MATEC Web of Conferences **232**, 04034 (2018) https://doi.org/10.1051/matecconf/201823204034
*EITCE 2018*

# Research on the Path Optimization Problem of Multi-Centre Distribution System

HE Kai-lun[1], DING Yi[1,a] and SUN Hui-long[2]

[1]School of Management, Chongqing University of Technology, 400054 Chongqing, China
[2]Department of Marketing, Chongqing Real Estate College, 401331 Chongqing, China

**Abstract**. Based on the actual environment, the routing problem of multi centre distribution system is theoretically described and analyzed, and a genetic algorithm for solving the problem is proposed and verified by an example. The research shows that the genetic algorithm can be used effectively to optimize the distribution path and reduce the distribution cost. At the same time, the program is easy to operate and is convenient for the enterprise to apply.

## 1 Introduction

The path optimization problem of multi-center distribution system is of great importance in developing the urban distribution resources and solving it properly will contribute to lowering the distribution cost, increasing the efficiency and profit as well. Mathematical optimization is a traditional way to study this problem [1-2]. However, due to the great difficulty, genetic algorithm and its improved form have been paid attention to and applied in recent years [3-5]. In this paper, the genetic algorithm designed is used to solve the distribution path of different distribution systems. By comparing the path distance of each vehicle from its distribution center, the optimal path can be selected for a vehicle, then the overall planning of the vehicle scheduling scheme with the shortest distribution path can be achieved. The calculation rules and optimal selection method presented in this paper are simple and effective, which are easy for enterprises to understand and operate.

## 2 The path problem description of multi-centre distribution system

The path problem of the multi-centre distribution system is an important issue that the urban distribution enterprises are confronted with [6-8]. In the daily operation, the distribution enterprises often need to break through the division of the branch so as to arrange some important business as a whole, and make the most use of the multiple distribution centers it owns to serve the customers. Through the effective coordination between the distribution centers, the maximum efficiency and high quality service of the distribution system can be obtained. The biggest problem that the distribution enterprise faces is the problem of distribution path. To solve this problem, a distribution plan is needed to make a number of vehicles run in the shortest total distance to meet the customer's total demand. The distribution plan is also known as the vehicle scheduling plan, including the quantity and route of each vehicle dispatched.

### 2.1 The basic assumptions

In order to fully describe the path problem of the multi-center distribution system, this paper gives the following basic assumptions: (1) The enterprise has multiple distribution centre, each distribution centre has enough vehicles; the delivery vehicle has the load weight limit, and the delivery weight does not exceed its maximum load weight. (2) The location and distance between distribution centre and customers are known, and all roads can be cleared without considering traffic congestion. (3) The demand of each customer is known, and its demand does not exceed the maximum carrying capacity of each vehicle. Each customer can only accept one distribution service by one vehicle. (4) Each vehicle has only one distribution path, whose distribution distance does not exceed the maximum driving distance of the vehicle. Each vehicle is required to return to the original distribution center after the delivery is finished. The above assumptions are in line with the actual situation of distribution service provided by urban distribution enterprises for customers, and it is of practical significance to build a multi centre distribution path problem model on this basis.

### 2.2 The path problem of multi-center distribution system

Based on the assumptions above, the path problem of the multi- centre distribution system can be described as follow. The enterprises that owns many distribution

[a] Corresponding author: 15320537572@163.com

centre offer the distribution service of certain kind of commodity to a number of customers living in a certain district and the need of each customer are known. Every distribution centre of the enterprise owns enough vehicles. Each vehicle can offer services to several customers. However, each customer can only get services from one vehicle, and the vehicle belonging to a distribution centre must return to its original place after completing the distribution task. The path problem of multi center distribution system is to formulate the optimal vehicle scheduling plan scientifically and achieve the vehicle scheduling of distribution system with shortest route.

## 3 Genetic algorithm design for path problem of multi-center distribution system

It is very difficult to solve the path problem of multi-center distribution system by mathematical optimization method. It is proved by practice that genetic algorithm is an effective method [9-10]. The genetic algorithm design for the path problem of multi-center distribution system includes coding, initialization, fitness function, genetic operator, termination of evolution conditions and so on.

### 3.1 Coding

Genetic algorithm needs to transform the solution of practical problem into the solution of genetic algorithm by coding. The genetic algorithm coding design of this study is as follows: the total number of customers in the enterprise is n, the customers are encoded bynatural number from 1 to n randomly, and a chromosome of length n represents a vehicle scheduling scheme. Each vehicle path for a distribution center is derived from the distribution constraints according to a chromosome. This scheme should meet all the customer's distribution needs, and each customer only receive it once. Finally, the distribution vehicle is required to return to the original distribution centre after completing the task.

### 3.2 Initialization population

The population is a collection of many chromosomes, whose size represents the number of chromosomes contained, and a population corresponds to a set of feasible vehicle scheduling schemes for the enterprise. In the process of solving the practical problem by genetic algorithm, the larger size of the population is, the slower the running speed will be and the smaller size of a population is, the faster the running speed will be. But the lower the diversity of the population is, the easier it is to fall into the local optimal solution for a small size of a population. Therefore, the appropriate size of a population is generally chosen in the range of 20-200.

### 3.3 Fitness function

The fitness function indicates the individual's adaptability to the environment. The value of the function, that is, the individual's fitness value determines the individual's ability to survive in the environment. In general, a good chromosome has a relatively high fitness function value, which can obtain a higher evaluation and has a stronger viability. The chromosome fitness value refers to the total distance of delivery paths in a vehicle scheduling scheme, which is an important criterion to determine whether a vehicle scheduling scheme is good or bad. To calculate the fitness value of chromosomes, the total distance of distribution paths for a chromosome in the existing population is needed to be calculated. The distribution center and the path of each vehicle are determined and exported by the calculation logic for a chromosome. The fitness values of the chromosome are used as the basis of parental preference so as to produce offspring population.

### 3.4 Genetic operators

Genetic operators follow the law of nature "natural selection and survival of the fittest". It chooses the one with strongest adaptability to produce the next generation, so that the best genes from the population can be inherited to the next generation.

#### *3.4.1 Selection operators*

The selection operators are to select good individuals from the previous generation to produce a new population. There are roulette wheel method, random selection method, binary tournament selection method and so on. The roulette method of this study is as follows: ① calculating of the fitness（$f_i$）of chromosome（i）; ②calculating the sum of the fitness of M chromosomes in the population; ③ finding the probability of each chromosome selection; ④ calculating the cumulative probability of each chromosome（$q_i$）; ⑤ producing a uniform distribution of random number u in the [0,1] interval. If $u<q_1$, select 1 of individuals, otherwise, select individual K, making $q_{k-1}<u\leq q_k$; ⑥ repeat step five M times.

#### *3.4.2 Cross and mutation operators*

The cross operation of this study is as follows: The two gene positions of a paternal chromosome namely P1 and P2 are randomly determined, and the sequence numbers of P1 to P2 are inverted to cross the chromosomes and produce a new progeny. The mutation operation is like that the two variant positions of a paternal chromosome, P1 and P2, are determined by a random way and the gene positions between the parent chromosomes P1 and P2 is exchanged, which result in the mutation of the gene, that is, the new progeny are produced.

### 3.5 Terminate evolution conditions

Genetic algorithm is a kind of random search method with cyclic operation. It must be set the terminate condition of the operation. When the genetic algorithm satisfies the terminate condition, it ends the loop. The common terminate rules are as follows: the optimal goal is achieved, the results are stable, no improvement is obtained, and the maximum evolutionary generations has been reached. In this paper, the maximum evolutionary generations and maximum evolutionary stagnation generations are used as the terminating rule. If the operation reaches the terminate condition, the operation is stopped.

## 4 An example

SQ logistics company offers the distribution service to the 42 community supermarkets distributed in the whole main city in Chongqing. According to field study, the information of the community supermarkets are presented in table 1. In table 1, ID means the sequence number of community supermarket, and each ID corresponds to a unique customer and the customer number, that is a community supermarket. The unit of X and Y axis is kilometre and the community supermarket requirement are gained from the normal operation of a certain day, which unit is "t". RM represent as the requirement of community supermarket. There are two distribution centers A and B, whose coordinate are （16.3,10.6） kilometers and （6.1,13.8） kilometers respectively. Both distribution centre have enough vehicles whose maximum driving distance is 70 kilometres.

**Table 1.** The basic information of supermarkets

| ID | x | y | RM | ID | x | y | RM |
|---|---|---|---|---|---|---|---|
| 1 | 8.6 | 9.2 | 0.1 | 22 | 11.0 | 9.7 | 0.3 |
| 2 | 1.5 | 9.2 | 0.4 | 23 | 10.5 | 11.4 | 0.5 |
| 3 | 4.5 | 15.2 | 0.6 | 24 | 6.5 | 14.8 | 0.8 |
| 4 | 3.9 | 9.2 | 0.7 | 25 | 13.8 | 5.8 | 0.7 |
| 5 | 7.5 | 2.0 | 0.4 | 26 | 8.7 | 1.6 | 0.6 |
| 6 | 8.0 | 1.8 | 0.5 | 27 | 10.3 | 4.0 | 0.9 |
| 7 | 9.9 | 2.4 | 0.8 | 28 | 19.1 | 15.6 | 0.9 |
| 8 | 9.9 | 8.4 | 0.3 | 29 | 14.6 | 0 | 0.3 |
| 9 | 9.0 | 3.3 | 0.6 | 30 | 12.8 | 11.0 | 0.6 |
| 10 | 12.4 | 13.7 | 0.4 | 31 | 8.0 | 9.1 | 0.4 |
| 11 | 9.7 | 0 | 0.3 | 32 | 19.1 | 15.6 | 0.3 |
| 12 | 15.9 | 2.5 | 0.8 | 33 | 14.6 | 0 | 0.6 |
| 13 | 16.7 | 3.4 | 0.5 | 34 | 16.8 | 2.1 | 0.4 |
| 14 | 15 | 5.5 | 0.7 | 35 | 6.9 | 1.6 | 0.1 |
| 15 | 9.3 | 4.5 | 0.2 | 36 | 21.3 | 14.6 | 0.6 |
| 16 | 7.8 | 7.2 | 0.4 | 37 | 25.6 | 10.2 | 0.3 |
| 17 | 5.2 | 7.8 | 0.6 | 38 | 28.4 | 16.5 | 0.5 |
| 18 | 7.7 | 8.2 | 0.3 | 39 | 19.5 | 12.3 | 0.4 |
| 19 | 5.5 | 8.9 | 1.0 | 40 | 2.8 | 6 | 0.8 |
| 20 | 10.3 | 9.0 | 0.5 | 41 | 11.6 | 12.5 | 0.6 |
| 21 | 11.2 | 8.3 | 0.6 | 42 | 10.6 | 3.1 | 0.2 |

### 4.1 Parameter setting of the genetic algorithm

According to the operation requirement of the double distribution centres, the software MATLAB2012 is used to design and achieve the optimization program of the multi-centre distribution system. In the genetic algorithm program designed, the total number of the community supermarket(or the customer) is n, and n is equal to 42, that is to say, the length of the chromosome is 42. The scale of the initialization population, namely N, is 60, and either condition listed bellow can be chosen as the terminate condition :① it stops operating when the maximum evolutionary generations reaches 500;② the adaptive value has no obvious rise when the evolutionary stagnation generations go through 200.

### 4.2 Analysis of simulation result

Running the genetic algorithm program of the multi-center distribution system in the MATLAB software and running the simulation trial over and over again, we can get many plans, in which the shortest path would be the best solution. In order to simplify the analysis, we make the assumption that the distance between the network nodes including distribution centres and supermarkets equals to the straight distance between two points.

Table 2 shows the information we get from the simulation trial. In table 2, PN represents path number, DD represents driving distance, which unit is kilometers (denoted as km briefly), LC represents loading capacity, which unit is ton (denoted as t briefly). In table 2, we can see, each path corresponds to a distribution vehicle; the letters A and B refer to the distribution center and the numbers beside the letter stands for the community supermarket. It is obvious that there are only 10 distribution path. That is to say 10 vehicles are needed to offer distribution service to 42 customers and the total driving distance is 166.2363 kilometers.

**Table 2.** Optimal path of the distribution system

| PN | DD | LC | Distribution path coding |
|---|---|---|---|
| 1 | 28.4709 | 2.3 | A—21—18—16—9—5—A |
| 2 | 29.6733 | 2 | A—6—26—33—29—A |

| | | | |
|---|---|---|---|
| 3 | 27.4433 | 2.1 | B—25—3—24—B |
| 4 | 18.5335 | 2.2 | B—23—4—19—B |
| 5 | 22.3011 | 2.4 | B—17—8—22—30—41—B |
| 6 | 21.2735 | 2 | A—10—39—32—28—A |
| 7 | 46.7486 | 2.4 | A—36—38—37—20—1—31—A |
| 8 | 30.7512 | 2.5 | B—15—27—42—7—11—35—B |
| 9 | 36.9771 | 1.9 | A—40—2—14—A |
| 10 | 17.6097 | 1.7 | A—12—34—13—A |

After the end of the simulation experiment, the simulation information is get in figure 1. Figure 1 indicates the simulation information of the optimized solution for the distribution system. The left part of the first line in figure 1 shows the best fitness value is 166.236 kilometers, the Mean fitness is equal to 220.313 kilometers, as well as the best fitness ( the black points) of each generation in the process of evolution and mean fitness( the blue points). The right part shows the each fitness value of the generation when the simulation trial completes. The second line in figure 1 indicates the best, worst and mean scores of each generation in the process of evolution.

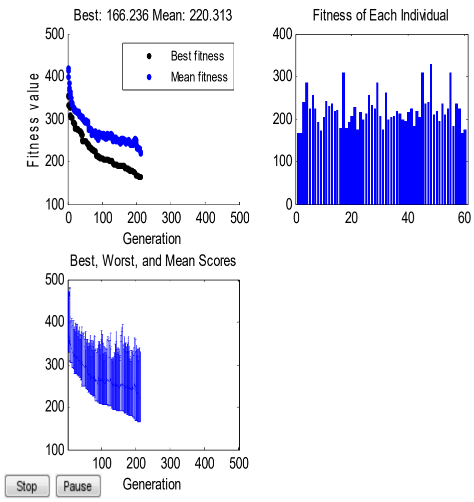


**Figure 1.** Distribution path simulation information

According to the vehicle scheduling plan of SQ company, if the distance between two points are straight, the actual driving distance is 201.6 kilometers. compared to the optimized one, 35.36 kilometers are saved so that the cost lowers by 17.5%. Therefore, using the genetic algorithm to optimize the vehicle scheduling plan can bring the enterprises great economic profit.

## 5 Conclusion

Under the premise of reasonable assumptions, this paper completes the theoretical description of the path problem for the multi-centre distribution system, and gets the following conclusions: (1) The solution to the path problem of the multi-centre distribution system is an enterprise vehicle scheduling scheme which is expressed by the customer sequence number. Each vehicle path is derived from the distribution constraint on the basis of the customer sequence number, and the solutions of the distribution path can be transformed into the individual and the population of the genetic algorithm. (2) The algorithm generally can obtain the optimal solution after ten optimization searches, which can effectively solve the problem of the actual distribution path for the enterprise. The operation process is simple and intuitive, and it is convenient for the enterprise to apply.

## Acknowledgments

This work was financially supported by 2018 Chongqing Education Commission humanities and social sciences research project "The research on special fresh agricultural products distribution system operation mechanism" (18SKGH105)

## References

1. Wassan N, Wassan N, Nagy G, et al. *The multiple trip vehicle routing problem with backhauls: formulation and a two-level variable neighbourhood search*, Computers .O.R, **78(c)**,454-467(2017).
2. Yin fat, Ye Chunming. *A hierarchical algorithm model for vehicle routing problem with multiple distribution centers*. Journal .S.M, **4**,602-606 (2014).
3. Xiong Ruiqi, Ma Changxi. *Robust optimization of delivery route for dangerous goods in distribution center.* *Computer* .A,**37(5)**, 1485 -1490,1515 (2017).
4. Liu Jiali, Guo Xiuping. *Multi center open loop vehicle routing problem with product exclusion and vehicle matching* . Journal .S.M , **1**,129-138 (2016).
5. Xiao Zhengzhong, Tan Jian et. *Research on Intelligent Optimization of vehicle dispatching in multi regional distribution centers*. Chinese. J.T, **3**,114-120 (2017).
6. Gao Yanjun. *Urban logistics distribution routing optimization based on joint distribution*. Management and science and technology of small and medium-sized enterprise **, 7,** 140-141 (2016).
7. Wang Yong, Ren Yin. *Optimization of revenue distribution based on multi center joint distribution*. Computer integrated manufacturing system **23(7)**, 1571-1580 (2017).
8. Bai Fan, Sui Yuming, Wang Xueling. *The development and planning of logistics industry in large and medium-sized cities in China.* Journal of agroforestry and economic management **8(1)**,108-111 (2009).
9. Zhang Dezhi, Qian Qi, Li Shuangyan. *Vehicle routing optimization model and algorithm based on CO2 emission*. Journal of Railway Science and

Engineering, **(2)**,424-429 (2015).

10. Qian Guang Yu. *Optimization of fresh agricultural products cold chain distribution routing considering carbon emissions*. Beijing Jiaotong University, (2016).