DEVELOPMENT OF A CALCULATING ALGORITHM FOR DSO SOLUTION ON A SIMPLE NETWORK

Kyoto University Student member ◎ Pirapol Limratanakulchai
Kyoto University Member Toshio Yoshii

1. Introduction

In 1970's, the pioneering dynamic network traffic simulation models were developed. *CONTRAM, SATURN* are famous models to calculate DUE (Dynamic User Equilibrium) solution, but it can be applied only to quite simple network due to computer capacity. After that, many dynamic traffic simulation models are developed and applied to actual traffic network for various purposes. Most of them reproduce traffic condition dynamically under the principle of DUO (Dynamic User Optimum). In the algorithm of DUO, vehicles are assumed to choose their routes based on present instantaneous travel times and individual driver will choose the minimum cost route in the simulation. On the other hand, DSO (Dynamic System Optimum) assignment is useful to "*Minimizing total cost*". It is strongly required for making effective traffic controls such as ramp metering, road pricing, TDM policies and others.This study, therefore, develops a DSO calculating algorithm, and it is verified by applying to a simple network.

2. Framework

2.1 Study network:

We consider a single OD demand onto a simple network, shown in Fig.1, of a parallel freeway and an arterial street on each of which one bottlenecks exists. And free flow travel time via freeway (T_f) is less than that via an arterial street (T_a), and the toll on freeway is not taken into account in this study.

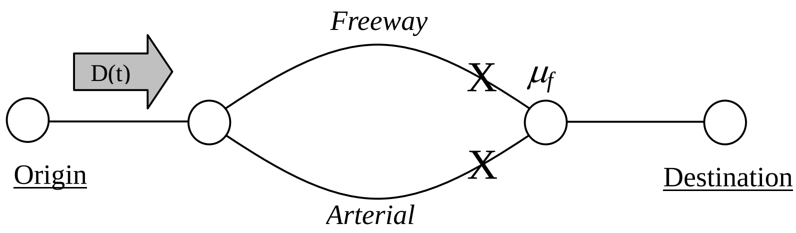


***Figure 1**: The study network*

2.2 Assumption:

- The demand function is convex, and has just one peak as shown in Fig.2, and the rate of the peak is greater than the capacity of the bottleneck on the freeway.
- The capacities of all links excluding freeway are assumed to be enough to allow the demand pass through without queue.

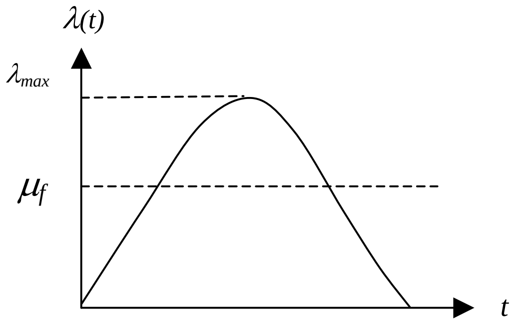


***Figure 2**: Traffic demand.*

2.3 Assignment

For the assignment, modified SOUND is used. SOUND[1)] is a dynamic traffic simulation model which can get the DUO solution. All individuals choose the minimum travel time route in SOUND, but the modified SOUND in this study deals with two groups of vehicles, "controlled group" in addition to the "uncontrolled group". Vehicles of controlled group are assigned to the route on which it is minimum Dynamic Marginal Cost (DMC). DMC at time t describes how much travel time changes due to the additional unit arrival rate at time t. It is reported by Kuwahara et al.[2)] that the marginal cost at time t is calculated as sum of free flow travel time and "congestion time" defined as the time duration from time t to the queue vanishing time.

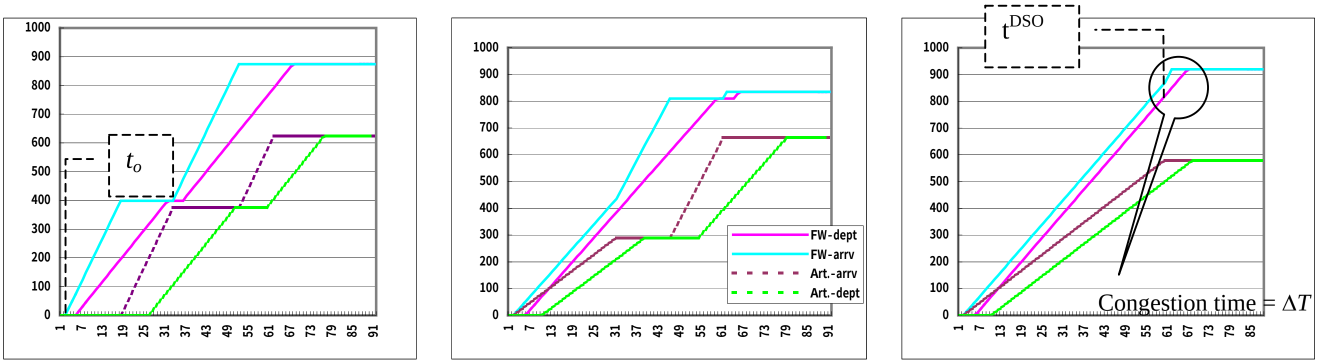
3. The DSO Algorithm

In order to achieve the DSO solution, the congestion time must equal to the difference between travel time of freeway and arterial ($\Delta T = T_f - T_a$). Repeated iteration is required for that purpose and this algorithm calculates the DSO

Keywords: DSO Assignment, Marginal Cost, Traffic Simulation
Address: 606-8501 京都市左京区吉田本町 京都大学大学院工学研究科都市社会工学専攻
TEL. +81-75-753-5136 / FAX. +81-75-753-5916
E-mail: pirapol@term.kuciv.kyoto-u.ac.jp

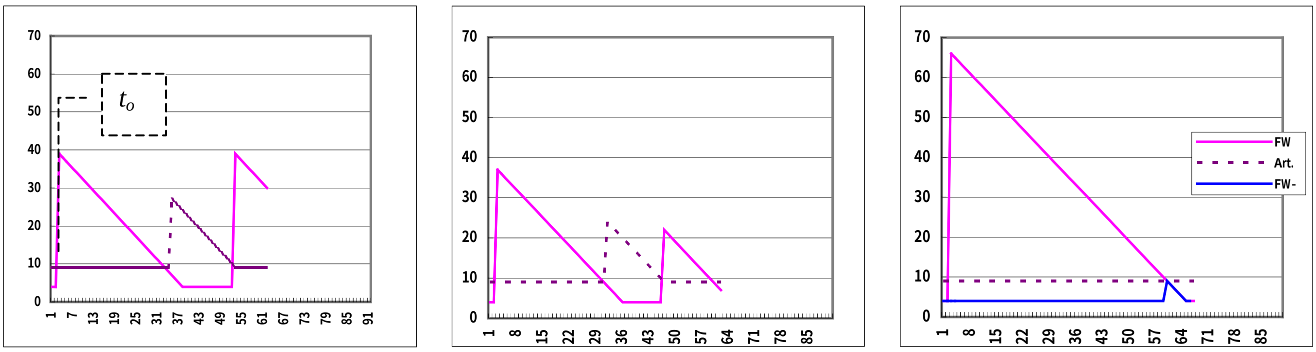
solution by iterating process as follows. In the first iteration, all vehicles are considered to belong to the uncontrolled group and they are assigned to each of the route in accordance with DUO principle. Figure 3(a) and 4(a) shows the solution of this iterative process in the cumulative numbers of vehicles arriving at and departing at the bottleneck links on each route, and also DMC of each links. Then travel demand in short time period, δt (says 1 min.), after t_o on freeway are separated into the 2 groups if the DMC of Freeway is greater than that of Arterial. The flow that stays just equal to its bottleneck capacity is identified as the uncontrolled group and the exceeding flow from bottleneck capacity is identified as the controlled group. Vehicles belong to the latter group are considered to choose the best route using the network which link costs are determined by DMC. Link costs of them are calculated by summing up their free flow travel time and the congestion time in previous iteration. In the following iterative process, some traffic demands in the next time period are shifted to the controlled group and the simulation is implemented. The calculation is iteratively implemented until the DMC of freeway is less than that of arterial during all of study time. Figure 3(b) and 4(b) shows the cumulative numbers of arriving and departing vehicles on each link, and also DMC of each link at 30th iteration. Finally, the iterative process terminated at 59th iteration, when congestion time equals to ΔT as shown in Fig 3(a) and 4(c).

According to Fig.4, the DMC of freeway at t_o is maximum value and decreases at the rate of –1. When the freeway marginal cost becomes smaller than the arterial marginal cost, the entire demand should be assigned to the freeway. Thus, no demand should be on arterial.



***(a)**: The first iteration.* ***(b)**: The 30th iteration.* ***(c)**: The final iteration (59th).*

Figure 3: The cumulative numbers of both links



***(a)**: The first iteration.* ***(b)**: The 30th iteration.* ***(c)**: The final iteration (59th).*

Figure 4: Dynamic Marginal Cost

4. Result and Future Scope

Now the proposed calculating algorithm in this study is confirmed to achieve DSO solution by applying on just simple network. However, a real network is much more complicated; therefore, we would expand to apply on general networks.

References

1) Yoshii, T. et al., “Development of Traffic Network Simulation Model for Oversaturated Traffic Flow on Urban Expressways”, Traffic Engineering Vol.30, No.1, pp.33-41, 1995.

2) Kuwahara, M, et al. “An Analysis on Dynamic System Optimal Assignment and Ramp Control on a Simple Network”, Journal of Infrastructure Planning and Management Vol.667/50, pp59-71, 2001