RESEARCH ON THE ROUTE OPTIMIZATION OF BOOK DISTRIBUTION BASED ON THE TABU SEARCH ALGORITHM

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Abstract: Currently, the research of distribution problems not only widens the area of distribution research, but also makes distribution research content more concrete. What's more, it can solve distribution problem in the actual industry. Distribution route optimization Problem, is the Vehicle Routing Problem （VRP）, and it is a research hotspot of logistics industry. Based on the book distribution route optimization, mainly aiming at all the sales network circumstance served by the distribution center, to optimize and analyze the distribution path will be a new attempt.

1 INTRODUCTION

In recent years, the research of distribution problems not only widens the problem of distribution areas of research, but also makes distribution research content more concrete. More still, it can solve distribution problem in the actual industry. Distribution route optimization problems, also called Vehicle Routing Problem (VRP), are a hotspot of the logistics industry research. VRP can improve the efficiency of supply, reduce distribution costs on the distribution vehicle and accomplish a specific purpose; can deliver the goods to the hands of customers on time and quickly, and improve customer satisfaction greatly; it also can improve efficiency for enterprises. In the case of society, VRP saves transportation vehicles, alleviate traffic emergencies, and reduce noise and emissions transport pollution. Therefore, optimizing vehicle distribution path is not only an important means of traffic control, also is a key link of the realization of green logistics.

2 INFLUENCING FACTORS OF DISTRIBUTION ROUTE OPTIMIZATION PROBLEMS

2.1 Influencing Factors of Distribution Scheme Selection

The selection of distribution scheme targets can be analyzed as follows:

(1) Distribution mileage

Distribution mileage has direct relation to the distribution vehicle's fuel consumption, worn degree and driver fatigue degree, etc. It directly determines the costs of transportation, and has a great effect on the economic benefit of distribution business. Also it has indirect relationship with environmental pollution.

(2) Distance of delivery vehicles.

The target is related to distribution distance and vehicle loads. The goal is to minimum the sum of the product between all the distribution vehicle the tonnage number (maximum load number) and driving distance

(3) Comprehensive cost

Reducing comprehensive cost is the basic requirement of realizing distribution business economic benefits. In distribution process, the fees concern with taking and delivery include: vehicles maintenance, driving expenses, team management

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fees, goods stevedore charges and relevant personnel salary expenses.

(4) Punctuality

Due to the customer has strict requirements for the distribution time, in order to improve the quality of distribution service, punctuality should be a goal of distribution route selection.

(5) Distribution of labor consumption

That is the goal of minimization materialized labor and narrow consumption. Something happening on various occasions, such as supply constraints of labor, fuel, vehicles and equipment, limits ranges of options of distribution operation. In this way we can consider distribution of labor, vehicle required or other related resources as the target.

(6) Reasonable capacity utilization

This goal requires use less vehicles to fulfill distribution task, and make the vehicle efficiency. To take full advantage of vehicle load ability, and reduce the requirement of environmental pollution.

To satisfy the optimal distribution scheme, the final results must meet the following conditions: Highest punctuality; shortest distribution mileage; least distance of delivery vehicles; lowest comprehensive cost; least distribution of labor consumption; most reasonable capacity utilization.

2.2 Constraint Factors of Distribution Scheme Selection

Distribution plan to achieve the goal of process is limited by many binding factors, therefore it must be satisfying the constraint factors obtained under limited lowest cost, shortest mileage, or consumption least objectives, etc. common constraint factors include:

(1)The consignee to goods varieties, specifications and quantities of requirements;

(2)The consignee to goods distribution time or time range of requirements;

(3)Road running conditions of distribution of restricting (road line to urban roads of the freight traffic, time, passage tonnage restrictions);

(4)Vehicles carrying capacity of maximum limit;

(5)Vehicles driving maximum mileage limit;

(6)The longest working time limit of drivers

The traditional VRP problem mostly only place weight on the positive logistics distribution, therefore, the reverse logistics is out of consideration. In this paper, the reverse logistics is also an important component of green logistics.

From a transportation perspective, positive logistics distribution is similar to reverse logistics recycling. With the realization of the logistics "the third profits source" value creation, the environment is caused by a certain degree of harm. Normally, positive logistics and reverse logistics transport have same routes, but opposite directions. For VRP problem, if distribution and recycling are organization by the distribution centre organization, vehicles by the distribution canter set out, distribute the book to various sales outlets, simultaneously get the return books the sales outlets need to book distribution centre. Distribution and recycling hand in hand can save vehicles, reduce pollution and reduce the cost.

Realizing seamless docking between positive logistics and reverse logistics is a necessary condition of structuring a green logistics system of symbiotic type circulating. Therefore, in addition to consider the distribution of each section of optimization and improve, return books recycle should be emphatically discussed.

3 DISTRIBUTION ROUTE OPTIMIZATION MODEL

3.1 Definition of Distribution Route Optimization Problem Type

Combined with specific situation of the distribution center, we can definite the type of distribution route optimization problem from the eight aspects: the number of books distribution center, freight condition, distribution task features, time required of books store distribution, vehicle type, subordinate relationship between vehicles and yard, optimized objectives and the information is determined or not (client, vehicle and so on).

(1)Number of books distribution center: single distribution center and many distribution centers.

In this article there is only a distribution center which we research, thus, books for each outlet are distributed by the distribution center.

(2)Freight condition: full loaded, not full, moderate problem between full loaded and not full

In this paper, the distribution of vehicle in daily distribution cannot reach its load; this issue can be treated as not full distribution problem.

(3)Distribution task features: Pure distribution problems, pure pickup problems and mixed problem for distribution and pickup.

When books distribution center carries on forward distribution, books of reverse recovery should be more considered. Here what we research is mixed problem for distribution and pickup.

(4)Time required of books store distribution: No time limit problem and time limit problem

No time limit problem is a good choice and reasonable for the realistic problems.

(5)Vehicle type. Here we choose single models problem

(6)Subordinate relationship between vehicles and yard.

Because of the particular case of distribution centre, this problem can be seen as closed problem.

(7)Optimized objectives. Single objective problem (only consider a distribution goal) and multi-objective question (considering multiple distribution targets)

(8)The information is determined or not. Static problems and dynamic problems

In this case, since the client, vehicle attribute information is all known and fixed, so it can be regarded as static problem.

Through the above analysis, there are more restrictions for path optimization problem of the distribution center. In order to simplify the modeling and operations, it is possible to simplify this problem appropriately and do appropriate hypotheses for non-key conditions. Therefore, the matter can be treated as: No Duration and two-way Distribution VRP.

3.2 The Distribution Centre Path Optimization Model

No Duration and two-way Distribution VRP can be described: use multiple distribution vehicles and send the books outlets need to the outlets from the distribution centre and get back the returned books from the outlets to the centre. In the process, the outlets position, cargo demand and supply, load capacity per distribution vehicle and maximum driving distance per distribution is all known. The next Requests is how to arrange vehicles distribution route reasonable and make the objective function optimal.

Because there is no time constraint for distribution and take the goods, in the process of distribution, the distribution vehicle may give the customer demand of books, and then loaded the return books, namely vehicles finish the distribution at the same time books returned task is done.

Supposed the number of distribution vehicles for the centre is K, the full-load of the first k vehicle is Q_k(k=1, 2, …, K). Maximum driving distance per distribution is D_k, the number of outlets is L, the demand amount of the first outlet i is q_i,the return amount is u_i(i=1,2, …,L),the distance between the first outlet i and j is d_{ij} , the distance between distribution and outlet is d_{0j} (i、 j=1,2, …,L),the number of outlets which the first k vehicle severs is n_k,the first k route is aggregate R_k ,among them, the factor r_{ki} means that the sequence that the client r_{ki} in the route k is i(the distribution centre is not included),when r_{k0} =0,it means the distribution centre. Making the number of total ton-km for the distribution vehicle minimum, we can construct the distribution centre path optimization model as follows:

$$minZ = \sum_{k=1}^{k} Q_k \left[\sum_{i=1}^{n_k} d_{r_{k(i-1)} r_{ki}} + d_{r_{kn_k} r_{k0}} si\,gn(n_k)\right] \quad (3\text{-}1)$$

s.t. :

$$\sum_{i=1}^{n_k} q_{r_{ki}} \le Q_k \quad (3\text{-}2)$$

$$\sum_{i=1}^{j} u_{r_{ki}} + \sum_{i=j+1}^{n_k} q_{r_{ki}} \le Q_k \ (j = 1,2,\dots,n_k - 1) \quad (3\text{-}3)$$

$$\sum_{i=1}^{n_k} u_{r_{ki}} \le Q_k \quad (3\text{-}4)$$

$$\sum_{i=1}^{n_k} d_{r_{k(i-1)} r_{ki}} + d_{r_{kn_k} r_{k0}} sign(n_k) \le D_k \quad (3\text{-}5)$$

$$0 \le n_k \le L \quad (3\text{-}6)$$

$$\sum_{i=1}^{K} n_k = L \quad (3\text{-}7)$$

$$R_k = \{r_{ki} | r_{ki} \in \{1,2,\dots,\ L\}, i = 1,2,\dots,n_k\} \quad (3\text{-}8)$$

$$R_{k_1} \cap R_{k_2} = \emptyset, \forall k_1 \ne k_2 \quad (3\text{-}9)$$

$$sign(n_k) = \begin{cases} 1, n_k \ge 1 \\ 0, Others \end{cases} \quad (3\text{-}10)$$

From the model above, the formula (3-1) is objective function, making the number of total ton-km for the distribution vehicle minimum that is a representation of lower cost; what is more, it is also a reflection for decreasing pollution and reducing environment hazards.

The formulas (3-2), (3-3), (3-4) are used to ensure its distribution volume still cannot exceed its load in the process of the vehicle distribution;

The formula (3-5) ensures the length of each distribution path does not exceed the maximum driving distance of distribution once;

The formula (3-6) shows that the client of each path should not exceed the total number of customers;

The formula (3-7) ensures that each of our customers gets distribution service;

The formula (3-8) shows the customers' composition of each path;

The formula (3-9) restrains that each customer can be supplied by only one distribution vehicle once;

The formula (3-10) indicates that if the number of the customer of the first k distribution vehicle is not less than 1,that means the vehicle attends the distribution, then $\mathrm{sign}(n_k) = 1$;else, $\mathrm{sign}(n_k) = 0$

4 SOLVING METHODS OF DISTRIBUTION ROUTE OPTIMIZATION MODEL

4.1 Common Methods of Distribution Route Optimization

As a problem of NP, The research of distribution route optimization has been a hot spot. Along with the increase of the number of customers, optional distribution path increase rapidly as an index number scheme speed. Therefore, only when the number of customer is less and the transportation network is simple, can the distribution vehicle scheduling go for precision optimal solution; as a more complex path optimization problem, the process for the accurate and optimal solution is relatively difficult.

At present, algorithms to solve the logistics distribution path optimization are divided into two categories: exact algorithm and heuristic algorithm. Exact algorithm is generally used to solve the small-scale path optimization problems, such as branch-and-bound method, cutting plane method, network flow algorithm, dynamic programming and so on. Heuristic algorithm is mainly used for large-scale path optimization problems. Unlike the exact algorithm, Heuristic algorithm pays attention to the satisfactory solution, not for the optimal solution. Thus, heuristic algorithm can get satisfactory solution in a short time when dealing with large-scale vehicle scheduling problems, and the generality of these algorithms is strong. There are several common kinds of heuristic algorithm as follows:

4.1.1 Tabu Search (TS) Algorithm

TS algorithm is also called List optimization method; it is promotion of local search algorithm. Tabu search algorithm is adopted taboo technology. In order to avoid insufficiency that local field search easily falls into local optimum, Tabu search algorithm records local optimal points passed with a taboo list record, at the next search, the use of the information in the Tabu search form no longer or selectively search for these points, so as to jump out of the local optimum.

4.1.2 Simulated Annealing (SA) Algorithm

Simulated annealing (SA) algorithm is promotion of local search algorithm. Its characteristic is to choose poor conditions of area of the objective function values by a certain probability. The algorithm was originally proposed by Metropolis in 1953, Osman used the method to solve the optimization problems in 1993. The simulated annealing algorithm combines optimization problem with solid annealing simulation, it can simulate internal energy as the objective function values, and can evolve temperature evolution into control parameters. It starts from the initial solution and initial control parameters, iterates the current solution repeatedly as "new solution→ Calculating different of target function→ to accept or abandon" and gradual attenuates the control parameter values. When algorithm terminates, the current solution is approximate optimal solution. This solution is used for no time limit one-way distribution vehicle routing optimization problems.

4.1.3 Genetic Algorithm (GA)

Using search technology and the survival of the fittest rule, this method does some local search improvement. It produces new generation by a series of genetic operations which is selection, crossover and mutation on the current groups, and gradually make groups evolution to contain or close to the state of optimal solution. When iteration times achieve maximum number of limitation or the individual of the group has no significant difference, Iterative terminates. The theory of GA was first applied to solve the vehicle path optimization problems by J.L awrence .

There are other methods such as: the artificial neural networks (anns), ant colony optimization, etc.

4.2 Tabu Search Algorithm Realization

The current path optimization problem study, more application Tabu search algorithm, simulated annealing method, the genetic algorithm three methods. With Tabu search algorithm in solving without time limit two-way distribution vehicle routing optimization problem is can achieve good results and algorithm of settlement calculation results more stable, computation efficiency is higher.

4.2.1 Tabu Search Algorithm Implementation Steps

For solving path optimization problem with tabu search algorithm, the implementation steps can be elaborated as follows:

Step 1: Select an initial solution x^{now}; Tabu list H= ϕ

Step 2: when meeting the termination criterion, then it goes to step 4; Else, select the candidate set which satisfies requirement of Tabu from the domain of x^{now},which named $N(x^{now})$,then goes to Step 3.

Step 3: Choose the best solution: x^{best} from $Can\_N(x^{now})$, command $x^{now}=x^{best}$, then exchange the new Tabu list, go to step 2.

Step 4: Input calculation results, and stop.

The structure of Tabu search algorithm program realization is shown in figure 1. Based on figure 1, make up the corresponding program of its composition modules and obtain the required results

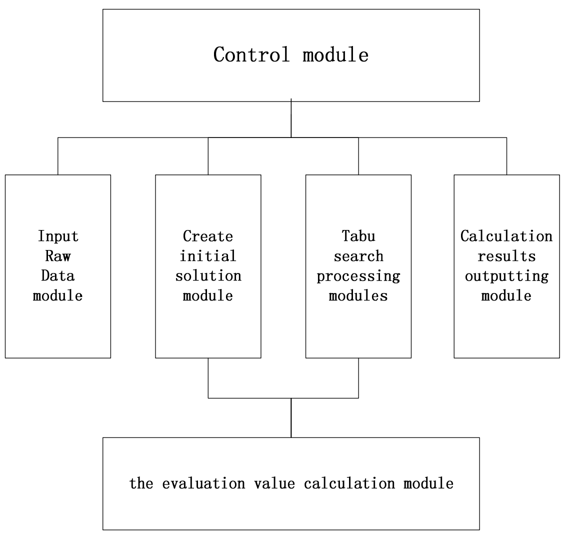

Figure 1: Structure of Tabu search algorithm module.

4.2.2 Determination of Tabu Search Algorithm Strategy

According to the model construction of no time limit two-way distribution route optimization problem, using the following algorithm strategy, we can realize the algorithm:

①Indicating method of solutions: By the way of store direct arrangement

Directly produce L sets of natural array between 1~L, and the L sets mutually uncorrelated repeat, then the store arrangement is a solution, and it Corresponds to a distribution route scheme. We get the satisfied solution when we substitute the solution elements (store) to the vehicles of distribution path.

②The evaluation method of solution: Using the formulas $E=Z+M*P_w$

After we solve the solution, we must evaluate the solution to make sure the solution good or not. In the process of iteration, more optimal solution is constantly searched, and finally optimal solution or approximate optimal solution comes out.

The specific evaluation method of solution of No Duration and two-way Distribution VRP can be described as: satisfy that the sum amount of each store distribution of each strip distribution path shall not exceed the maximum weight of the distribution vehicles and the length of each distribution path should not exceed the maximum driving distance. As to some solution, if all the stores can be involved into a distribution path, the number of no desirable path of the distribution M=0, and it means the solution is a feasible solution; if several store cannot be involved into a distribution path, the number of no desirable path of the distribution M=1, and it means the solution is not a feasible solution. The target value of Distribution route schemes is Z, then we can get E from the formulas $E=Z+M*P_w$, and the value of E is the value of evaluation. Among the formulas, P_w is the punishment weight of no viable path and the less the value of E is, the better quality of solution is.

③Neighborhood operation method : By two-exchange way

Two-exchange way is a method of selecting two elements of solutions randomly and exchange their neighborhood.

④Determination of Taboo object: Put the best solution each iteration into taboo list

⑤Determination of the taboo length: Select a constant according to the scale of the problem.

⑥ Determination of candidate set: Choose several neighbors from the current adjacent domain random.

⑦Stopping rule: Using iterative specified steps

4.2.3 Structure of Tabu Search Algorithm

Its algorithm structure can be conveyed as follows:

```
{  Input the known condition of No
Duration and two-way Distribution VRP;
Input operation parameters of algorithm,
including the number of termination
iteration steps T ,the number of
adjacent domain each iteration N, the
length of taboo l and the punishment
weight of no viable path P_w, and so on;
Initialization taboo list H;
Consider random generation an initial
solution S as the current solution,
iteration step t=0; evaluate the
solution S;
Then, S_best=S;
The current best solution evaluation
value E_best= the evaluation of S;
While (t<Termination iteration steps T)
    do
{  The number of neighbors searched
this iteration n=0;
The evaluation value of the best
solution this iteration E_localbest is a
large positive number;
    While (n<N) do
{  S' can be got from S by two-
exchange ways in the process of
adjacent domain operation;
        If (S' is not a factor of the
    Tabu list H)
            {  Calculate the evaluation
        value of S' by the solution
        evaluation method;
                If (the evaluation
                value of S'<E_localbest)
                {  S_localbest< S';
                   E_localbest= evaluation
                value of S';
                }
            n=n+1
            }
        }
        If (E_localbest<E_best)
        {  S_best= S_localbest;
           E_best= E_localbest;
        }
        S= S_localbest
           The first factor of the Tabu
        list is lifted a ban, and put
        S_localbest into the Tabu list and
        consider it as the list factor
        of the list;
        t=t+1;
       }
    Output the optimal distribution
path scheme and the objective function
values corresponding with S_best
}
```

5 CONCLUSIONS

The article optimizes the path of distribution by the Tabu search algorithm and his path can be used as the path of the daily distribution. The algorithm makes an attempt to combine the positive logistics and reverse logistics. Structure of Models and implementation of algorithm provides certain theoretical support for the selections of distribution vehicle path and it is of great practical significance. Construction of this model and algorithm implementation provides a theoretical support for the Vehicle Routing distribution problem.

The next step for the research is to focus on improving the model based on single object and establishing multi-objective model. Besides, the influence of external environment should be considered in the new model.

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