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Lexicographic approach in location-distribution modeling considering customers priorities

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Abstract: In this paper a multi-echelon location-distribution problem is modeled considering customer priorities. A lexicographic approach is implemented to determine the most preferred distribution path according to the customers' priorities. We also considered capacity of trucks that moved from depots and satellites. The results show that the proposed approach can better consider the customers with different priorities while more important customers will have less total costs considering the classic approach. More over The sensitivity analysis has been done for the proposed approach.
Keywords: lexicographic, location-distribution, customer priorities, distribution network design

1. INTRODUCTION

In this paper dealing with a multi-echelon location-distribution problem with different customers' priorities is presented considering predefined number of trucks. Related works of this study can be divided in two main groups of distribution center location and problems considering customer priority. The distribution centers location is a well-known problem of supply chain network design, which considers the location of central depots, depots, satellites and their allocation structure to the customers. There are lots of works in these two groups, while there are a few works considering two groups together. The following table compares existing studies of mentioned groups:

Table 1

Researcher	*Type of problem*	*Echelon*	*Capacity*	*Customer priority*
Hindi and basta [1]	Distribution center	Single	No	No
s cokekez [2]	Distribution center	Single	Yes	No
Tragantalerngsak [3]	Distribution center	Multi	Yes	No
Eskigun E [4]	Distribution center	Single	Yes	No
Gendron B [5]	Distribution center	Multi	No	No
Cobham [6]	Assignment	Single	No	Yes
Hemant [7]	Job shop environment	Single	No	Yes
Schilling [8]	Maximal covering	Single	No	Yes
This research	Distribution center	multi	Yes	Yes

This paper has been organized as following; in the next section related parameters, variables and assumptions are presented. In section 3 the proposed model and proposed solution algorithm are presented. Hypothetical numerical example has been illustrated considering sensitivity analyses have been reported in the last section.

2. DEFINITION AND ASSUMPTION

Parameters and variables are defined as following.

T: number of priority and t is counter.

D, S, L, Lt : Sets of potential sites to locate depots, satellites, customers, and customers with priority t.

$D_j^s, S_i^D, S_l^L, S^{Lt}$: Sets of potential sites to locate depots connected to satellite j, satellites connected to depot i, satellites connected to customer l, satellites connected to customers with priority t.

Lt_j^S, Lt_i^D : Sets of customers with priority t connected to satellite j and depot i.

n_l : Number of product units be delivered to customer l.

Q : Number of units in one batch.

P, R : Capacity of large-size and small-size trucks for transportation of products units

f_i, fs_j : Fixed establishment cost of depot i and satellite j.

g_j : Packing cost per one batch in the satellite j.

d_i, e_{ij}, c_{jl} : Transportation cost for using one large-size truck (between center depot and depot i), small-size truck (between depot i and satellite j), and transportation between satellite j and customer l.

Tc_c^t, Tc_i^t : Number of large-trucks in central depot, and number of small-size trucks in depot i for iteration t

<u>*Integer variables*</u>;

$u_j, t_i, h_{i,j}$: The number of batches, large-size trucks, small-size trucks that are required for satellite j, depot i.

<u>*Binary variables:*</u>

$x_{jl}=1, w_{ij}=1$: If connected between satellite j and customer l, between depot i and satellite j

$y_i=1, ys_j=1$: If depot i, satellite j are opened

$ky_i=1, o_j=1$: If depot i, satellite j be opened in previous iterations.

<u>*Continues variable:*</u>

v_{ij} : Number of products transshipped between depot i and satellite j.

F_{ij}^{t+1}, VT_i^{t+1} : Remaining capacity of small-size trucks between depot i and satellite j, large-size trucks between center depot and depot i in iteration $t+1$

ss_j^{t+1} : Remaining capacity of products in batch in satellite j for iteration $t+1$

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A. *Assumption*

1. There are two types of trucks include of large-size (for move between central depot and depots) and small-size (for move between depots and satellites)
2. Customer priorities are obtained according to the DM opinion.

3. MODELING AND SOLUTION ALGORITHM

A. *Modeling (with customer priority)*

$$\sum_{i\in D} f_i y_i^t (1-ky_i^t) + \sum_{j\in S} fs_j ys_j^t (1-o_j^t) + \sum_{j\in S} g_j u_j^t + \sum_{i\in D} d_i N_i + \sum_{i\in D}\sum_{j\in S} e_{ij} Ns_{ij}$$
$$+\sum_{j\in S}\sum_{l\in L} c_{jl} x_{jl} + \sum_{i\in D} 2d_i (t_i - N_i) + \sum_{i\in D}\sum_{j\in S} 2e_{ij}(h_{ij} + Ns_{ij}) \qquad (1)$$

$$\sum_{j\in S_l^{Lt}} x_{jl} = 1 \qquad \forall l \in Lt, \qquad (2)$$

$$\sum_{i\in D_j^S} w_{ij} \le 1 \qquad \forall j \in S^{Lt}, \qquad (3)$$

$$N_i \le t_i \qquad \forall i \in D, \qquad (4)$$

$$N_i \le Tc_c^t \qquad \forall i \in D, \qquad (5)$$

$$Ns_{ij} \le h_{ij} \qquad \forall i \in D, \forall j \in S, \qquad (6)$$

$$Ns_{ij} \le Tc_i^t \qquad \forall i \in D, \forall j \in S, \qquad (7)$$

$$w_{ij} \le y_i^t \qquad \forall i \in D, \forall j \in S_i^D, \qquad (8)$$

$$w_{ij} \le ys_j^t \qquad \forall i \in D, \forall j \in S_i^D, \qquad (9)$$

$$\sum_{j\in S_i^D} v_{ij} \le (\sum_{l\in Lt_i^D} n_l) y_i^t \qquad \forall i \in D, \qquad (10)$$

$$\sum_{j\in D_j^{S^{Lt}}} v_{ij} \le \sum_{l\in L_j^{S^{Lt}}} n_l x_{jl} \qquad \forall j \in S^{Lt}, \qquad (11)$$

$$v_{ij} \le (\sum_{l\in L_j^{S^{Lt}}} n_l) w_{ij} \qquad \forall i \in D, \forall j \in S^{Lt}, \qquad (12)$$

$$x_{jl} \le \sum_{i\in D_j^S} w_{ij} \qquad \forall j \in S^{Lt}, \forall l \in Lt_j^S, \qquad (13)$$

$$\sum_{l\in lt_j^S} n_{lt} x_{jl} \le u_j^t Q + ss_j^t \qquad \forall j \in S \qquad (14)$$

$$\sum_{j\in S_i^D} v_{ij} \le t_i P + VT_i^t \qquad \forall i \in D, \qquad (15)$$

$$v_{ij} \le h_{ij} R + F_{ij}^t \qquad \forall i \in D, \forall j \in S_i^D, \qquad (16)$$

$$ky_i^{t+1} \le y_i^t + ky_i^t \qquad \forall i \in D, \qquad (17)$$

$$o_j^{t+1} \le ys_j^t + o_j^t \qquad \forall j \in S, \qquad (18)$$

$$ss_j^{t+1} = (u_j^t Q - \sum_{l\in Lt_j^S} n_{lt} x_{jl}) + ss_j^t \qquad \forall j \in S, \qquad (19)$$

$$VT_i^{t+1} = (t_i P - \sum_{j\in S_i^D} v_{ij}) + VT_i^t \qquad \forall i \in D, \qquad (20)$$

$$F_{ij}^{t+1} = (h_{ij} R - v_{ij}) + F_{ij}^t \qquad \forall i \in D, \forall j \in S, \qquad (21)$$

$$Tc_c^{t+1} = Tc_c^t - \sum_{i\in D} N_i \qquad (22)$$

$$Tc_i^{t+1} = Tc_i^t - \sum_{j\in S} Ns_{ij} \qquad \forall i \in D, \qquad (23)$$

$$u_j, t_i, h_{i,j}, N_i, Ns_{i,j} \ge 0 \text{ and integer} \qquad (24-28)$$

$$x_{jl}, w_{ij}, y_i, ky_j, ys_j, o_j \in \{0,1\} \qquad (29-34)$$

$$v_{ij}, F_{i,j}, VT_i, ss_j \ge 0 \qquad (35-38)$$

The objective function (1) consists of operational cost in the satellite and transportation cost between the center depot and depots, depots and satellites, satellites and customers, (2)-(3) ensure that each customer is connected to depot with one path, (4 to 7) determine the minimum number of existing and required trucks in depot and satellites, (14 to 16) determine number of required trucks and batches considering remain capacities from previous iterations.

B. *Solution algorithm*

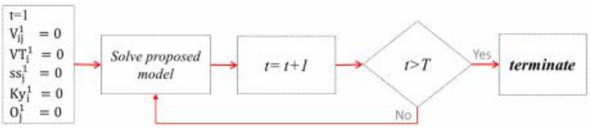

Figure 1: The schematic view of proposed iterative algorithm

The proposed solution algorithm has been illustrated in fig.1. It is worth to mention that the proposed procedure contains customer priorities so the problem should be solved in different iterations. In the case of customers with the same priority (T=1), then proposed procedure will have the same result of classical model.

4. ILLUSTRATIVE EXAMPLE

	proposed approach	classic approach
total cost	22845	20380
total cost considering more important customers	11015	11375

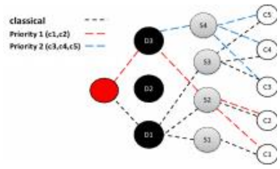

Figure 2: An example of proposed model application

According to fig.2 it can be concluded that the total cost of customers with higher priorities have been reduced about 3.2% by the proposed model.

Some simulated data were generated according to the problem assumption, then the proposed model was solved by the solution algorithm for each generated data set. The sensitivity analysis shows that if the priority is based on customer demands, by increasing of the average difference between demands of customers, the proposed model result will be closer to the classical model.

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