SINGLE FACILITY LOCATION WITH THE PRESENCE OF BARRIERS

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INTRODUCTION

In this study, we are given a set of customers, located at *n* fixed points, with their respective demands. We are required to locate *M* facilities in continuous space to serve these *n* customers, and to find the allocation of these customers to these *M* facilities. The objective is to minimize the sum of transportation costs. This continuous location-allocation problem is also known as the multi-source Weber problem which can be formulated as follows:

$$\text{Minimize} \quad \sum_{i=1}^{M}\sum_{j=1}^{n} x_{ij}\; d\left(X_i, a_j\right) \tag{1}$$

Subject to

$$\sum_{i=1}^{M} x_{ij} = w_j, \quad j = 1, \ldots, n \tag{2}$$

$$X_i = \left(X_i^1, X_i^2\right) \in S \subset \Re^2, \quad i = 1, \ldots, M \tag{3}$$

$$x_{ij} \geq 0, \quad i = 1, \ldots M; \quad j = 1, \ldots, n \tag{4}$$

where M is the number of facilities to be located, S is the feasible region to be considered, x_{ij} is the quantity assigned from facility i to customer j, $i = 1, \ldots M$; $j = 1, \ldots, n$, $d(X_i, a_j)$ is the Euclidean distance between facility i and customer j, $a_j = \left(a_j^1, a_j^2\right) \in \Re^2$ is the location of customer j, $X_i = \left(X_i^1, X_i^2\right)$ are coordinates of facility i, w_j is the demand, or weight, of customer j, where $w_j \in$ č;

The objective function (1) is to minimize the sum of the transportation costs. Constraints (2) guarantee that the total demand of each customer is satisfied. Constraints (3) describe the restricted regions and Constraints (4) refer to the non-negativity of the decision variables.

There is however a shortage of papers on the facility location problem with barriers. This problem is the constrained Weber problem which is also known as the Weber problem in the presence of forbidden regions and/or barriers to travel. This was initially investigated by Katz and Cooper (1981). They considered a Weber problem with the Euclidean metric and with one circular barrier. A heuristic algorithm was suggested that is based on a sequential unconstrained minimization technique for nonlinear programming problems. Hansen et al. (1982) provided an algorithm for solving the location problem when the set of feasible points is the union of a finite number of convex polygons. Other studies include Aneja and Parlar (1994) and Butt and Cavalier (1996) who developed heuristics for the median problem with *lp* distance and barriers that are closed polyhedra. Batta, Ghose, and Palekar (1989) obtained discretization results for median problems with *l*1-distance and arbitrarily shaped barriers by transforming these problems into equivalent network location problems. Their results were generalized by Hamacher and Klamroth (2000) for arbitrary block norms, although it is not possible to transform these problems to the analogous network location problems. Bischoff and Klamroth (2007) proposed a genetic algorithm based solution to the problem..

Our aim is to introduce a constructive heuristic as an efficient method to solve this typical problem of facility location-allocation.

THE BARRIERS

Let X be a customer location and P a facility location. Let $T_1T_2T_3T_4T_5$ be a convex polygonal barrier. From facility *P*, one can travel to customer *X* through vertices or along the edges of the barrier, but cannot cross the interior of the barrier.

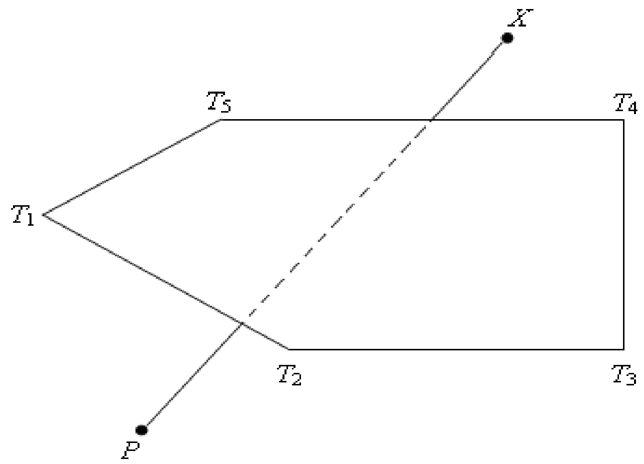

Figure 1

From Figure 1, the wall with respect to P is $W(P) := \{T_1T_2, T_2T_3\}$ and the wall with respect to X is $W(X) = \{T_4T_5\}$.

Proposition For any *P*, *X*, and a barrier, segment *PX* must intersect two walls $W(P)$ and $W(X)$ to be invisible.

Proof Assume that *P* and *X* not in the boundary of the barrier. Suppose that line segment *PX* touches one point at the edges of the barrier. Since the barrier is convex polygonal, the point must be a vertex of the barrier. So, *P* and *X* is visible, and there is no wall. Suppose that line *PX* intersects the edges of the barrier at point *A* and *B*. Since the barrier is convex, the line segment $AB \subset PX$ must lie inside the barrier and *A* lies at one edge of the barrier and *B* at another edge of it. Thus, *PX* intersects two walls. ■

FUTURE WORK

A constructive heuristic will be developed to solve the single facility location-allocation problem with the presence of convex polygonal barriers defined in the above section. The algorithm developed will be tested on some benchmark problems and the results will compared with the ones found so far in the literatures.

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