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Characterization of Model on Location Facilities

Ompal Singh

Department of Mathematics, SRM Institute of Science and Technology, Modinagar-201204, India

ABSTRACT

This paper presented how to partition a network in a number of zones. Once a zone has been determined first node to end node, it is time to decide on the location of stationary facilities within the zone. Location decisions belong to the node and it depends on the type of service being offered. In some cases, the imperative concern is to minimize the average distance or the facilities for the population. Approaches to location and models for applying location policy, two major classes of considerations are highly instrumental in selecting an approach to solving; this concern is usually dominant for cases such as locating a post office, a transportation terminal, or an office of a government agency. One class relates to management objectives, the other class is concerned with the nature of the demand for services and nature of the service provided.

Keywords: Network, policy, service, stationary facilities, zone

INTRODUCTION

In a service network, particularly in emergency services, the worst case would be the maximum shortest distance between a node and the closest facility. An attempt to minimize the maximum distance assures that in the worst case the response time would not exceed the value obtained by the optimal solution. The general term for models striving to minimize a maximum value is minimal. The class of problems related to location on network is called center problem. Center problems can be classified into two groups by distinguishing between one-facility and multiple-facility problems. Thus, we define a one-center problem (Baker, 1974) to be a limited problem, where only one stationary facility is to be positioned, whereas a p-center problem is the more general case where the number of facilities is not restricted to one. Unlike median problems, in center problems there is no equivalence to Hakimi's theorem that allows us to confine (Hall, 2009). Therefore, the number of candidate locations is potentially

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infinite. Management, however, may opt to restrict the solution only to nodes for administrative and logistic reasons. Center problems where the solution is constrained to reside on nodes are labeled nodal center problems. The unconstrained problems are called absolute center problems.

THE ONE NODAL CENTRE PROBLEM

The one nodal-center problem deals with locating one stationary facility on a network so as to minimize the maximum distance between the facility and the network nodes, however, the facility must be located on a node. Constraining the location to a node makes the solution very simple. All that we have to do is to examine the shortest distance matrix, mark the maximum and then select the node where the marked. The network G_1 in Figure 1 this number indicates maximum distance a server would have to travel had the stationary facility been located in the node corresponding to that column. If the facility is located at either node 3 or node 5, the maximum distance would be 5, and this is the best that we can get. So the solution to the one-nodal-center problem is to position the stationary facility either at node 3 or at node 5(Beckman, 1981).

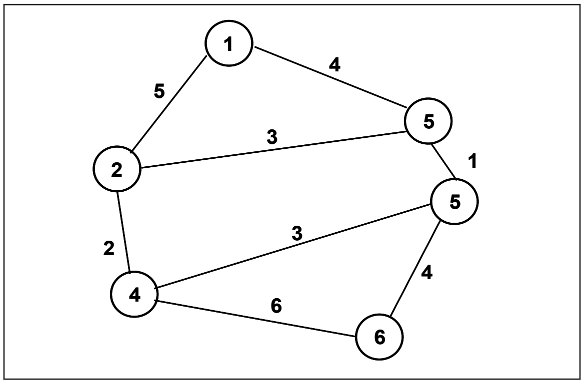

Figure 1. Sample Network G_1

THE ONE ABSOLUTE CENTRE PROBLEM

When the optimal solution is not restricted to residing on a node, problem becomes more complicated since now there are many points which may be candidates to inhabit the stationary facility. This procedure for solving the problem undergoes a number of steps, in each step points on only one link of the network are examined for a possible optimal location (Hallpern & Maimon, 2011). Finally, the best location among all the links is selected. Let us demonstrate how the algorithm operates on G_1 of Figure 1. Select any link of G_1, say between nodes 2 and 1. The length is 5 units. Let us place a hypothetical facility at point X on the link, and examine the distance between the facility and any node of G_1. Let us consider that the facility is located at a distance x from node 2.

The distance functions between node 1 and point X is 5 - x. The distance between node 2 and point X is simply x. We have combined graph drawn in bold shows the maximum distance from point X to any of the nodes 1 and 2.Suppose our problem was to find the one-center location for a simple case of a network consisting of nodes 1 and 2 only. The least tolerable among all the "worst cases" would be the bottom of the bold line, namely, at point x = 2.5. The bold is called the upper envelope of the graph (in shorts the envelope) and the optimal solution is at the lowest point of the envelope. Unfortunately, the network G_1 is more involved so we have to extend the search. Let us examine the distance between points on link (2, 1) and node 3. If the facility is located at node 2, the shortest distance to node 3 would be 3 units. When we move point X along the link, the shortest distance (Berman & Odoni, 1982) function becomes 3 + x. However, stops when X reaches 3 units from node 2, because at that point it is better to approach node 3 via node 1. The distance function X to 3 becomes 9 – x, where 9 is the sum of the distance of links (2, 1) and (1, 3), and x is the distance of point X from node 2. The complete distance function is given by

$$d(x,3) = \begin{cases} 3 + x\,, for\ 0 \leq x < 3 \\ 9 - x\,,\ for\ 3 \leq x \leq 5 \end{cases} \qquad (1)$$

The distance functions to nodes 1 and 2 with the distance to node 3. The new envelope is now drawn in bold. It describes the maximum shortest distance to nodes 1, 2 and 3, depending on the location of facility. The minimum among the shortest distances is obtained when the facility is placed on point x = 1, namely, 1 unit of distance from node 2. The maximum value of the maximum shortest distance would be 4. We proceed to inquire about the distance functions between points of link (2, 1) and all the nodes of the network G_1. The final envelope for (2, 1) is shown in Figure 2 the lines designating node numbers with which the function are associated. The distance function associated with node 5 contains all the other functions. Therefore, it solely constitutes the envelope for link (2, 1). In other cases, however, the envelope may certainly be composed of segments of various functions. Anyway, the best point on this envelope is at x = 0, yielding a minimum of 8 distance units. This point is called the local center of link (2, 1).We now have to repeat the same process for each link of G_1. The process might become somewhat tiring (Camerini et al., 1983). However, there is a way to save some calculations. The location of the nodal center of G_1, that is at node 3 with maximum distance of 5 units. Suppose we wish to examine the candidacy of a certain link m(*a*, *b*). This inspection is aided by the condition expressed by:

$$\frac{m(a) + m(b) - \ell(a,b)}{2} \geq m\ (\mathrm{j}^*) \qquad (2)$$

Where m (a) is the maximum distance between node a and any node network; m (b) is the maximum between b and any node; $\ell(a,b)$ is length of the link (a, b) and m (j^*) is the maximum distance for the one nodal-center problem. If condition (2) holds, there is no potential improvement beyond the one-nodal-center and the link can be skipped. Let us examine, for instance, link (5, 6). We have the maximum distance from node 5 is 5, i.e. m (5) = 5 for node 6, m (6) = 9. The link length is 4 substituting into (2).

$$\frac{5+9-4}{2}=5\geq 5$$

Consequently, link (5, 6) does not have to be examined. Let us now perform this inspection for all the links (Table 1).

$$\text{Link } (1,2)=\frac{9+8-5}{2}=6>5 \qquad \text{skip}$$

$$\text{Link } (1,3)=\frac{9+5-4}{2}=5\geq 5 \qquad \text{skip}$$

$$\text{Line } (2,3)=\frac{8+5-3}{2}=5\geq 5 \qquad \text{skip}$$

$$\text{Link } (2,4)=\frac{8+7-2}{2}=6.5>5 \qquad \text{skip}$$

$$\text{Link } (3,5)=\frac{5+5-1}{2}=4.5<5 \qquad \text{examine}$$

$$\text{Line } (4,5)=\frac{7+5-3}{2}=4.5<5 \qquad \text{examine}$$

$$\text{Link } (4,6)=\frac{7+9-6}{2}=5\geq 5 \qquad \text{skip}$$

$$\text{Link } (5,6)=\frac{5+9-4}{2}=5\geq 5 \qquad \text{skip}$$

We are left with only two links to examine this is a significant reduction of the work.

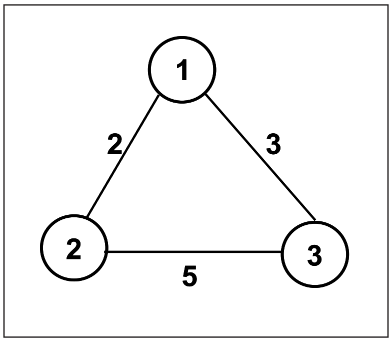

Figure 2. A Sample Network G_2

Table 1
Shortest distance for G_1

	To					
From	**1**	**2**	**3**	**4**	**5**	**6**
1	0	5	4	7	5	9
2	5	0	3	2	4	8
3	4	3	0	4	1	5
4	7	2	4	0	3	6
5	5	4	1	3	0	4
6	9	8	5	6	4	0
Maximum Distance	9	8	3	7	5	9

CLASSIFICATION OF LOCATION MODELS

In other cases, the average distance is considered less important than the maximum distance. Such cases are more relevant to issues of equity, where management would not like to deprive any portion of the population, even when this portion is small and remote. In such cases, management will strive to minimize the maximum distance between a potential user and all the location of service provider. This objective pertains mostly to emergency services such as ambulance, firefighting, or utility repair service. Model dealing with this type of objective are called center problems (Church & Garfinkel, 1978). In Figure 1 some cases, management would attempt to fulfil exactly the opposite objective, that is, to maximize the minimum distance between residential communities and a certain facility. The number of facilities to be located may also become subject to management policy. In some cases, the number of facilities is set prior to many location decisions. Then the objective would be to minimize either one of the above functions, for a given number of facilities. In other cases, management may set a certain performance level to be a target, and then seek to minimize the number of facilities to be located and to determine their locations, provided that the required performance is definitely met. This latter approach is often called a requirement problem. So for, we have classified location problems only in light of management objective. There is another class of considerations, namely, those related to the nature of the demand and the service. Neither demand nor service is deterministic, but rather they behave in a probabilistic manner. There are cases where we have to account for the stochastic nature of the system. This is particularly true when the servers are mobile service units and the major concern is not the travel time, but the system response time, that is, the time lapsed from an initiation of a request until a service unit arrives at the scene of call. The response time is highly affected by the distribution of the rate of calls and the service time (Hall, 2009). Models dealing with stochastic cases are called stochastic location problems. Such models allow for congestion, namely, queues can be generated and should be accounted for in the model.

ONE-MEDIAN PROBLEM

We discussion of location problem by presenting a very simple case of the one-median problem. The median problem in general deals with identifying locations for stationary facilities such that the average shortest distance from a node to the nearest facility would be minimized. The one median problem is, therefore, a reduction of the general median problem to case where only a single facility is to be located. The number of possible locations is infinite since the location of the facility is not necessarily limited to nodal locations (Dearing & Francis, 1974). We have to do, therefore, is to calculate the average distance for each alternative location and then select the node yielding the least value. A tree is connected network without loops (cycles). A path should exist between any two nodes of a tree, but this path is unique. A natural example of tree is a revere network. When we wish to locate a single stationary facility on a tree, we may use a special algorithm. Here we will demonstrate the algorithm on T_1 in Figure 3.

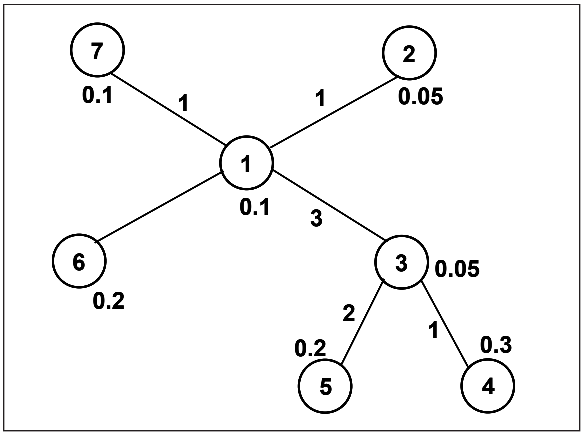

Figure 3. A Sample tree-type Network T_1

THE P- MEDIAN PROBLEM

Let us suppose a number of facilities say p, are to be located on a network. In order to solve this problem, we have to make one additional assumption a request for service will always be served by the closest facility. Under this assumption, we would like to find a set of points on the set of points on the network such that the average shortest distance between any node of the network and the closest facility would be minimized. When a server as dispatched to a calling node as well as when a customer has a travel to a facility (Goldman, 1971). The search for an optimal set of p location may be confined only to nodes of the network. Hence, one way to solve the problem is simply by enumerating all the possible subset p nodes and calculating the shortest distance between any node and its closest facility. We assume that travel times are deterministic, and service capacity is infinite. Suppose we place the stationary facility at point X on the link connecting node 1 and 2.

Assume that x is the distance between node 1 and the location of the stationary facility. The weighted average distance (or time) t, the server will have to travel to the nodes is given by.

$$E(t) = hx + (1-h)(l-x) \qquad (3)$$

The value of the first part of (3) is constant; it does not depend on the location of X.

THE P-CENTRE PROBLEM

The p-center problem is a natural extension of the one-center problem. The objective now is to locate p stationary facilities on a network such that the maximum shortest distance from any node to the closest facility is minimized. The algorithm for this problem is much more involved than that of the one-center problem.

Let G_2 be a service network portrayed in Figure 2 G_2 consists of three nodes and three links. Suppose it is desired to locate two facilities on the network such that the maximum distance from a node link to the closet facility is minimized (Goldman & Witzgall, 1971). Before getting to the search for optimal points, we would like first to identify the entire midpoint on each. A midpoint is a point on a link (1, 2) where the distance from this point to a certain node 1 is equal to the distance from the same point to another node 2. For example, the point located 5 units away from node 2 on link (2, 3) is a midpoint with regard to nodes 1 and 2, since it takes 2 units of distance to travel from this point to node 1 or to node 2.

CONCLUSION

The reason for the intensive search of midpoints is that an optimal solution for the p-median problem exists on midpoints. A great advantage of p-median problem is that the search for a solution can be confined to a finite identifiable set of locations. It was assumed that the number of facilities to be located is predetermined, and management objective is to minimize a certain performance measure. The performance measure is set ahead, and management wishes to minimize the number of stationary facilities that conforms to the imposed. We have successfully obtained all the midpoints, the shortest distance matrix of every node and every midpoint using proposed algorithm.

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