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Study on the Location Planning Approach of Outbound Collection Centers

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Abstract: The collecting and distributing of container highway transportation is the head and the tail of main transport lines. To minimize the unit cost and the complexity of transportation schedules, this paper addresses the Collection Center Location Planning Problem (CCLPP) concerned with how many Collection Centers (CCs) should be set up and where CCs locate at and which area a CC provides the service of supplies collection for. Followed by the essential CCLPP workflow, we introduce a mixed-integer mathematic model to represent the CCLPP. Afterwards, the performances of the traditional algorithms applied for the large scale mix-integer model with lots of decision variables and constraints are not so good, thus we have extensively investigated an improved algorithm to find an approximate solution for CCLPP. The chromosome is designed with a mixed encoding strategy and sub-chromosomes are proposed to represent the location and the service area respectively and determine the appropriate value ranges of parameters. From numerical experiments for an actual retailer, the approach was used for illustrating the CCLPP model and the improved algorithm. The results show that the solution included the total number of CCs and the locations and the service areas will minimize the transportation cost of this company.

Key words: Sporadic freight transportation, outbound collection center, location planning, sub-chromosome, mixed encoding

INTRODUCTION

Since the freight rates between them differ quite a bit, then assembling vehicle transportation is a good choice to lower the transportation cost. We can pile one or several goods which belong to no fixed suppliers in collecting center, shown in Fig. 1. To reduce the transportation expenses, we have carried out the gathering transportation operation. Gathering transportation of assembling vehicle transportation is effective in improving highway transportation efficiency. Through gathering transportation, we can achieve the goal of the fully-loaded, enhance the actual load rate of conveyance, make the best use of rated capacity of transportation and lessen the time of empty-loaded and no fully-loaded driving. In addition, gathering transportation can decrease the number of on-road vehicles and lead to the improvement of the traffic and environment. These improvements will have a great impact on the following aspects: Rationalization of the transportation, utilization rate of vehicles improved fewer numbers of on-road vehicles, relieving traffic jams and corresponding pollution in an effective way. All of these aspects will create better economic benefits.

As to the problem of assembling vehicle transportation and location planning of collection centers, we do not have a specified research home and abroad. Collection center is a logistics center holding great number of goods which are originally decentralized parts, production and objects. While distribution center is an logistic node in supply chain providing distribution services to downstream distributors, retailers and customers. The function of the collection center and distribution center is just the opposite. Collection center gathers the goods from various dispersion points; however, distribution center is used to distribute the goods in collection center to dispersion points. So the

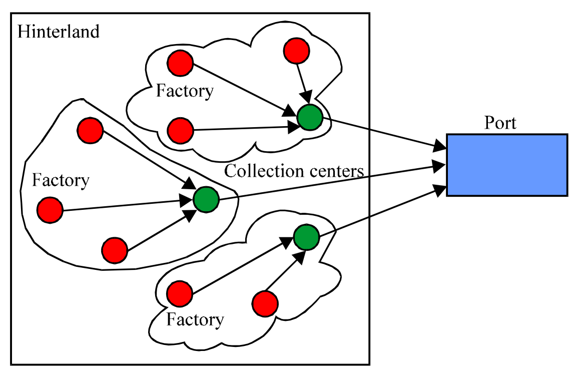

Fig. 1: The diagram of CC

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location planning problem of collection centers can be transformed to a special form of the location planning problem of distribution centers. At the same time, planning approach of distribution centers is also adaptive to that of collection center. Location of distribution center is a typical problem in logistics system planning and many scholars form home and abroad have carried on research for a variety of methods.

There are mainly three kinds of location models. Continuous location models concerned with the continuous solution space and a suitable metric of the distance (Rosing, 1992; Klamroth, 2001). As the counterpart, the distance in network location models are represented as the shortest paths in a graph (Boland *et al*., 2006; Dominguez-Marin *et al*., 2005; Boffey *et al*., 2003). The CCLPP model proposed in this paper fall into the category of the mixed integer programming models (MIPM), will determine how to select the CCs from the given factories. A new algorithm called branch and peg algorithm was investigated for the plant location problem by Goldengorin *et al*. (2003), which refers to fixing values of variables at each sub-problem in the branch and bound tree. Harkness and ReVelle (2003) introduced a new type of facility location model, which combines aspects of the well-studied simple un-capacitated and capacitated facility location problems. Chardaire *et al*. (1999) addressed the two levels of facilities of the simple plant location problem (SPLP), showed that the linear programming relaxations of both formulations have the same optimal values. Gourdin *et al*. (2000) considered the two clients allocated to a facility can be matched, so the allocation cost is either the cost of a return trip between the facility and the client, or the length of a tour containing the facility and two clients. Recently, the multi-objective location models are proposed to deal with uncertainty of supply chain (Liu *et al*., 2011; Awasthi *et al*., 2011). Huang *et al*. (2012) considered the location of a DC and the choice of suppliers offering different, possibly random, prices for the location problem.

To solve the problem that small amount of sporadic goods have higher export transportation cost, complicated organization and so on, the paper proposes the method of establishing the collection center between factories and harbor. The key to collection center planning is the location of the collection center. We can get the location approach by building the location model and constructing algorithm for solving the problem. The structure of this paper is as follows: In section 2, this paper gives out the mathematic model of location of the collection center, explaining the objective function, constraint conditions of the location model. To solve this location problem, hybrid genetic algorithm is designed in Section 3, which determines the range of the genetic operator and guarantee the location model can be solved effectively. Finally, the case study explains its location approach using a set of real data for location of retailers.

PROBLEM FORMULATIONS

Model assumption: (1) Quantity of the collecting center is limited; (2) One factory can only collect goods through one collection center; (3) Construction capacity of the collecting center is determined by supplies within the scope of supplies radiation, which can meet all the needs; (4) Supplies of the factories are given and they will be calculated according to the region; (5) All-in cost contains the cost of sporadic freight transportation, the collection operating cost in collection center, the transportation cost between collection center and harbor as well as operating cost of the terminal warehouse.

Indices:

m = Total No. of collection centers

n = Total No. of factories

i(= 1, 2, ..., m) =I C Set of collection centers

j(= 1, 2, ..., n)I F Set of factories

Objective function: We establish the objective function of the collection center location on basis of the consumption above and select the best in the candidate location. The condition is that it will lead to the total minimum cost, including the transportation expenses between supplies and collection center, operating expense in collection center, transportation expenses between collection center and wharf and the operating expense of the terminal warehouse. The objective function is shown as formula 1:

$$\begin{aligned}&\sum_{i=1}^{m}\sum_{j=1}^{n} T_{ij} \text{ EMBED Equation.DSMT4+}\\&\sum_{i=1}^{m} \text{ EMBED Equation.DSMT4 } z_i +\\&\sum_{i=1}^{m} \text{ EMBED Equation.DSMT4 } z_i +\\&\sum_{i=1}^{m} \text{ EMBED Equation.DSMT4}\end{aligned} \tag{1}$$

Constraints:

$$\sum_{i=1}^{m} h_{ij} = 1\left(j=1,2,...,n\right) \tag{3}$$

$$h_{ij}\, z_{ij} = 1, 2, ..., m;\ j = 1, 2, ..., n \tag{4}$$

$$W_i = \sum_{j=1}^{n} h_{ij} R_j \left(i = 1, 2, ..., m;\ j = 1, 2, ..., n\right) \tag{5}$$

$$W_i = \sum_{j=1}^{n} h_{ij} R_j \tag{6}$$

$$F_i = f \bullet W_i \left(i = 1, 2, ..., m\right) \tag{7}$$

- Equation 2 ensures that the total number of selected collection center is not over 1
- Equation 3 ensures that one factory can only collect goods from one collection center
- Equation 4 ensures that only the selected collection center can collect goods
- Equation 5 ensures the transportation cost between factory j and collection center i and the least of which is ¥30
- Equation 6 ensures the scale of the collection center wi
- Equation 7 ensures the collection cost of through the collection center i

ALGORITHMS OF CCLPP DESIGN

Framework: Genetic algorithm replaces the parameter space of the problem with code space, with the fitness function as evaluation basis, with the encoding group as the basis of evolution. To realize the individual genetic manipulation in groups by regrouping gene of encoding bit string randomly and make the fitness of descendant better than parent. We can gradually approach the optimal solution through the development of the individual issue solution. The basic steps of the genetic algorithm are shown as follows.

Encoding representation: Considering the flexibility of realizing the algorithm, the paper defines the location problem as the mixed-integer programming problem. Therefore we select the mixed encoding representation to express the solution of the location mathematic model. The location of the collection center is expressed with binary coding. In Fig. 2, 6 factories are chosen as the candidate collection center, we give them the serial number from 1 to 6. Coding bit string {0, 0 , 1 ,0 ,1, 0} means the third and fifth factories are selected.

While in the service region of collection center, it is expressed in the way of decimal real number encoding. In Fig. 3, number 3 in the service region of collection center contains factories of 1,2,3. While number 5 incorporates factories of 4, 5, 6.

Candidate CC ID i	1	2	3	4	5	6
C(zi)	0	0	1	0	1	0

Fig. 2: Chromosome for CC location

Factory ID j	1	2	3	4	5	6
$F(h_{ij})$	3	3	3	5	5	5

Fig. 3: Chromosome for CC service area

Stoppage rule: The stoppage rule of the arithmetic in the paper executes breaks in accordance with maximum number of iterations.

NUMERICAL EXPERIMENTS

To explain the method of the location of the collection center, we give out an example with the real location data of an international retailer. The retailer delivers goods from Shanghai to Canada in the region of east China in mainland. Since there are 51 factories and the export to Canada is few, so the transportation cannot use the way of CY vehicle transportation if each factory transports by itself to the wharf. Therefore we address the way of establishing collection center to solve the problem of high transportation cost and complex management. Experimental environment of the numerical computation is under the computer of Intel(R) Core(TM) i7 Q720 @ 1.60 GHz CPU and 8 GB RAM. The computer has installed the operating system of windows7, 64 bit.

Parameters: We establish the location model and adopt the improved genetic algorithm to solve the planning approach of the mixed integer. The specific parameters are as follows. The population size is set as 50; the crossover probability is set as 0.8 the mutation probability is set as 0.05 The maximum iteration algebra is set as 40.

Performance analysis: The software Matlab7.0 is used to realize the mixed integer genetic algorithm and Fig. 4 shows the convergence curve of the algorithm during the solution of the model.

Results: In the light of the basic statistic input in this case, we adopt the location planning approach, initially calculate the potential collection center in the region of Shanghai Harbor service region. It is located in Changzhou, Nanxiang and Jiaxing. Among the collection center, the average supplies in Jiaxing are the largest and

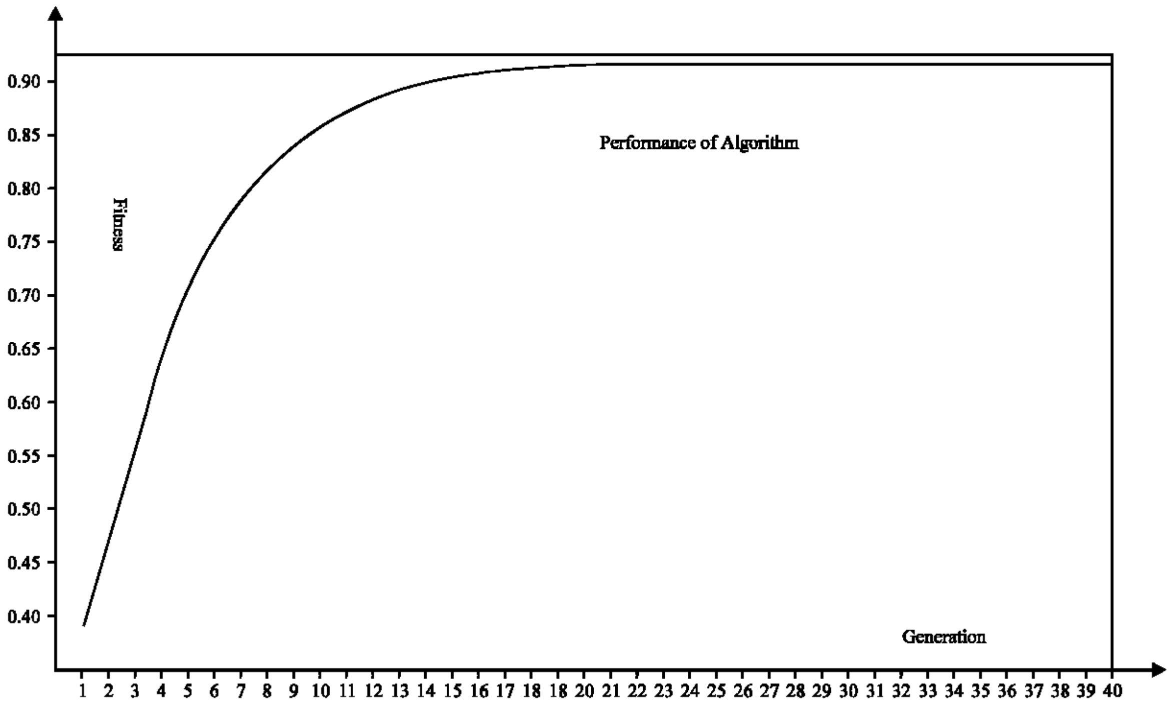

Fig. 4: The performance of improved GA

the proportion of cost reduction is also the largest. Accordingly, transportation cost of Nanxiang decreases 3.3% as its fewer average supplies.

CONCLUSIONS

To solve and lower the above problems in sporadic freight transportation, this study addressed a location planning approach of outbound collection centers by establishing the collection center in the region of harbor service. We can pile one or several goods which belong to no fixed suppliers in collecting center. By means of the process of the collection center, goods which is originally decentralized,small-scaled, with hybrid quality and specification and not easy to transport in large volumes and sold can conduct a vehicle transportation. It can also play the role of scale effect of road transportation, lower the collecting and distributing transportation cost of small-scaled gods. In allusion to outbound collection operation, the study addressed the Workflow of CCLPP, analyze the number and location of collection centers. On the basis of factor analysis, we establish the mathematic model for the location of the collection center. By analyzing the character of the model, we design a mixed genetic algorithm and determine the best range of genetic operator. Finally, illustrate the use procedure of the approach through a set of actual location of retailer's collection center and calculate the number and specified location of the collection center. Our program suggest establishing collection centers in Changzhou and Jiaxing, which can lower the road transportation cost of retailer's outbound goods.

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