Two Iterative Algorithms for Transfer Point Location Problem

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Abstract: In this paper, we develop two heuristic algorithms for transfer point location problem. The first algorithm is based on determining clusters of demand points and the latter determine location of TP in first step. Computational results show stability of these algorithms. [Journal of American Science 2010; 6(9):827-830]. (ISSN: 1545-1003).

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1. Introduction

One of the oldest activities done by industrial engineers is facilities planning. The term facilities planning can be divided into two parts: facility location and facility layout (Tompkins et al., 2003). Facility location is and has been a well established research area within Operations Research (OR) (Melo et al., 2009). Many papers and books in this area are evidence for this claim. Newly, many review papers were published that may be useful to better comprehending of facility location (see Farahani et al 2010, Melo et al. 2009, Şahin and Süral, 2007 and ReVelle and Eiselt, 2005). Farahani et al. (2010) classify facility location problems based on their objectives, Melo et al. (2009) investigate role of facility location in supply chain networks, Şahin and Süral (2007) reviewed hierarchical facility location problem since mid-80s, ReVelle and Eiselt (2005) surveyed the important problems in facility location.

One of attractive branch of facility location is hub location. Since Weber in 1900, many researchers have focused on studying the problems of hub location. In the area of transport, many of their studies have been concerned with defining the optimum location for manufacturing plants, distribution centers, and hubs (Rodríguez et al. 2007). Baird (2006) focused on optimal site for international container transshipment. Wagner (2007) developed a mixed integer programming (MIP) formulation for hub network design problem. It is also shown that the problem is NP-hard. Alumur and Kara (2008) categorized and summarized network hub location models. They also consider some recent approach of hub location. Rodríguez-Martín and Salazar-González (2008) proposed an MIP formulation and two branch and cut (B&C) algorithm for determining route and location of hubs. Contreras et al. (2010) present an integer programming formulation for the tree of hubs location problem.

One of the related models in the location literature for the hubs location is transfer point location problem (TPLP). Consider n demand points that are served by a new facility. Suppose we use a transfer point. Unit cost of travelling from transfer point to facility is multiplied by a reduction factor as $\alpha, (\alpha \leq 1)$. This problem can be imagined by considering a hospital as facility, a helicopter pad as transfer point (TP) and n potential point for accident that are far from hospital as n demand points (See Figure 1).

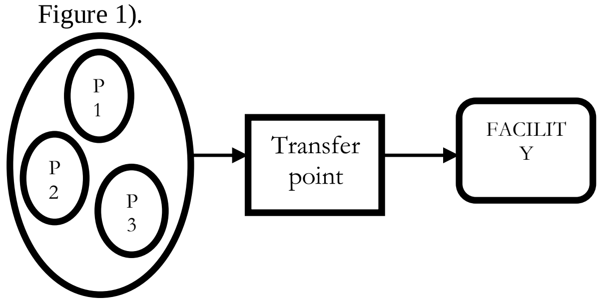

Figure 1. A scheme of TPLP

At the first time, Berman et al. (2007) introduced TPLP and they explored minimisum and minimax versions of objective function for TPLP. In this paper, we develop two iterative algorithms for solving multi transfer point location problem (MTPLP). Two proposed algorithms compared with each other and effect of coefficient α is investigated. The remainder of paper is organized as follows: in the section II, algorithms are developed, in section III, computational results are illustrated and conclusions are discussed in section IV.

2. Algorithms

The Mathematical model for MTPLP with two transfer points are as follows:

Let

n : be the number of demand points,

l_j : be the location of transfer point $j = 1,2$

d_{ij} : be the travel time between demand point i and transfer point j,

$D(l_j)$ be the travel time between transfer point j and facility.

$$X_k = \begin{cases} 1, & \text{If the demand point } i \text{ is assigned to the transfer point } 1 \\ 0, & \text{Otherwise} \end{cases}$$

```
Obj=Inf
C=True, Iteration=1
Assign demand points to transfer points
  randomly
While C is True do
     P=sets of clusters
     solve equation 1 and find locations of
  transfer points
     T=sets of transfer points location, P=∅
     solve equation 1 (Determine SUM) and
  assign transfer demand points to transfer
  points
     If SUM<Obj Then
          Obj=SUM
     elseif  SUM<Obj
          Iteration=Iteration+1
     endif
     If Iteration>Max_Iter Then
          C=False
     endif
 endwhile
Output= cluster of demand points and location
  of transfer points
```

Figure 2. Pseudo code for Algorithm1

$$SUM = \min\left\{\max_{i=1,\ldots,n}\left(w_i\left(\begin{array}{l} X_i\left[d_{i1} + \alpha D(l_1)\right] \\ +(1-X_i)[d_{i2} + \alpha D(l_2)] \end{array}\right)\right)\right\}$$

To solve this problem, we present two iterative algorithms. There are two algorithms for TPLP that works iteratively as follows:

Algorithm 1: Starting with clustering demand points, then determining location of transfer points.

Algorithm 2: Starting with determination of transfer points location and then clustering the demand points. The pseudo codes of algorithms are as are shown in Figure 2 and 3 respectively.

2. Computational Results

Data generation

We generate three test problems with 8, 12 and 20 demand points respectively. Coordination weight of each demand points are as follows:

```
Obj=Inf
C=True, Iteration=1
Determine location of transfer points randomly
While C is True do
     T=sets of transfer points location
     solve equation 1 and define cluster of
  demand points
     P=sets of clusters, T=∅
     solve equation 1 and  Determine location
  of transfer points Determine location of
  transfer points
     If SUM<Obj Then
          Obj=SUM
     elseif  SUM<Obj
          Iteration=Iteration+1
     endif
     If Iteration>Max_Iter Then
          C=False
     endif
 endwhile
Output= cluster of demand points and location
  of transfer points
```

Figure 3. Pseudo code for Algorithm2

Case 1: Facility coordination (12,12)

Table 1. Test problem

	1	2	3	4	5	6	7	8
Coordination	2	3	6	8	5	6	4	5
weight	(2,3)	(3,4)	(5,1)	(6,2)	(8,3)	(7,6)	(4,7)	(6,8)

Continue of Table 1. Test problem

	1	2	3	4	5	6
Coordination	(3,5)	(5,2)	(6,1)	(7,4))	(4,8)	(1,9)
weight	5	2	6	4	3	8
	7	8	9	10	11	12
Coordination	(3,11)	(6,3)	(8,9)	(10,2)	(11,8)	(5,12)
weight	1	9	4	7	6	3

Continue of Table 1. Test problem

	1	2	3	4	5
Coordination	6	3	5	4	8
weight	(2,5)	(4,3)	(11,5)	(12,9)	(8,10)
	6	7	8	9	10
Coordination	9	7	1	2	4
weight	(9,6)	(7,11)	(5,5)	(6,8)	(3,9)
	11	12	13	14	15
Coordination	3	3	5	7	2
weight	(10,11)	(12,6)	(6,5)	(9,2)	(1,11)
	16	17	18	19	20
Coordination	6	8	9	1	4
weight	(7,12)	(10,13)	(13,4)	(2,9)	(4,12)

2.1. Results:

We solve these problems with a varying of α from 0.3 to 0.9 the best result of two algorithm are illustrated in Table 2. It is shown when α is increased, TP points approach to facility and when it is decreased TP points approach to demand points.

2.2. Sensitivity analysis of Initial Solution:

We investigate effect of initial solution generated randomly on solution of algorithm 2. Changing the location of initial solution may change solution. As it is depicted in Table 3, we run algorithm 2 in seven run with a different initial solution in each run and there are two different solutions. Algorithm 2 is a rapid heuristic algorithm and it can solve large sized problem, but it depend on initial solutions.

3. Conclusions

In this paper, we develop two heuristic algorithms for transfer point location problem. The first algorithm is based on determining clusters of demand points and the latter determine location of TP in first step. We use minimax as objective function since in emergencies, it is important to have least distances to hospital. For the future research, it is recommend to solve multiple transfer point location with efficient heuristics or meta heuristics algorithm.

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Table 2. Sensitivity analysis on α for case 1.

α	0.3	0.4	0.5	0.6	0.7	0.8	**0.9**
X_{PT_1}	6.0326	6.0326	6.0326	6.0326	7.1404	7.1255	**7.1255**
Y_{PT_1}	2.3757	2.3757	2.3757	2.3757	2.6986	2.7334	**2.7334**
X_{PT_2}	5.3876	5.3876	5.3876	5.3876	5.3309	5.3362	**5.3362**
Y_{PT_2}	7.5677	7.5677	7.5677	7.5677	6.7136	6.7311	**6.7311**
CLUSTER1	{6,7,8}	{6,7,8}	{6,7,8}	{6,7,8}	{3,4,5}	{3,4,5}	**{3,4,5}**
CLUSTER2	{1,2,3,4,5}	{1,2,3,4,5}	{1,2,3,4,5}	{1,2,3,4,5}	{1,2,6,7,8}	{1,2,6,7,8}	**{1,2,6,7,8}**

Continue of Table 2. Sensitivity analysis on α for case 2.

α	0.3	0.4	0.5	0.6	0.7	0.8	0.9
X_{PT_1}	7.3778	7.4021	7.427	7.4524	7.4784	7.505	7.5322
Y_{PT_1}	3.3125	3.3654	3.4185	3.4717	3.525	3.5786	3.6323
X_{PT_2}	5.0437	5.0574	5.0625	5.0625	5.0625	5.0625	5.0625
Y_{PT_2}	10.3123	10.3489	10.3626	10.3626	10.3626	10.3626	10.3626
CLUSTER1	{1,2,3,4, 8,10,11}	{1,2,3,4, 8,10,11}	{1,2,3,4, 8,10,11}	{1,2,3,4, 8,10,11}	{1,2,3,4, 8,10,11}	{1,2,3,4, 8,10,11}	{1,2,3,4, 8,10,11}
CLUSTER2	{5,6,7,9,12}	{5,6,7,9,12}	{5,6,7,9,12}	{5,6,7,9,12}	{5,6,7,9,12}	{5,6,7,9,12}	{5,6,7,9,12}

Continue of Table 2. Sensitivity analysis on α for case 3.

α	0.3	0.4	0.5	0.6	0.7	0.8	0.9
X_{PT_1}	6.0461	6.0461	6.0461	6.0461	6.0461	6.0461	6.0461
Y_{PT_1}	6.4832	6.4832	6.4832	6.4832	6.4832	6.4832	6.4832
X_{PT_2}	5.1891	5.1855	5.1819	5.1784	5.1749	5.1714	5.1679
Y_{PT_2}	11.9824	11.9984	12.0143	12.03	12.0455	12.0609	12.0762

Table 3. Sensitivity analysis on initial solution for case 3 ($\alpha = 0.9$)

		Run						
		1	2	3	4	5	6	**7**
Initial Solutions	X_{PT_1}	9	10	8	9	7	9	**11**
	Y_{PT_1}	4	7	7	15	12	6	**16**
	X_{PT_2}	7	10	12	12	8	8	**7**
	Y_{PT_2}	12	13	10	10	5	13	**7**
Final Solutions	$X^*_{PT_1}$	6.0461	6.0461	6.2806	5.1679	5.1679	6.0461	**3.4444**
	$Y^*_{PT_1}$	6.4832	6.4832	8.267	12.0762	12.0762	6.4832	**8.9179**
	$X^*_{PT_2}$	5.1679	5.1679	8.4688	6.0461	6.0461	5.1679	**7.4263**
	$Y^*_{PT_2}$	12.0762	12.0762	4.9967	6.4832	6.4832	12.0762	**8.2681**

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