8.15 | 8.25 |

Table 2. Distribution information table

| Route | Distance | The volume of transport | Truck type | The number of drivers |
|-------|----------|-------------------------|------------|-----------------------|
| 0-1-2-0 | 21.37km | 300 boxes | 7t | 1 |
| 0-3-4-0 | 37.34km | 180 boxes | 7t | 1 |
| 0-5-6-0 | 31.54km | 300 boxes | 7t | 1 |
| 0-7-8-0 | 20.27km | 160 boxes | 7t | 1 |
| 0-9-0 | 16.50km | 200 boxes | 7t | 1 |

Figure 1. The relative position distribution of each customer point
4. Optimized Design of Distribution Route for D Logistics Enterprises

4.1. Analysis on Distribution Route of D Logistics Enterprises

By calculating the shortest distance between each points, we can obtain the shortest distance between each points, as shown in the table 3.

Table 3. The shortest distance between each points

|   | V0 | V1 | V2 | V3 | V4 | V5 | V6 | V7 | V8 | V9 |
|---|----|----|----|----|----|----|----|----|----|----|
| V0 | 0  | 7.59 | 8.92 | 18.06 | 16.42 | 5.70 | 15.38 | 11.57 | 8.15 | 8.25 |
| V1 | 0  | 4.86 | 14.59 | 16.23 | 13.29 | 22.97 | 19.16 | 15.74 | 15.47 |
| V2 | 0  | 9.73 | 11.37 | 14.62 | 23.38 | 20.49 | 17.07 | 17.17 |
| V3 | 0  | 1.64 | 12.36 | 13.65 | 21.98 | 25.22 | 26.31 |
| V4 | 0  | 10.72 | 12.01 | 20.34 | 23.58 | 24.67 |
| V5 | 0  | 21.08 | 17.27 | 13.85 | 13.95 |
| V6 | 0  | 8.33 | 11.57 | 20.71 |
| V7 | 0  | 3.42 | 12.68 |
| V8 | 0  | 9.14 |
| V9 | 0  |

4.2. Optimization of enterprise distribution route based on Saving Algorithm

The Saving Algorithm is calculated by the formula \[ \Delta C_{ij} = C_{0j} + C_{0i} \] \[ - C_{ij}, \] for \[ i,j=0,1,2,3,4...9 \] [7], and the calculation results are as follows:

\[
\begin{bmatrix}
0 & 11.65 & 11.06 & 7.78 & 0 & 0 & 0 & 0 & 0.37 \\
0 & 17.25 & 13.97 & 0.13 & 0.92 & 0.13 & 0.13 & 0.13 & 0 \\
0 & 32.84 & 11.4 & 19.79 & 7.65 & 0.99 & 0 & 0 & 0 \\
0 & 11.4 & 19.79 & 7.65 & 0.99 & 0 & 0 & 0 & 0 \\
0 & 18.62 & 11.96 & 2.92 & 0 & 16.3 & 7.14 & 0 & 7.26 \\
0 & 7.26 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\end{bmatrix}
\]

We arrange the \( \Delta C_{ij} \) in ascending order, as shown in Table 4.

Table 4. Information about \( \Delta C_{ij} \)

| V1, Vj | \( \Delta C_{ij} \) | V1, Vj | \( \Delta C_{ij} \) | V1, Vj | \( \Delta C_{ij} \) |
|---|---|---|---|---|---|
| 3-4 | 32.84 | 1-2 | 11.65 | 7-9 | 7.14 |
| 3-6 | 19.79 | 3-5 | 11.4 | 6-9 | 2.92 |
| 4-6 | 19.79 | 4-5 | 11.4 | 3-8 | 0.99 |
| 6-7 | 18.62 | 1-3 | 11.06 | 4-8 | 0.99 |
| 2-3 | 17.25 | 1-4 | 7.78 | 2-6 | 0.92 |
| 7-8 | 16.3 | 3-7 | 7.65 | 1-9 | 0.37 |
| 2-4 | 13.97 | 4-7 | 7.65 | 2-4 | 0.13 |
| 6-8 | 11.96 | 8-9 | 7.26 | 2-6 | 0.13 |

The results of the optimization are shown in table 5.
Table 5. The result of using Saving Algorithm optimization

| Route      | Distance  | The volume of transport | Truck type | The number of drivers |
|------------|-----------|-------------------------|------------|-----------------------|
| 0-3-4-6-7-0| 51.61km   | 470 boxes               | 11 t       | 1                     |
| 0-1-2-0    | 21.37km   | 300 boxes               | 7 t        | 1                     |
| 0-8-9-0    | 25.54km   | 290 boxes               | 7 t        | 1                     |
| 0-5-0      | 11.4km    | 80 boxes                | 7 t        | 1                     |

As can be seen from table 5, the scheme needs the truck to run at least four times and the driver to run four times, the total transport mileage is 109.92km. The optimized route for the vehicle is shown in Figure 2.

Figure 2. The optimize route result

4.3. Optimization of enterprise distribution route based on Value-inserting Method

Using the improved value-inserting method to optimize the results is shown in Table 6, the optimize route results shown in Figure 3.

Table 6. The result of using Value-inserting Method optimization

| Route      | Distance  | The volume of transport | Truck type | The number of drivers |
|------------|-----------|-------------------------|------------|-----------------------|
| 0-1-2-5-0  | 32.77km   | 380 boxes               | 11 t       | 1                     |
| 0-3-4-6-0  | 43.84km   | 470.9 boxes             | 11 t       | 1                     |
| 0-7-8-9-0  | 29.51km   | 323.8 boxes             | 11 t       | 1                     |

As can be seen from Table 6, the scheme needs the truck to run at least three times and the driver to run three times, the total transport mileage is 106.12km. The optimized route for the vehicle is shown in Figure 3.

Figure 3. The optimize route result

4.4. Optimization of enterprise distribution route based on Sweep Algorithm

The optimization of enterprise distribution line based on Sweep Algorithm, we did a scanning calculate analysis by making different customers as a starting point and compared it [8]. The optimal solution we get is the project by 1 as a starting point, as shown in figure 4.

The polar coordinate system is established and 0 is the origin of the polar coordinate system. From the angle of zero to counterclockwise scan, The first group is the customer 1, Load1 = 180; continue to turn, the next group is the customer 2, Load1 = 300. Since the load has not exceeded the limit Load limit = 500, continue to turn. The next group is the customer 5, Load1 = 380, continue to turn; the next group is the customer 3, Load = 500; So this route has reached the maximum, need a new group, so that the first There are only customers in the group 1,2,5,3. In the second group, there are customers 4,6,7,8, Load2 = 440. Continue the above steps, the third group of customers 9, Load3 = 200, so all customers are assigned to complete. The result of the grouping is shown in Figure 5.
The route optimization within the group. The above three groups are already a one-way transport problem, the following with the nearest neighbor heuristic algorithm for route optimization:

First, we assume that \( T = \{V_1\} , N = \{1, 2, 5, 3\} \)

\[ \therefore \min \{C_{i|} \mid i = 2, 5, 3\} = C_{i2} = 4.86 \therefore T = \{V_1, V_2\} \]

\[ \therefore \min \{C_{i|} \mid i = 5, 3\} = C_{i5} = 9.73 \therefore T = \{V_1, V_2, V_3\} \]

\[ \therefore \min \{C_{i|} \mid i = 5\} = C_{i5} = 12.36 \therefore T = \{V_1, V_2, V_3, V_5\} \]

The optimized route of the first group is 0—1—2—3—5—0.

According to the same operation, we can get the other following results that the last two are 0—4—6—7—8—0 and 0—9—0.

**Table 7.** The result of using Sweep Algorithm optimization

| Route     | Distance | The volume of transport | Truck type | The number of drivers |
|-----------|----------|-------------------------|------------|-----------------------|
| 0-1-2-3-5-0 | 40.24km  | 500 boxes               | 11 t       | 1                     |
| 0-4-6-7-8-0 | 48.33km  | 440 boxes               | 11 t       | 1                     |
| 0-9-0      | 16.5km   | 200 boxes               | 7 t        | 1                     |

4.5. *Analysis of Three Optimization Schemes*

Route optimization study about D logistics company, we use the saving algorithm, the improved value-inserting method and the *sweep algorithm* to calculate, we has carried on the simple comparison in table 8, and choose the more satisfactory distribution scheme.
Table 8. Results comparison table

| situation                     | The result before optimization | The result after optimization |
|-------------------------------|--------------------------------|--------------------------------|
| The number of truck movements (times) | 7t 5 3 0 1 | 11t 0 1 3 2 |
| Total transport mileage (km)  | 127.02 109.92 106.12 105.07 | 17.1 20.9 21.95 |
| The number of drivers         | 5 4 3 3 | 2 2 2 |

According to table 4.6, we combine demand the number of truck movements, the total mileage of transport, the human resource consumption, etc., to make a comprehensive comparison analysis. This paper assumes that the fuel consumption of 11 ton car is equal to the 7 ton car, per kilometer fuel consumption of 0.12 liters, driver wages per month for 3500 yuan, and the price of diesel is 7.3.

We found that the saving algorithm can save mileage of 17.1km, which can be calculated to save 14.98 yuan per day, saving 449.39 yuan per month. The savings algorithm can be reduced by reducing a driver, so the total savings are 3949.39 yuan per month.

The improved Value-inserting Method saves the mileage of 20.9 km, which can be calculated to save 18.31 yuan per day, which is 549.25 yuan per month, which can be reduced by reducing two drivers, so the totally savings are 7549.25 yuan per month.

Sweep Algorithm can save mileage of 21.95km and calculate the daily savings of 19.23 yuan, 576.85 yuan per month, which can save up two drivers, so it can save a total of 7576.85 yuan per month.

In addition to the route problem of vehicle distribution, in order to enable enterprises competitively and get more economic benefits in the market economy, enterprises should do some proper adjustment in the enterprise organization structure and business formation. Enterprises should streamline the organizational structure of enterprises and reduce the duplication of those departments, which can reduce labor costs. In addition, enterprises also need to deepen the degree of enterprise business information, to purchase and use of intelligent equipment to order and find goods, and to continue to adjust the distribution route planning with scientific means, which can improve the efficiency of business operations. Only in this way, can enterprises have a better development and competitiveness.

5. Conclusion
The optimization problem of logistics distribution vehicle route is a typical combinatorial optimization problem, which belongs to the Non-deterministic Polynomial problem and has high computational complexity. However, the traditional distribution route is chosen to rely solely on the experience of the laborers, which may easily cause the logistics enterprises to operate inefficiently and limit the further development of logistics enterprises.

This paper analyzes the characteristics of logistics distribution vehicle routing problems, and adopts the three methods, Saving Algorithm, Value-inserting Method and Sweep Algorithm respectively. By optimizing the actual cases, we find that the scientific method can be more suitable and effective for the vehicle route design, thus seeking the optimal solution. Therefore, the conclusion of this paper has great reference value to the research of logistics enterprises’ vehicle problems.

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