

Hybrid genetic algorithm for network locating problem by considering multi-purpose trip in stochastic stateSajjad Najafi¹, Vahid Majazi Dalfard² and Ghorbanali Mohammadi³¹Department of Industrial Engineering, Shahed University, Tehran, Iran.²Islamic Azad University, Qazvin Branch, Faculty of Industrial and Mechanical Engineering, Qazvin, Iran*³Department of Industrial Engineering, Shahid Bahonar University Kerman, Kerman, 7618891167, Iran

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Abstract

In this paper, the locating problem was studied by considering a network of nodes and edges, and also two types of facilities which were defined for locating on nodes. It was assumed that there were three types of consumers, which were classified according to their demands. The first and the second types of them referred to one facility of the first or the second, but the third type of consumers needed the two facilities-the first and the second. These consumers according to their distance to the facilities based on a specified probability, referred to the facilities and solved their problems. Considering the existence of competitors in the market, the aim of this issue is to maximize market share for the new facilities. To solve the problem the hybrid genetic algorithm was used.

Keywords: Consumer, Market, Trip, Network, Hybrid genetic algorithm, Logit function**Introduction**

The multi-purpose trips are happening every day. For example, when we get home from work, we may buy some food from shops and take our children from school and on return to home after going to doctor we may buy drugs. Although a considerable research has been done on multi-purpose trips (McLafferty & Ghosh, 1986; Mulligan, 1987; Thill, 1992), but studies on locating the facilities during multi-purpose trips are much of need (Hakimi, 1983; Dobson & Karmarkar, 1987; Marianov, 2003; Berman & Huang, 2004, 2007; Huang, 2005; Marianov *et al.*, 2007; Marianov *et al.*, 2008).

Berman and Huang (2007) made study on consumer's referrals to the closest facility to solve the problem according to the distance, but the competitors were not studied. Marianov *et al.* (2008) considered only special-purpose trips. But the competitive conditions and the possibility that the consumer does not refer to the closest facility are not studied.

In this issue, the consumer refers to the facilities according to his distance from the different facilities with specific probability which is obtained by logit function provided by Mcfadden (1974). We provide hybrid genetic algorithm which was applied earlier for locating network applications (Goodarzian *et al.*, 2011; Nikzad *et al.*, 2011). For this purpose, we considered the issue of locating two kinds of facilities in a network with three types of consumers.

In each referral, the first and the second types of consumers refer to any one kind of facility. The third type of consumers needs both the two facilities to meet their needs. The referrals of consumers of each group to each facility are determined as a probability as the function of the distance between nodes and facilities. The aim of the issue is to locate the facilities in order to maximize the market share.

Materials and methods**Problem modeling**

There are two kinds of facilities in the studied issue, which are named facility x and y . Accordingly, a consumer can have dual purpose trip which are determined for three kinds of consumers as follows:

x -class consumer: this consumer is the only applicant of service x ; y -class consumer: this consumer is the only applicant of service y ; xy -class Consumer: this consumer applies the two kinds of services x and y in each dual purpose trip.

The aim of this issue is to locate p_1 facilities of x and p_2 facilities of y , to maximize the total demands by constructing new facilities.

Model assumptions

The basic assumptions of the issue are: In some places the rival facilities from x and y have already been constructed; In the similar places the same facilities cannot be located. It is assumed that there are not any capacity constraints in facilities. Applicant's customers are in nodes. Demand is fixed in nodes. The consumers choose the facility according to the distance to it, by specified probability. The probability of choosing the facilities follows the logit function. Without minimizing whole issue, it is assumed that the consumer in a dual purpose trip complies demand x first and then y . All of the demands of the consumer will be complied completely.

The objective function is the total of demands x and y in the constructed places of the new facilitations.

2-2-Decision parameters in problem

Model parameters are: i : index of consumer place; j, h : index of facility place; n : number of the nodes in network; γ : parameter of logit function; x_{ij}^y : The probability of the consumer's referral to the facility of place j in place i to show the need y ; x_{ijh} : The probability of the consumer's referral to the facility of place j in place i to show the need x and from place j to facility place h in order to shoe the

need y ; N_x : the places, in which is facility x ; N_y : the places, in which is facility y ; N_x : candidate locations for locating the new facility x ; N_y : candidate locations for locating the new facility y

h_i^x : demand of x in node i ; h_i^y : demand of y in node i ; x_j^x : demand x in place facility j ; x_j^y : demand y in facility place j ; d_{ij} : distance of consumer place i to facility place j ; p_1 : numbers of new facility x ; p_2 : numbers of new facility y .

L_j^x : has a fixed amount 0 or as follows:

1: if the facility x exists in place j ; 0: if the facility x does not exists in place j ;

L_j^y : has a fixed amount 0 or 1 as follows:

1: if the facility y exists in place j ; 0: if the facility y does not exists in place j

The parameters of decision making issue are defined as following:

Y_i^x : parameters 0 and 1 as following:

1: constructing facility x in place j ; 0: not constructing facility x in place j

Y_i^y : parameters 0 and 1 as following:

1: constructing facility y in place j ; 0: not constructing facility y in place j

Problem formulating

By considering the lagit function for probability of consumer's referral from place i to facility place j for demand x :

$$x^{x_{ij}} = \frac{y_i^x e^{-\gamma d_{ij}}}{\sum_{k \in N_x} (y_k^x e^{-\gamma d_{ik}}) + \sum_{k \in N'_x} (y_k^x e^{-\gamma d_{ik}})}$$

X_{ij}^y is calculated as above. In dual-purpose trips for the probability of consumer's referral from node i to facility place j for demand x and facility place k for y :

$$x_{ijk} = \frac{y_j^y y_k^y e^{-\gamma d_{ijk}}}{\sum_L \sum_K (y_k^y + L_k^x)(y_L^y + L_L^y) e^{-\gamma d_{ijk}}}$$

Demand x in node i is h_i^x and demand y in node i is h_i^y , so demand xy in node i is h_i^{xy} . Demand of facility place j is as following:

$$\lambda_j^x = \sum_{i=1}^n (h_i^x x_{ij}^x + h_i^{xy} \sum_k x_{ijk}^x) \quad \forall j$$

$$\lambda_j^y = \sum_{i=1}^n (h_i^x x_{ij}^y + h_i^{xy} \sum_k x_{ijk}^y) \quad \forall j$$

By considering the defined parameters and functions the model is formulated as following for locating p_1 facility x and p_2 facility y :

$$\begin{aligned} \max & \sum_{j \in N_x \cup N_y} \lambda_j^x + \lambda_j^y \\ \lambda_j^x &= \sum_{i=1}^n (h_i^x x_{ij}^x + h_i^{xy} \sum_k x_{ijk}^x) \quad \forall j \end{aligned} \quad (1)$$

$$\lambda_j^y = \sum_{i=1}^n (h_i^x x_{ij}^y + h_i^{xy} \sum_k x_{ijk}^y) \quad \forall j \quad (2)$$

$$x^{x_{ij}} = \frac{y_i^x e^{-\gamma d_{ij}}}{\sum_{k \in N_x} (y_k^x e^{-\gamma d_{ik}}) + \sum_{k \in N'_x} (y_k^x e^{-\gamma d_{ik}})} \quad (3)$$

$$x^{y_{ij}} = \frac{y_j^y e^{-\gamma d_{ij}}}{\sum_{k \in N_y} (y_k^y e^{-\gamma d_{ik}}) + \sum_{k \in N'_y} (y_k^y e^{-\gamma d_{ik}})} \quad (4)$$

$$x_{ijk} = \frac{y_j^y y_k^y e^{-\gamma d_{ijk}}}{\sum_L \sum_K (y_k^y + L_k^x)(y_L^y + L_L^y) e^{-\gamma d_{ijk}}} \quad (5)$$

$$y_k^x + L_k^x \leq 1 \quad \forall k \in N \quad (6)$$

$$y_k^y + L_k^y \leq 1 \quad \forall k \in N \quad (7)$$

$$\sum_k y_k^y = p_1 \quad (8)$$

$$\sum_k y_k^y = p_2 \quad (9)$$

$$y_j^x, y_j^y, L_j^x, L_j^y \in \{0,1\} \quad (10)$$

In this model, the objective function is the total of the demands x and y in constructed places of new facility. Limitations 1 to 5 are defined earlier. Limitation 6 certifies that in the place, in which facility x exists, the new facility x cannot be located.

Limitation 7 certifies that in the place, in which facility y exists, the new facility y cannot be located.

Limitation 8 certifies that only p_1 new facilities x will be located.

Limitation 9 certifies that only p_2 new facilities y will be located.

Problem solving method

In this section, two methods of problem solving are provided. The first method is lingo solution method that provides the optimized answer but it is not usable in great problems. This method is developed for reviewing and validation the innovative methods. The second method is a metaheuristic method based on hyper genetic algorithm.

Lingo solution for determining the optimal solution

A lingo solution that reviews all the possible answers for locating the facilities is run by Matlab software. By using this program, the optimal answer is obtained. The method of this algorithm is in this form that reviews all the possible pairs for demands x and y and provides the best answer. Since the possibility of the consumer’s referral to the facilities can be changed by each alternation and also by considering the existence of two kinds of facilities, the search space grows by growing problem dimensions. The program can be used in small problem solving and to evaluate hyper genetic algorithm.

Solving the OR model in lingo software

In lingo software, according to the fast growth of the space dimensions of the answer, it takes a long time to reach a definitive answer and if $n > 30$, it is not possible to reach the answer. Thus, this issue is NP-hard (Jani & Shahvandi, 2010).

Outline of Hybrid Genetic Algorithm (HGA)

The Hybrid Genetic Algorithm (HGA) acts as global search technique which is similar to simple genetic algorithm with only deviation of generation of initial solution. In HGA, initial feasible solution is generated with the help of some heuristics and then this initial sequence can be used according to population size for the executing the procedure of simple genetic algorithm. The proposed HGA is described as:

Step 1: Initialization and evaluation

a) The algorithm begins with generation of initial sequence with special heuristics (SH) called as one of the chromosome of population

b) Generation of (Ps-1) sequences randomly as per population size (Ps).

c) Combining of initial sequence obtained by special heuristics with randomly generated sequence to form number of sequences equal to population size (Ps).

Step2: Reproduction

The algorithm then creates a set of new populations. At each generation, the algorithm uses the individuals in the current generation to generate the next population. To generate the new population, the algorithm performs the following steps:

- a) Scores each member of the current population by computing fitness.
- b) Selects parents based on the fitness function.
- c) Some of the individuals in the current population that have best fitness are chosen as elite and these elite individuals are utilized in the next population.
- d) Production of offspring from the parents by crossover from the pair of parents or by making random changes to a single parent (mutation).
- e) Replaces the current population with the children to form the next generation.

Step3: Stopping limit

Stopping condition is used to terminate the algorithm for certain numbers of generations (Ashwani & Pankaj, 2010). Many researchers used the Genetic algorithm earlier (Mohammadi, 2011; Ghasemi & Javadian, 2011).

Results and discussion

Considering the function of Hybrid Genetic Algorithm (HGA)

In this section, 21 experimental issues of locating in different dimensions are mentioned for logic parameter 0.01 by the two methods (lingo solution and HGA).

In all of the experiments, the distances between the points and demands are random numbers between 1 and 100. Then, the diagrams related to amount of objective function and process time is shown. In all of the issues, the fixed numbers of places, which are considered for competitive facilities, are three and the number of places which are considered for two facilities are four.

Table 1. The result of objective function obtained by lingo solution and HGA

| Size | HGA Objective function | HGA Time (S) (hour: minute: second) | Lingo Objective function | Lingo Time (S) (hour: minute: second) |
|------|------------------------|-------------------------------------|--------------------------|---------------------------------------|
| 9 | 853 | 0:00:02 | 853 | 0:00:1.01 |
| 9 | 890 | 0:00:02.02 | 890 | 0:00:01.21 |
| 9 | 969 | 0:00:02.01 | 971 | 0:00:03.2 |
| 10 | 1029 | 0:00:02.02 | 1029 | 0:00:39 |
| 10 | 1215 | 0:00:02.3 | 1218 | 0:00:32 |
| 10 | 1529 | 0:00:02.7 | 1529 | 0:00:38 |
| 30 | 3852 | 0:00:05.9 | 3852 | 7:12:14 |
| 30 | 3912 | 0:00:06.1 | 3912 | 7:52:42 |
| 30 | 3748 | 0:00:05.9 | 3748 | 7:19:56 |
| 50 | 8526 | 0:00:12 | - | 20:00:00 |
| 50 | 8599 | 0:00:13 | - | 20:00:00 |
| 50 | 8219 | 0:00:13 | - | 20:00:00 |
| 100 | 19218 | 0:00:21 | - | 20:00:00 |
| 100 | 21948 | 0:00:23 | - | 20:00:00 |
| 100 | 20541 | 0:00:21 | - | 20:00:00 |
| 200 | 49526 | 0:01:16 | - | 20:00:00 |
| 200 | 48333 | 0:01:19 | - | 20:00:00 |
| 200 | 50064 | 0:01:18 | - | 20:00:00 |
| 250 | 79488 | 0:02:54 | - | 20:00:00 |
| 250 | 81659 | 0:03:09 | - | 20:00:00 |
| 250 | 80497 | 0:03:05 | - | 20:00:00 |

For programming the lingo solution and HGA, MATLAB 7.5 was used and for running the algorithm, in a PC with 3.2 PIV, 2 GB RAM was used.

In Table 1 the amount of objective function obtained by lingo solution and HGA with their process time are mentioned. The objective function of HGA has a low deviation comparing to lingo solution. HGA method has less time in all of the issues, especially in those cases that the issue size increases. It should be noted that by using the written algorithm it is possible to solve a network with 30 nodes.

Parameter setting

In this section, the results of the computational experiments are used to evaluate the performance of the proposed algorithm for Network Locating Problem by Considering Multi-purpose Trip in Stochastic state. There are nine instances for each problem size. At this point, some information about parameter analysis would be useful. Initially, several experiments were conducted on test problems in order to determine the tendency for the values of parameters. Six test problems were used for this purpose (Majazi, 2011).

In each step, only one of the parameters was tested. Each test was repeated four times. We considered the following values for the several parameters required by the proposed HGA:

Crossover probability (pc): four levels (0.90, 0.85, 0.80 and 0.75).

Mutation probability (pm): four levels (0.02, 0.04, 0.06 and 0.08).

Number of initial population (np): three levels (300, 200 and 100).

Number of generation (ng): one level (200).

Test results showed that these values were suitable for the problem. Later, additional tests were conducted in order to determine the best values. After completing the tests, Taguchi analysis is applied for the different values of parameters. The best values of the computational experiments for Considering Multi-purpose Trip in Stochastic state were obtained for pc = 0.85, pm = 0.06, np = 200 and ng = 200. These values were set as the default value of the Parameters.

Conclusion

In this paper, the issues that have dual purpose trips were studied according to their facilities servicing. Also a mathematical locating model and two methods of lingo solutions and HGA solution were provided. Lingo solution was used for considering the function of HGA. The results of HGA calculations were mentioned. To develop the provided model, the multi-purpose trips or changing the probability of consumers refers to facilitates based on parameters except distance, can be used.

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