Optimization of VRP for Single Distribution Center Based on Improved Saving Method

Xia Li

***Abstract*—**As the "third source of profit" in the world economic activities, logistics has been paid attention by all countries in the world, especially in the developed countries. The development of logistics has been quite mature, and the logistics management and technology have been widely used. In order to reduce the cost of logistics distribution, vehicle routing problem in logistics system has become a hot issue. The selection of rational distribution path for vehicles directly affects the service level and the cost of the distribution center. The optimization and scheduling of the distribution center can improve the economic efficiency of the logistics and realize the scientific logistics. On the basis of saving mileage, the author considers the influence of distance between distribution centers and users and users on path planning, so as to achieve the path search of the shortest distance. Taking a chain supermarket as an example, the author combines the distance factor and plans the distribution route of vehicle. The results show that the algorithm can effectively solve the optimal solution of vehicle routing problem for single distribution center.

***Keywords*—**saving mileage method, heuristic algorithm, single distribution Center, VRP problem.

I. INTRODUCTION

WITH the continuous development of social economy, logistics, as the “third profit source”, has attracted more and more attention, in which the vehicle routing problem is a key ring. The vehicle scheduling in logistics distribution has a great impact on the logistics cost. The selection of the distribution scheme is reasonable, which has a very important impact on the cost of distribution, the efficiency of transportation and the satisfaction of the customers. The question of how to improve distribution efficiency, reduce logistics costs and improve service quality through scientific logistics management methods is the focus of current research. And the way of optimizing the distribution vehicle routing and reducing the cost of logistics distribution is the research objective of the problem. Vehicle routing problem for logistics distribution was first proposed by Dantzig and Ramser in 1959, called Vehicle Routing Problem (abbreviated as VRP). This problem is generally defined as: the appropriate vehicle route is determined to make the delivery start from the distribution center and through the given set of customers (pick up or delivery points) in order, and finally return to the distribution center, in order to achieve a certain goal (such as the shortest distance and the least cost etc.) with certain constraint conditions (such as vehicle capacity constraints, the customer demand, pay delivery time etc.).

In the past twenty years, VRP has been a very active research field at home and abroad. Jiansheng Liu et al. (2017) consider total route cost of vehicle team, designated vehicle availability, geometric constraints of time windows and penalty function, and compare the cost difference between penalty factor, transportation cost and transportation speed. In fact, there is relationship between these parameters. They solve the problem of vehicle route by using the genetic algorithm with time window load model in solving the traffic route optimization model of penalty function[1]; R Baldacci, A Mingozzi, R Roberti (2011) study TSP taboo search heuristic algorithm of the split delivery vehicle routing problem (SDVRP), point out that SDVRP is an easy problem, and classical vehicle routing problem (CVRP) can make each customer accessed many times simultaneously[2]; Tas Duygu, N Dellaert, T van Woensel, T De Kok (2017) solve VRP by using the local search algorithm of gravity simulation[3]; Yunyun Niu et al. (2017) research the green open VRP with time window by using the hybrid taboo search algorithm containing a number of neighborhood search strategy for logistics outsourcing[4]; P Toth, D Vigo (2016) carry out a research on vehicle routing optimization model based on taxi picking, under the conditions of the traffic congestion and its intensifies, more and more attention for public transportation and the advocating of energy-saving and environmental protection[5]. From the perspective of cost analysis, SY Wang, M Zhao (2012) analyze fixed cost, purchase cost and inventory cost and establish a model, which not only reduces the purchase cost, but also decrease the delivery time, increase vehicle handling efficiency and shorten the delivery time[6]; Y Ma, J Xu (2015) study the problem on path optimization of multi-objective decision with fuzzy random time window by using particle swarm algorithm[7]; M Reed, A Yiannakou, R Evering (2014) combine GIS and use ant colony algorithm to search the taxi nearest to the passenger[8]. A scholar mainly focuses on the routing optimization of logistics vehicles with different constraints, makes three improvements to the ant colony algorithm, and uses the improved algorithm to simulate the effectiveness of the algorithm respectively. Firstly, according to the problem that ant colony algorithm is prone to fall into local optimal when solving VRPTW, the ant transfer probability is defined based

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on the idea of saving, and the global pheromone updating rule of Pareto optimal solution set is adopted, and an improved Pareto ant colony algorithm is proposed. The simulation experiment shows that the algorithm improves the global search ability of the ant colony algorithm, avoids the local optimal algorithm and reduces the total distribution cost (distance), thus verifies the effectiveness of the algorithm. Secondly, the author analyses and establishes the corresponding mathematical model for the changes of the customer time window or the change of demand in the logistics vehicle routing problem with the time window, and solves the problem by the ant colony algorithm. Then, the adaptive memory algorithm is mixed with the ant colony algorithm, an ant colony algorithm based on adaptive memory is proposed, and the algorithm is used to solve the vehicle routing problem with the delivery and the demand of the goods at the same time[9]. Another scholar (2015) first analyzes the research value of the most important VRP in logistics distribution and the development situation in recent years, introduces some related concepts and some problems and constraints that VRP may encounter in real life. Then the methods used in solving vehicle routing problems in recent years are analyzed, and their respective advantages and disadvantages are compared and analyzed, and an improved genetic algorithm is selected to solve the problem of vehicle routing optimization. Firstly, the partition method of center of gravity and vertical line is adopted to solve the problem of multi distribution center. It is divided into one single distribution center to solve the problem. Then, the main improvements of genetic algorithm are as follows: (1) removing the infeasible solution of initial solution with constraint of vehicle capacity and maximum mileage; (2) combining the advantages of roulette and best individual reservation as selection operators; (3) the adaptive cross mutation probability is selected because the probability of cross and mutation is different in the whole process of heredity. Finally, the MATLAB language is used to verify case two and the time window is strictly required. The results show that this improved genetic algorithm has a great improvement in solving this kind of optimization problem before the improvement, which not only produces a better initial population, but also has a better convergence rate than before the improvement[10].

The optimization of vehicle scheduling path for logistics distribution is a typical NP-hard problem in combinatorial optimization, and the time of calculating VRP problem will increase with the expansion of the problem scale. When the problem is large, the exact algorithm is difficult to solve. At present, the modern mathematical methods to solve this problem are divided into two categories: accurate optimization method and heuristic method. The former includes branch and bound algorithm, K degree center tree and related algorithm, dynamic programming, set partitioning and column generation, three index vehicle flow patterns, two index vehicle flow mode and other precise algorithm. But the method is very complicated. With the complicated transportation system and the scheduling of multiple objectives, and more and more difficult in obtaining exact optimization solution of the whole system, accurate optimization method takes too much time and cost, so it is only applied to the local optimization of transportation instead of the logistic vehicle routing problem with large scale. Saving method is the most representative one in heuristic method referring to the mathematical method of obtaining satisfactory solution of transportation process through experience, proposed by Clarck and Wright. Many successful software of vehicle scheduling is developed according to this method or its improved method. Typical heuristics also include branch exchange exploration method proposed by Lin and Kemighan and promoted by Chtistofidests and Gilbertla Porte et al. The method always maintains the feasibility of the solution and tries to advance toward the optimal goal. At each step, a feasible solution is changed to reduce the total cost until the process continues to no longer reduce the total cost. The scanning method (Sweep Method) proposed by Gillet and Milled first grouped or grouped the requirements of nodes or arcs, and then an economic route was designed for each group according to the traveling salesman problem (TSP). In addition, the commonly used heuristic methods include two stage method, incomplete tree search algorithm and so on. The main difference between heuristic methods is that the speed and degree of convergence are different. Heuristic method can meet the requirements of solving problems and detailed description, which is a most simple and practical method for the theoretical solution for adjusting vehicle.

In conclusion, this author takes full advantage of the distance information between logistics nodes, uses the principle of that the sum of the two sides is not less than the third side of a triangle, and applies the saving mileage method to solve the vehicle routing problem of single distribution center. On the basis of the detailed description of the principle for the classical saving method, the author analyzes the factors affecting the vehicle scheduling. Taking a large supermarket chain as an example, she analyzes the distribution status of centers and supermarkets, uses saving method to optimize the vehicle routing, and finds out the best delivery plan. Based on this, by collecting the data between users and users and distribution centers, she calculates the saving mileage of dual loop to single loop, and develops efficient delivery scheme, which saves distribution costs and effectively improves the delivery efficiency.

II. THE THEORETICAL BASIS

A. The Preconditions of Distribution Route of Single Distribution Center and Vehicle Scheduling

Generally speaking, the optimization of VRP can be roughly divided into three types: single vehicle dispatching to single point, single vehicle dispatching to multi-points, and multiple vehicles dispatching to multi-points. The freight train route of distribution center belongs to a single distribution center to the nearby stores, which belongs to the type of multiple vehicles dispatching multi points.

There are various constraints in the problem of actual distribution route optimization, which is very complex. In order to simplify the problem, some assumptions are put forward first:

(1)the distribution is known as one or several materials;

(2)the location and demand of each user is known;

(3)the distance from the distribution center to the various users is known;

(4)the number of various types of vehicles is known, which can meet the requirements of transportation.

(5)there is a certain limit on the loading of each vehicle, which cannot be overloaded.

B. The Optimization Model of VRP for Single Distribution Center

(1) An Overview of Saving Mileage Method

When The saving mileage method is put forward by Clarck and Wright, also known as saving algorithm or saving method. It is the most famous heuristic algorithm to solve the VRP of uncertain number of transportation vehicles. It can optimize the distance between vehicles by parallel and serial ways. The core idea is to merge the two loops into one in the transportation problem, and to reduce the total distance of the combined transportation to a maximum extent each time until the load limit of a vehicle is reached. Then the next vehicle is optimized.

The specific approach is: Based on the initial solution, a lattice is chosen with maximum saving value, which should meet the following conditions: (1) user p_i and user p_j are not in the same route; (2) in original plan, goods transported to user p_i and user p_j can be delivered by car with the load greater than $Q_i + Q_j$. The two users corresponding to the lattice are connected, the first route will be modified, the needs of the two users are changed into the sum of demand, and the revised plan can be obtained. To further optimize the selection, the second big saving value in the odometer is selected, and the users are connected to modify the route for the second time until the existing vehicle tonnage situation and the load of each route cannot be increased again. The algorithm is over, that is the optimal scheme.

(2)The Calculation of Saving Mileage

There is a distribution center p_0 , and two distribution points p_i and p_j. If the distribution center delivers separately to the distribution point, the transport route is $p_0 \to p_i \to p_0 \to p_j \to p_0$, and the transport distance is $2(d_{oi} + d_{oj})$. If the direct distribution model for distribution points is discarded, the car is used to deliver continuously to the two distribution points p_i and p_j , which meets other conditions. Then the transport route is $p_0 \to p_i \to p_j \to p_0$ and the transport distance is $d_{oi} + d_{oj} + d_{ij}$ as shown in Figure 1.

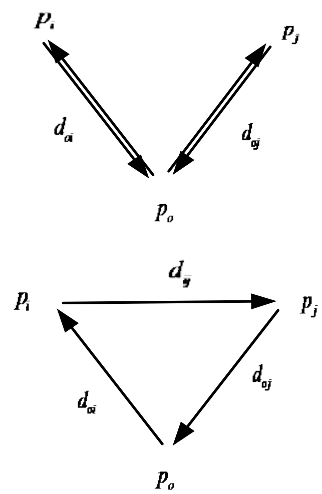

Fig. 1. Distribution Network Diagram

The saving mileage method is to calculate the savings of all distribution points, and the saving of the route after the change is:

$$
\begin{aligned}
S_{ij} &= 2(d_{oi} + d_{oj}) - (d_{oi} + d_{oj} + d_{ij}) \\
&= d_{oi} + d_{oj} - d_{ij}
\end{aligned}
\quad (1)
$$

From the property of the sum of the two sides is larger than the third of a triangle: $d_{oi} + d_{oj} > d_{ij}$ (i.e. $S_{ij} > 0$).

Therefore, under certain constraint conditions, the second distribution plan is obviously better than the first one. And the more delivery points in the same distribution network, the greater the mileage savings and the saving volume.

(3) The Improved Saving Method

In the traditional saving mileage method, the maximum saving value is selected successively, so that users are connected to match loading, the two loops are integrated into one, and the other points are delivered by the distribution center separately. If the two users are connected only with the maximum value of the savings, it will appear that the saving value of the user is still the maximum in the remaining savings value. And currently there are two users connected with the user, the saving value of route p_i is not available, the judgment will be repeated, and the calculation process is relatively slow.

In view of the above shortcomings, the author improves the traditional saving mileage method in this paper, that is, the maximum saving value is selected in turn to connect with the users to match stowage. If the amount of savings exceeds the tonnage requirement of vehicles, it will jump directly to the checking calculation of sub small saving value, and so on. When the second line is found, the plan will start from the unconnected users in the remaining savings.

(4) The Algorithm Flow

Assuming that the distance between the distribution center and each user is known, the calculation is as follows:

Step 1: make a table of transport odometer, list the shortest distance between the distribution center and the user and users;

Step 2: find out the corresponding saving mileage by the mileage formula;

Step 3: arrange the mileage in descending order;

Step 4: connect the nodes of the users in order to form a number of distribution lines according to the load constraint and save mileage.

The chart of the algorithm flow is as follows(Fig. 2):

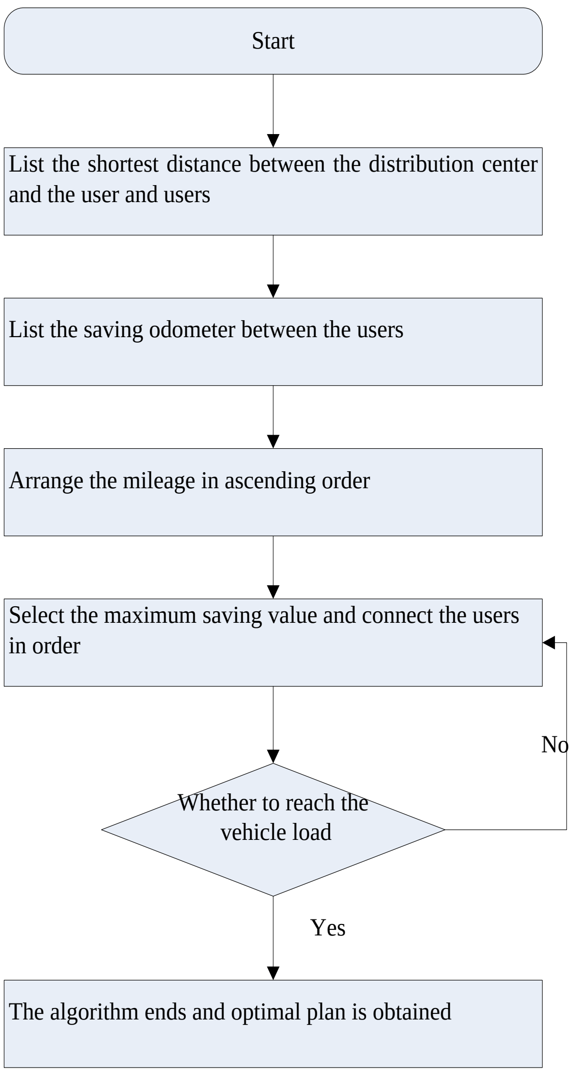

Fig. 2. The Flow Chart of Saving Mileage Method

III. DATA DESIGN

To use saving method correctly, the best and the shortest path between distribution centers and users and users is the key. This author mainly uses Baidu map and double labelling method to get this data. The following steps are as follows.

(1)The location of each node will be found out according to Baidu map, for example, putting the location of eight points in the map, the location diagram can be obtained as shown in Figure 3.

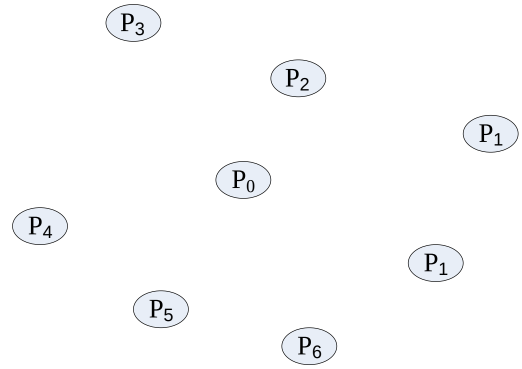

Fig.3. The Location Relations of Nodes in Baidu Map

(2)All routes between any two nodes will be found out, if there is a route before two nodes, they will be linked up. The distance between any two nodes will be measured by using Baidu map, and the line network will be drawn, such as the line network between p_0 and p_1 as shown in Figure 4. d_{ij} stands for the distance before the two nodes.

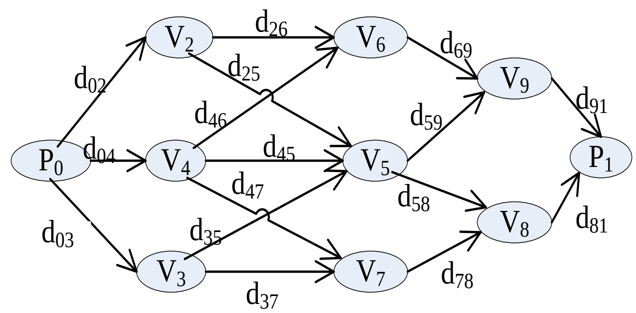

Fig.4. The Line Network Between Node p_0 and p_1

(3) The shortest distance and the optimal path between p_0 and p_1 can be obtained by using double mark method, and the shortest distance and optimal path between other nodes can be obtained in turn. It is annotated on Figure 3, and the network graph shown in Figure 5 is obtained.

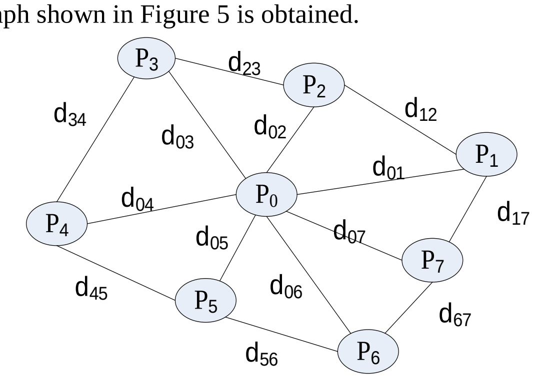

Fig.5. The Network Diagram of the Nodes and Shortest Distance Between Nodes

The following is a brief introduction to the basic principle and steps of the double mark method for the shortest path.

The double labeling method is a simplification of Dijkstra's algorithm. Its basic idea is as follows: starting from the starting point v_s , searching for the shortest path outward gradually, during execution, marking each vertex v_j (λ_j , l_j), in which λ_j is a positive number indicating the number of the previous point where this label is obtained; l_j is for the shortest way from the starting point v_s to the point v_j (called a fixed number, labeled as P), or the upper bound of the shortest right from the starting point v_s to the point v_j (called a temporary label, marked as T). Each step of the method is to modify label T and change a point with a T label to a point with a P label such that there is one more vertex with a P label in the graph. Then, after a limited number of steps, the shortest path from point v_s to v_t and other points v_j can be calculated. According to the first number λ_j of each point, the shortest path can be found by reverse tracking. The calculation process is as follows:

The starting point is label as v_s (0, 0), namely, i=0, S_0 ={ v_s }(a collection of numbered points), $\lambda_1 = s$, $l_{(v_s)}$ =0 ; similarly, when point v_j is marked, each point will be found out which is associated with the arc of v_j and the arrow points to it. If v_{i1} , v_{i2} , …, v_{im} is the starting point of v_j and the marked number is $l_{(v_{i1})}$, $l_{(v_{i2})}$,…, $l_{(v_{im})}$, the weight value of the arc (v_{i1} , j), (v_{i2} , j) ,… , (v_{im} , j) is ($w_{(v_{i1},j)}$), ($w_{(v_{i2},j)}$) ,… , ($w_{(v_{im},j)}$), and point v_j is labeled (v_{ik} , $l_{(v_j)}$) , in which,

$$l_{(v_j)} = \min\left\{l_{(v_{i1})} + w_{(v_{i1},j)}, l_{(v_{i2})} + w_{(v_{i2},j)}, \ldots, l_{(v_{im})} + w_{(v_{im},j)}\right\} = l_{(v_{ik})} + w_{(v_{ik},j)} \quad (2)$$

The algorithm terminates until all nodes get the P label.

IV. THE INSTANCE ANALYSIS

A. *The Description of the Problem*

In this paper, a large supermarket is taken as an example, and the optimization of its VRP are studied. The supermarket has a distribution center (p_0 in Figure 6 and seven chain stores p_1 , p_2 , p_3 , …, p_7 in Figure 3). Goods are unified deployment from the distribution center p_0 to each supermarket p_i . The distribution network diagram (as shown in Figure 6) are structured according to the relative position of the distribution center and each supermarket chain, delivery route network, the distance between the distribution center and the supermarket, the distance between each supermarket. The figure in brackets is the demand Q_i for the supermarket (in tons), the number on the line indicates the distance between the two supermarkets (in km), and the delivery center has eight 4-ton trucks and three 6-tonne vehicles available.

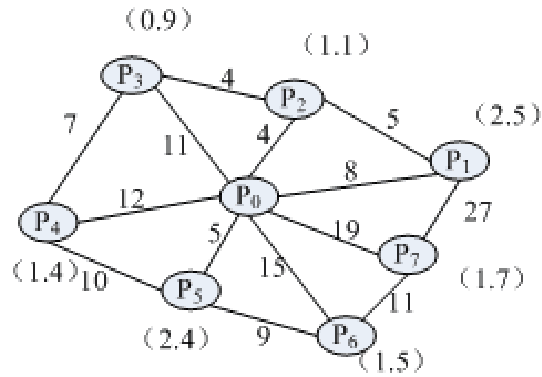

Fig.6. Distribution Network Map for a Large Supermarket

B. *The Realization of Traditional Saving Method*

According to Figure 6, the optimization of VRP for the distribution center of the large supermarket is transformed into a vehicle scheduling problem in which a single distribution center distributes goods to seven users (nodes). The calculation process is as follows:

Step 1: According to the distribution network diagram, the distribution odometer is made out between the distribution center and each user as shown in Table 1.

Table 1 The Delivery Odometer

demand /tons	p_0							
2.5	8	p_1						
1.1	4	5	p_2					
0.9	11	9	4	p_3				
1.4	12	16	11	7	p_4			
2.4	5	13	9	13	10	p_5		
1.5	15	22	18	22	19	9	p_6	
1.7	19	27	23	30	30	20	11	p_7

The initial program is: the distribution center delivers separately to each user, seven 4-ton trucks are needed.

The total mileage: S_0 =2×（8+4+11+12+5+15+19）=148（km）

The vehicle allocation program: seven 4-ton trucks and no 6-ton truck is used.

Step 2：According to the saving formula ($S_{ij} = d_{oi} + d_{oj} - d_{ij}$) , delivery mileage savings connected to the user is found out as shown in Table 2:

Table 2. Delivery Mileage Savings Connected to the User

dem and /tons	p_0							
2.5	8	p_1						
1.1	4	7	p_2					
0.9	11	10	11	p_3				
1.4	12	0	5	16	p_4			
2.4	5	0	0	3	7	p_5		
1.5	15	1	1	4	8	11	p_6	
1.7	19	0	0	0	1	4	23	p_7

On the basis of the initial solution, the lattice with the maximum saving value is selected. The lattice should satisfy the following conditions.

(1) User P_i and user P_j are not on the same route;

(2) Goods of user P_i and user P_j originally planned to deliver can be transported by vehicles carrying more than ($Q_i + Q_j$) loads.

Step 3: The maximum savings $S_{67} = 23$ is selected from Table 2 to connect user P_6 and user P_7 for the first route modification.

The requirement of user P_6 and user P_7 is respectively changed into the total load capacity of $Q_6 + Q_7$ (1.5+1.7=3.2). The distribution scheme modified is obtained:

The scheme of vehicle allocation is as follows: 6 units of 4-ton vehicles are used and 0 unit of 6-ton. The total mileage is reduced by 23, and the total mileage S_1 is =148-23=125 (km).

Step 4: There is further optimization. The secondary saving value $S_{34} = 16$ is selected in Table 2. User P_3 and user P_4 are connected to make the second route modification.

The requirement of user P_3 and user P_4 is respectively changed into the total load capacity $Q_3 + Q_4$ (0.9+1.4=2.3) and the revised delivery plan is got.

The scheme of vehicle allocation is as follows: 5 units of 4-ton vehicles and 0 unit of 6-ton. The total mileage is decreased by 16, and the total mileage S_2 is=125-16=109 (km).

Step 5: There is still further optimization. Saving values $S_{23} = 11$ and $S_{56} = 11$ smaller than 16 are selected from Table 2. One of them is optimized, user P_2 and user P_3 are connected and the third route modification is made.

The requirement of user P_2 , P_3 and P_4 is respectively changed into the total load $Q_2 + Q_3 + Q_4$ (1.1+0.9+1.4=3.4). Because both ends of user P_3 are connected to user P_2 and user P_4 respectively, it is impossible to connect with the other points. Therefore, the saving value of line P_3 in Table 2 is deleted and is no longer considered. the scheme of modified distribution is obtained.

The scheme of vehicle allocation is as follows: 4 units of 4-ton vehicles and 0 unit of 6-ton. The total mileage is decreased by 11, and the total mileage S_3 is =109-11=98 (km).

Step 6: $S_{56} = 11$ is selected and optimized. User P_5 and user P_6 are connected and the fourth route modification is made.

The requirement of user P_5 , P_6 and P_7 is respectively changed into the total load $Q_5 + Q_6 + Q_7$ (2.4+1.5+1.7=5.6). Because both ends of user P_6 are connected with user P_5 and user P_7 respectively, it is impossible to connect with the other points. Therefore, the saving value of line P_6 in Table 2 is deleted and is no longer considered. The modified distribution scheme is got.

The scheme of vehicle allocation is as follows: 2 units of 4-ton vehicles and 1 unit of 6-ton. The total mileage is decreased by 11, and the total mileage S_4 is =98-11=87 (km).

Step 7: The saving values are 10 and 8 smaller than 11. Because they are in line P_3 and line P_6 , they are not considered. In $S_{12} = 7$ and $S_{45} = 7$, if S_{45} is selected to optimize, the existing vehicle tonnage is not enough. Therefore, the line of user P_4 and user P_5 cannot be connected. If $S_{12} = 7$ is selected to optimize, user P_1 is connected with P_2 , P_3 and P_4 , and the fifth route modification is obtained.

The requirement of user P_1 , P_2 , P_3 and P_4 is respectively changed into the total load $Q_1 + Q_2 + Q_3 + Q_4$ (2.5+1.1+0.9+1.4=5.9). Because user P_2 is connected with P_1 and P_3 , it is impossible to connect with the other points. Therefore, the saving value of line P_2 in Table 2 is deleted and is no longer considered. the modified distribution scheme is got.

The scheme of vehicle allocation is as follows: 0 unit of 4-ton vehicles and 2 units of 6-ton. The total mileage is decreased by 7, and the total mileage S_5 is =87-7=80 (km).

In a word, there are two lines of distribution now. it is impossible to increase the load of each line based on the existing vehicle tonnage situation. Therefore, the scheme of the fifth revision is the optimal one.

C. The Realization of Improved Saving Method

From the calculation process above, the calculation process of traditional mileage method is long, and the lower mileage method is improved. The first two steps are the same as that of the traditional mileage method. The following solution process is shown as follows:

Step 1: Arranging the saving mileage in descending order, as shown in Table 3:

Table 3. The Arrangement of Saving Mileage

No.	1	2	3	4	5	6
Combination	p_6p_7	p_3p_4	p_2p_3	p_5p_6	p_2p_3	p_4p_6
Saving Mileage	23	16	11	11	10	8
No.	7	8	9	10	11	12
Combination	p_1p_2	p_4p_5	p_2p_4	p_1p_4	p_3p_6	p_5p_7
Saving Mileage	7	7	5	4	4	4
No.	13	14	15	16		
Combination	p_3p_5	p_1p_6	p_2p_6	p_4p_7		
Saving Mileage	3	1	1	1		

Step 2: The maximum mileage is selected S_{67} = 23, users 2 and 3 are connected, and the load is 3.2 tons (1.5 + 1.7 = 3.2) less than the maximum load of vehicles; and the maximum savings connected to the user 6 or 7 are selected S_{56} = 11, users 7, 6, 5 are connected, and the carrying capacity is 5.6 tons (1.5 +1.7 +2.4). If the user is connected with other nodes, the vehicle will be overloaded, so line 1 as follows:

Line 1: $p_o \rightarrow p_7 \rightarrow p_6 \rightarrow p_5 \rightarrow p_0$, a 6-ton truck is needed, and the load is 5.6 tons (less than 6 tons). The total mileage is: S_1 =19+11+9+5=44 (km) , the load of the node p_5 , p_6 , p_7 .

Similarly, users 4, 3, 2 and 1 are connected with the load of 5.9 tons (2.5 +1.1 +0.9 +1.4), and if they are connected with other nodes, the vehicle will be overloaded, so the line 2 is as follows:

Line 2: $p_0 \rightarrow p_4 \rightarrow p_3 \rightarrow p_2 \rightarrow p_1 \rightarrow p_0$, a 6-ton truck is needed, and the total mileage is: S_2 =12+7+4+5+8=36 (km) , the load of the node p_1 , p_2 , p_3 , p_4 .

V. THE RESULTS ANALYSIS

According to the above calculation, the distribution center can also send two 6-ton trucks in accordance with the two lines respectively to the seven store delivery. In order to meet the requirements of the time, a truck start from the distribution center p_o through the nodes p_1, p_2, p_3, p_4 (or p_4 , p_3 , p_2 , p_1 in turn) and back to the distribution center p_o ; at the same time, another truck also starts from the distribution center p_o through the nodes p_5 , p_6 , p_7 (or p_7 , p_6 , p_5 in turn) and back to the distribution center p_o .

The total mileage is: $S^{'}$ = S_1 + S_2 =44+36=80 (km), 68km is saved (S_0 - $S^{'}$ =148-80=68), and two 6-ton trucks are needed.

To sum up, the best plan is: the four nodes p_1, p_2, p_3, p_4 are matched stowage, and the three nodes p_5 , p_6 , p_7 are matched. Meanwhile, two 6-ton trucks will be run on two lines. The best distribution line is shown in Figure 7, except the lines from the distribution center to the users 2 and 3 and to the user 6 alone.

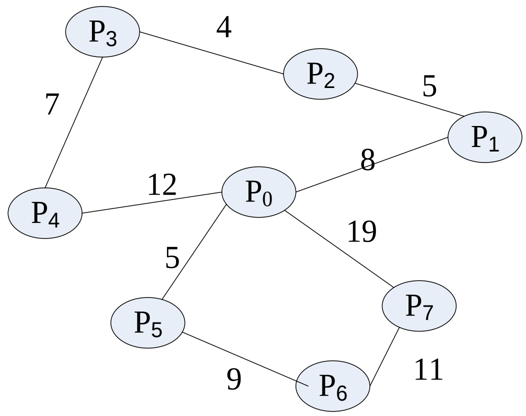

Fig. 7. The Distribution Line Map of a Large Supermarket

If branching is further used to compare the optimization schemes of various route combination, the bifurcation diagram can be obtained as shown in Figure 8.

Through the branch method, the solving process of this kind of problem can be improved, and the best solution and sub optimal solution can be got more clearly, so as to make better choice.

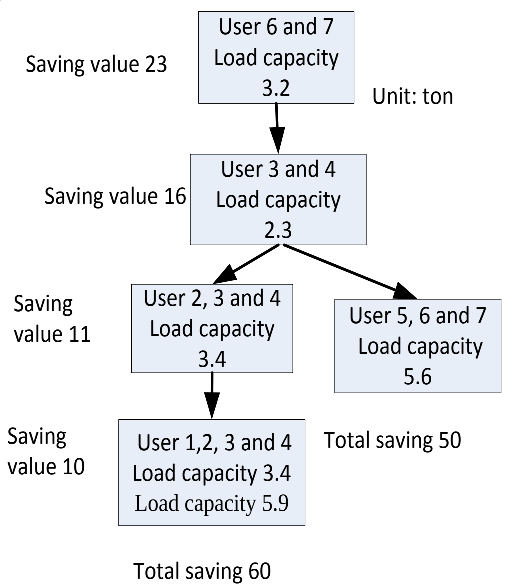

Fig. 8. The Comparison for Optimization Scheme of Route Combination

VI. CONCLUSION

Taking a distribution center as an example, this author analyzes the application mode and effect of the improved saving method for the optimization of vehicle routing in a single distribution center. Through the example, it can be found that the improved saving method can optimize the distribution route rationally, save the delivery cost and improve the delivery effectively. It is also suitable for solving the routing problem of delivery vehicles. The calculation process is simpler and faster than the traditional method.

The heuristic method represents the direction of recent research. As a successive approximation algorithm, the optimal solution cannot be obtained, but the solution with higher accuracy can be efficiently found out, and various practical problems can be easily considered. Therefore, it has become an important method to solve the distribution problem. Sometimes there will be only satisfied with the solution from saving mileage method to solve the optimization of VRP, but it can be found a relatively good result in a relatively fast time, and it is the best solution to the optimization of current routing problem.

In real life, in order to improve economic efficiency, sometimes, it is necessary to use multiple distribution centers for distribution, that is, multiple distribution centers are used to serve the users. This kind of problem can be regarded as a traveling salesman problem with several closed loop lines, and it is one of the combinatorial optimization problems. The goal of dispatching is to make use of the minimum number of vehicles and arrange the route of each vehicle under the premise of completing the user's freight task.

The saving mileage method for this kind of problem is still applicable, and there are two basic algorithms. One arranges the route after grouping users, that is, the users are divided into different groups according to certain scheduling rules. Each group corresponds to a distribution center and then is solved for each distribution center. If any distribution center vehicle is insufficient to schedule tasks, the original group will be revised and the new single distribution center problem can be solved. This process has been carried out in accordance with the group rules and has been satisfactorily resolved. The rules for dividing users can be the actual experience scheduling, such as "on the spot", and so on. At present, it is generally used in this way, or some heuristic rules that contribute to local optimization. The other first arranges the line after the grouping, that is, to solve the line arrangement for all users first, and no matter where the distribution center is, it builds a large route, which is usually not feasible, and it contains all the users. Then, assign a distribution center to the route of each vehicle. The purpose is to minimize the total transport distance by meeting the vehicle constraints of the distribution center. When the distance between vehicles entering and leaving the distribution center is far less than the distance traveled by the vehicle, this method is more reasonable and the satisfaction degree of solution is also very high.

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