# WAREHOUSE LOCATION PROBLEM WITH GENETIC ALGORITHM

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***Abstract:****Locating an economic facility (e.g. plant, warehouse or retail store) is one of the most strategic and important issue that a business company faces. This planning question is in the operations research literature referred as a facility location problem. It focuses on defining number and location of economic facilities. The problem is to determine how many warehouses to set up, where to locate those warehouses.*

*A Genetic Algorithm (GA) is shown to be an effective and efficient heuristic optimization method on problems of varying size. This paper presents a GA approach for the Warehouse Location Problem (WLP). According to the WLP, all cities in Turkey are considered where to the warehouses construct for minimizing the distribution costs. In the end, the results of various problems are reported.*

***Keywords:*** *Warehouse Location Problem, Genetic Algorithms, Distribution Costs*

## Introduction

The location of a facility, a corporation, or any organization is generally the most important and strategic decision. Facility location is a long-term decision and is influenced by many quantitative and qualitative factors. Location also greatly affects cost and revenue. Once a location is selected, many different costs such as energy, raw materials, transportation, and labor costs, will not change for a long time due to the prohibitive expense of moving established facilities.

In today's business environment, location of storage and distribution facilities may give a firm a substantial competitive advantage. In fact, strategic positioning of distribution centers aids in development of physical distribution systems which can provide high levels of customer service at relatively low total cost.

In determining where to locate an emergency facility such as a hospital or fire station, we would like to minimize response time between the facility and the location of a possible emergency. In choosing the position for a service facility such as a post office or power station, we want to minimize the travel distances needed to reach everyone in the region (Buckley, 1987, 24).

Warehouse location is one of the key issues of Supply Chain Management and a key component of a logistical system (Zhang, Xue and Lai, 2002, 731). In determining where to locate the warehouses, the companies want them to be close to market and plants so as to minimize the transportation inventory and the other costs. The problem is to determine how many warehouses to set up, where to locate them, how to serve the retailers using these warehouses (Teo and Shu, 2004, 396).

The WLP has attracted considerable attention in mathematical programming (Gao and Robinson, 1994, 411). In order to give a mathematical description of this problem, we use a mixed integer programming formulation. The mixed integer linear programming problems of interest are the large scale facility location and allocation problems in supply chain optimization (Giddings, Bailey and Moore, 2000, 38). Generally the problem of distributing partitions into one or more target devices can be adopted from the facility (or plant, warehouse) location problem (FLP). Here the goal is to minimize the total cost including installation cost of warehouses and the costs of transporting goods from a warehouse to a customer. With given customer locations, the locations for the warehouses must be selected to minimize the transport costs. The solution to this problem gives the optimal locations for facilities to satisfy all customers' demands.

**Problem Description, Notations and Mathematical Model**

The problem in this study is at what places the warehouses are to be constructed and from which warehouses to which retailers the goods are delivered such that the overall costs are minimal (Image 1). The notations and the mathematical model of the problem can be formulated as follows:

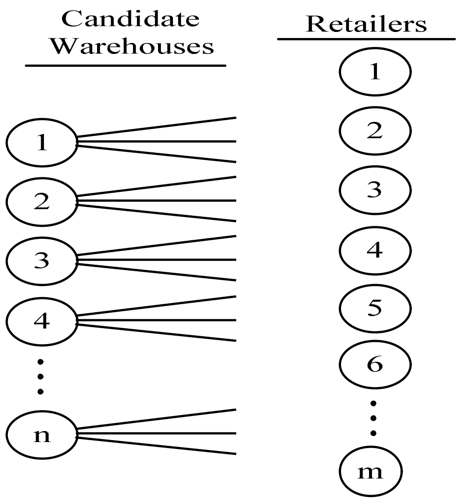
$J = \{1, 2, ..., m\}$ , set of retailers, indexed by $j$

$I = \{1, 2, ..., n\}$ , set of warehouse locations, indexed by $i$

$IC_j$ , installation cost of locating a warehouse at candidate site $j \in I$

$d_{ij}$ , distance from warehouse to retailer

$$Min \sum_{i=1}^{n} IC_j + \sum_{j=1}^{m} \min_{l=1:n} \{d_{ij} * P_j / 10000\}$$



GA is a robust and adaptive method that can be used to solve search and optimization problems and it has been shown to be very successful on WLP.

**Genetic Algorithms**

Genetic algorithms (GAs) are search and optimization methods which were introduced by Holland (Reeves, 1995: 152). GA attempts to optimize the fitness of a population of elements through recombining and mutating their genes (Hsu, Chen and Chen, 2005, 171). GA maintains a population of solution candidates and evaluates the quality of each solution candidates according to the problem-specific fitness function. New solution candidates are created by selecting relatively fit members of the population and recombining them through various operators (Allen and Karjalainen, 1999: 245-271). The steps of GA are as follows:

Step 1. Generation of initial population
Step 2. Evaluation of each individual
Step 3. Selection
Step 4. Crossover
Step 5. Mutation
Step 6. If stopping criteria is not met return to Step 2
Step 7. Select the best individual as a final solution.

A chromosome (string) is composed of genes which represents a candidate warehouses in our model (1 if the warehouse candidate is constructed; 0, otherwise). Each chromosome represents one potential solution. In the initial stage of the optimization, a number of chromosomes are arbitrarily created as initial population. It defines the size of solution pool. More chromosomes may increase the probability of finding optimal solution, but may induce a longer computation time (Felix, *et al*, 2005: 345-355).

An objective function is a measuring mechanism that is used to evaluate the status of a chromosome. This is a very important link to relate the GA and the system concerned. (Man, 2000: 25) Fitness function in our model is considered as minimization of the total cost including installation cost of warehouses and the costs of transporting goods from a warehouse to a customer as given below.

```
function fitness(population,distances,installationcosts);
for i=1:number of individuals ‘(rows)
   fitness(i)= population (i,:)* installationcost; ‘binary chromosomes
   for j=1: number of genes   ‘warehouses candidates (columns)
      if population(i,j)==1
        fitness(i)=fitness(i);
      else
         fitness(i)=fitness(i)+min(nonzeros(population (i,:)'.*distances(:,j)));
      end
   end
   end
end
```

Installation costs are accepted the same for all retailers (cities) and distribution costs are defined as the distances from warehouse to retailers. If the population of a city is considered as the demand of the retailer, distribution cost is calculated as the multiplication of distance between the warehouse and city and the population of the city. In Figure 3 there is a sample related with this cost calculation.

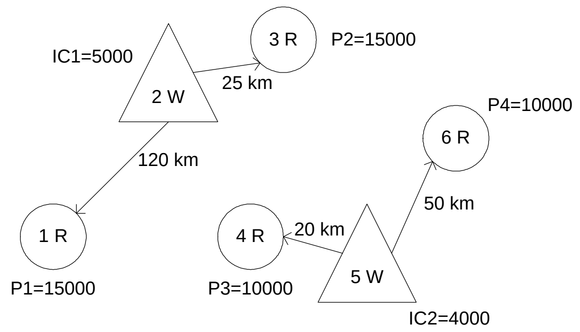


Figure 6. Multi-stage network flow model for warehouses and retailers

The possibility of locating warehouses to the cities that have high demand (population) was increased by adding demand to the model as a function of population. The representation of the sample of Figure 2 in GA model chromosome is demonstrated in Figure 3. The values of genes in chromosome are 1 if the cities have a warehouse, and the others are 0. Total cost of this chromosome is a 9000+27500 = 36500.

| | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 1 | 0 |

Figure 7. Structure of chromosome

**Selection:** The purpose of parent selection in GA is to offer additional reproductive chances to those population members that are the fittest. One commonly used technique, the roulette-wheel-selection, is used for this proposed GA (Ip, *et al*, 2000). After selection operator is applied, the new population special operators called crossover and mutation are applied with a certain probability. (Pendharkar and Rodger, 2004)

**Crossover:** The crossover is the main operator used for global searches. The traditional crossover operator by selecting randomly genes from parent chromosomes creates new chromosomes (individuals). Chromosomes of the two parents are split into two (equal or unequal) halves each. Both the chromosomes are cut similarly. The halves are interchanged. (Chick, *et al*, 2003) There are various versions of crossover. In this paper, two-point crossover, which is the most widely used version, is considered (Yamamoto and Naito, 2002).

**Mutation:** Mutation plays decidedly secondary role in the operation of GA. In artificial genetic systems the mutation operator protects against such an irrecoverable loss (Goldberg, 1989: p.14). Mutation arbitrarily alters one or more genes of a selected chromosome, by a random change with a probability equal to the mutation rate (Michalewicz, 1992: 17). In our model one-point mutation is used.

**GA Results**

We implement our proposed method using Matlab 7.0. The performance of the proposed method is tested on the different problems as given in Table 1. These problems have been developed by using the populations of 81 cities (potential locations for the warehouses) of Turkey and the distances between them. For example; in problem 1, when the installation cost is 20.000, the GA selects only one warehouse to be located in the city of "Kayseri" which is almost in the central region of Turkey.

Table 1. The results of GA approach

| Problem Type | Installation Cost | GA Solution | Optimal Solution | Number of Warehouses |
|---|---|---|---|---|
| 1 | 20.000 | 145.793 | 145.793 | 1 |
| 2 | 10.000 | 49.387 | 49.387 | 2 |
| 3 | 5.000 | 39.239 | 39.239 | 3 |
| 4 | 3.000 | 33.107 | 33.107 | 4 |
| 5 * | 2.000 | 27.828 | - | 6 |
| 6 | 1.000 | 21.267 | - | 9 |
| 7 | 500 | 16.253 | - | 12 |
| 8 | 250 | 12.160 | - | 24 |
| 9 | 10.000 | 164.880 | - | 7 |
| 10 | 20.000 | 224.050 | - | 5 |

For the eight problems, 1 to 8, the distribution costs are accepted as the distances from warehouses to retailers. And the last two problems, the distribution costs have been found by multiplying the distances with the demands of retailers (population of the cities).

( * ) Warehouse locations and distribution model for this problem is shown in Figure 6.

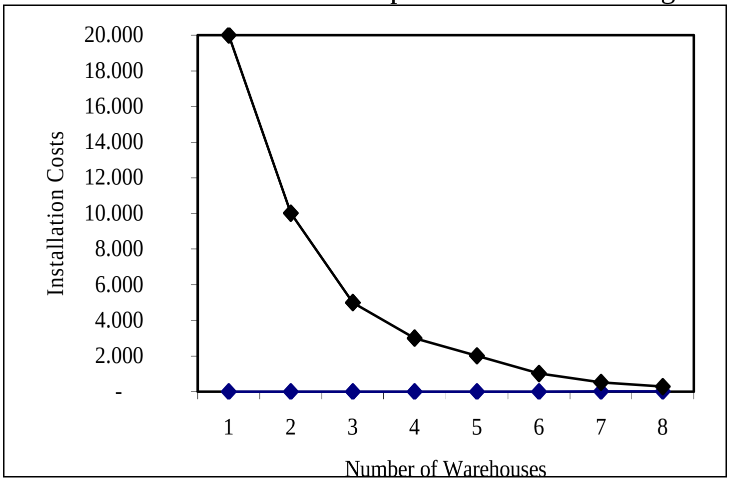



Figure 8. The number of warehouses with respect to different installation costs

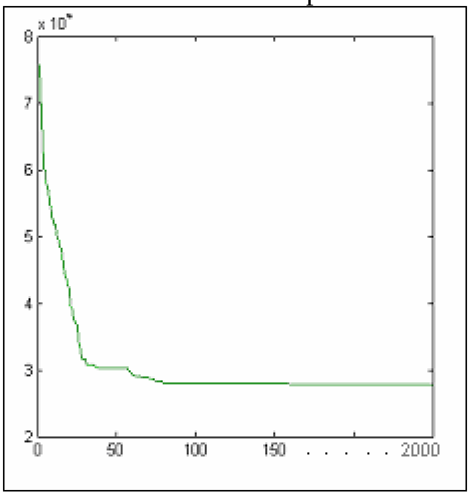



Figure 9. GA results of problem type 5
(Fitness value = 27.828, Iteration = 2000)

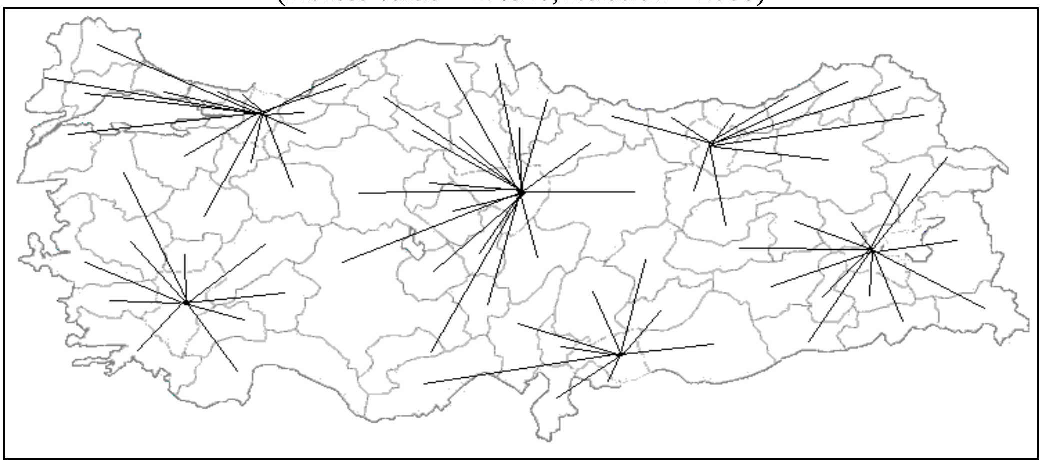


Figure 10. Appropriate warehouse locations in Turkey (for problem 5, number of warehouse=6, total cost=27.828)

## Conclusion

In this paper we have proposed a GA method approach for the large size of warehouse location problem. It has been seen from the results that while the number of constructed warehouses is less because of the high installation costs, our proposed GA method can find the optimal solution in all of the time. In the big size warehouse location problems, the solution can be got in a short time by using our model. But, it is not guaranteed that these solutions are optimal because of being unknown optimal.

If the results are examined, it has been seen that, the number of warehouses are increased as the installation cost is decreased as shown in Figure 4. The number of warehouse is defined according to the level of installation cost. If the populations of the cities are taken into account, the model has selected the warehouse locations in big cities like Istanbul, Ankara and Izmir. If the demands of the retailers are important, the decision maker can use this type of model.

If decision makers obtain more realistic values for the warehouse installation costs and the distribution costs this model can be more useful for determining real locations.

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