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RECONNECTION OF ROUTES IN DESIGNING OPTIMAL BUS NETWORK

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1. INTRODUCTION

Network Design Problem is rich in many suboptimal solutions, it is then preferable to concentrate on good alternative rather than devoting a considerable amount of effort while searching for the optimal one. It is argued, however, in Sutanto [1)] that 'best' routing for bus network might be improved by route reconnection and so results in better objective function optimized in the model. In the remainder of this paper the heuristic approach developed to deal with bus network problem is explained.

2. MODEL DESCRIPTION

The model developed deals with optimizing bus network in which demand is elastic, so shifting of demand between modes (i.e. bus and automobile) is considered. Furthermore routes and frequencies are chosen as control variables in the optimization process. It is , however, assumed in this paper that pattern of bus routes has been obtained so that the remaining problems are to find more connections of each route and the related frequency. The bus network design problem is formulated as minimization of generalized total system cost, Z, along with a set of constraints:

$$\begin{aligned} \min_{F,R} \quad Z(\mathbf{F},\mathbf{R}) \quad = & \quad \alpha_1 \Sigma_{rs} q_{rs} + \alpha_2 \Sigma_k M_k F_k + \alpha_3 \Sigma_{rs}(q_{rs}T_{rs} + \hat{q}_{rs}\hat{T}_{rs}) \\ & + \alpha_4 \Sigma_l Cp_l + \alpha_5 \Sigma_{rs} Tr_{rs} \end{aligned} \tag{1}$$

Subject to;

$$\mathbf{x}(\mathbf{F},\mathbf{R}) \tag{2}$$

$$F_k \geq F_{min} \quad \forall \quad k \tag{3}$$

$$\Sigma_k Tb_k \leq FS \tag{4}$$

The total system cost determined above comprises of total car operating cost, total bus operating cost, total time cost for both users, crowding and transfer costs for bus users respectively. $(\mathbf{F},\mathbf{R})$ denotes sets of frequencies and routes, while constraints are multimodal user-optimal flow, frequency and fleet size constraint respectively.

3. METHODOLOGY OF SOLUTION

Given the availability of data needed such as layout of physical network and its link cost functions, existing routes and OD demand the following steps are used to solve the problem.

Step 1.

This step deals with Modal-Split Assignment for a certain set of frequencies and computes the objective function. For this step Frank-Wolfe algorithm based on Logit demand model is used.

Step 2.

In this step the frequencies are optimized by using Hooke-Jeeves algorithm. The optimization is done by comparing values of objective function for certain set of frequencies under its optimal flow condition given in step 1.

			Difference	
For $\theta = 1.0$	Up to phase 4	Complete	Absolute	Relative (%)
Objective Function	450.877	446.652	-4.225	-0.94
No. of Buses	132	128	-4	-3.03
No. of Bus Riders	26.492	31.437	4.945	18.67
For $\theta = 0.5$				
Objective Function	420.929	396.823	-24.106	-5.73
No. of Buses	94	146	52	55.32
No. of Bus Riders	67.099	92.875	25.776	38.42
For $\theta = 0.25$				
Objective Function	404.316	365.946	-38.370	-9.49
No. of Buses	54	80	26	48.15
No. of Bus Riders	112.940	138.908	25.968	22.99

Table 1: Some Determinants for Different Values of θ

Step 3.

Knowing the frequency of each route and bus travel time obtained in previous steps, average dwell time of bus at bus stop and bus layover time, the number of buses needed can be computed. This is done by re-dispatching bus, which has served one direction, to serve the opposite direction.Furthermore it is assumed that the first bus arrives will be re-dispatched first and no interlining is allowed. Similar discussion can be found in Sutanto and Shimazaki [2].

Step 4.

This step is purely the reconnection of each bus route to some adjacent nodes that would improve the objective function. This step is done on each link along the route by imposing also travel constraint so that reconnection between two nodes must not exceed certain percentage of direct travel time between the two nodes. For this purpose, two heuristic searches and their combinations are used, that is a) Route Length order (random, ascending and descending) and b) Link Load Order (random, ascending and descending). Finally, this step is repeated by involving execution of step 1 to 3 until no more improvement is made.

4. NUMERICAL RESULTS AND CONCLUSIONS

Sioux-Falls[3] network data is used to see the performance of the model. The network consists of 24 nodes and 76 links, and for sensitivity analysis different value of θ of the logit model are tested. Table 1 shows the numerical results and some determinants of the related network.

It is seen from the table that improvement level is increasing by decreasing values of θ which means also the increasing number of bus ridership. Finally, it is expected that this model can be used for improving existing routes and evaluating various objective functions and parameters for different purposes of design.

REFERENCES

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3) LeBlanc, L.J. et.al. An Efficient Approach to Solving The Road Network Equilibrium Traffic Assignment Problem. Trans. Res. Vol. 9, 1975. pp. 309-318.