Evaluation of Traffic Information Provision with Stochastic User Equilibrium

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1. Introduction

The traffic information is provided to the drivers rather easily by recent development of Intelligent Transport System (ITS). The information provision is considered with many types of equipment such as navigation, information board, information radio and so forth. If the drivers obtain the traffic information on the road, he may change the routes corresponding to the informed traffic condition. It is commonly known that the impact of information provision is quite large for the decision of drivers. In this sense, traffic flow is automatically balanced though the information provision. However, the optimal distribution of traffic information on the network is considered in the study. The evaluation process is proposed with considering SUE conditions and the numerical example is introduced as well.

2. The Concept of Traffic Information Provision

The present situation of traffic information provision is mentioned to consider the efficient way to distribute the information on the networks. As many events occur on the roads, several types of information are demonstrated to the drivers in urban networks. Traffic information is relating with two types of events such as daily event and accidental event. For example, the bottleneck congestion, traffic restriction and construction works are informed to the drivers as usual events. On the other hand, the traffic accidents, breakdowns are considered as non-daily events. The traffic management sectors such as regional police and expressway public corporation usually take the sequential steps as data collection, data processing and information provision[1]. The traffic information is formulated through the process and provided to the drivers. Therefore, the evaluation of information provision is commonly formulated as $S = m \cdot f$ where m and f indicate the importance of the information and traffic flow concerning with the event respectively. The importance of the event is determined from its characteristics. It is often determined concerning with the scale of impacts and level of emergency. Even though this measure is easily determined, it cannot indicate the dynamic change of traffic corresponding to the traffic information. In the study, the measure related with the traffic would be proposed.

3. Representation of Traffic Information Provision

The numerical example is illustrated in **Figure 1** to represent the realistic situation. All links on the network are regarded as one-way roads. A link is characterized by a BPR function as $t_a(x_a) = t_a^0[1 + 0.15(x_a/Q)^4]$. Each traffic volume for possible O-D is assumed to be 10,000. There are four variable information boards indicated as rectangles on the networks. Assume that three events are observed on the links as follows:

E-1: The speed of vehicles should be reduced because of the frozen surface of the road as link 13.

E-2: The capacity of the road should be reduced because of the breakdown vehicle staying on link 14.

E-3: The capacity of the road should be reduced because of the serious accident occurring on link 23.

The stochastic user equilibrium is assumed to describe the traffic flow on the network. The advantage of the SUE algorithm is to determine the paths used by the drivers between the particular origin and destination.

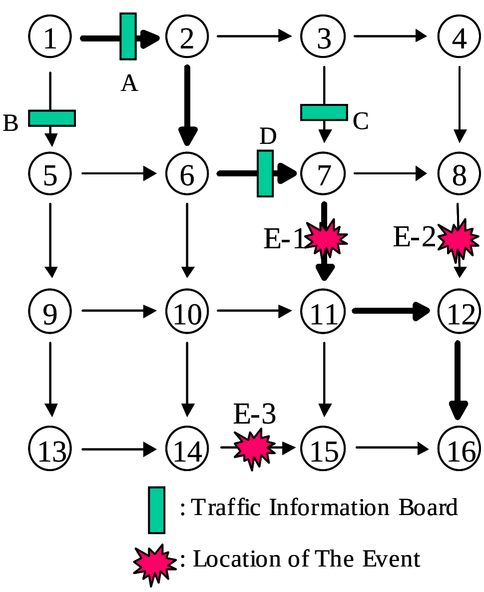

Figure 1 Network Example

Key words : Information Provision, SUE, Traffic Information, Route Guidance, Total Travel Time, Social Cost

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4. Evaluation of Information Provision

Evaluation steps are proposed considering the traffic flow on the network with/without information provision as follows:

[Step 1]: The traffic flows on the network are estimated under the normal condition without any event. It corresponds to SUE traffic flows. The path flows are estimated by SUE algorithm as MSA involving the Dial approach[2].

[Step 2]: The physical conditions for related links are changed according to the observed events on the networks.

[Step 3]: Calculate the total travel time assuming that all drivers use the route as before because they do not recognize the change of road conditions without traffic information. The total travel time becomes greater than that of Step 2.

[Step 4]: Determine the paths via the link installed the information equipment and the link located the events. The path flows are removed from the loaded traffic on the network. The flows should be loaded on the network again.

[Step 5]: Assume the drivers on the related paths mentioned above may change the route according to the provided information. At the same time, the other drivers do not change the route to maintain the same paths.

[Step 6]: The removed path flows are assigned on the network under the physical road conditions with events.

[Step 7]: Calculate the total travel time from the link flows loaded in Step 6. It corresponds to the social costs.

[Step 8]: Evaluation. The reduction of total travel time on the network is calculated from the results in step 3 and step 6. The reduction indicates the benefit of traffic information provision in terms of social cost.

The effects of the events are described as the change of physical conditions on the road. The value of initial travel time for link 13, t_{13}^{0} is changed from 0.5 to 1.0 in the BPR function for **E-1**. The capacity of link 14 is reduced from 40,000 to 30,000 for **E-2**. Similarly, the capacity for link 23 is reduced from 40,000 to 20,000 for **E-3**. In this formulation, three pieces of information relating the events are separated to display at four locations. Therefore, the combination for locations of traffic information can be counted as 3^4=81. The reduction of total travel time is regarded as the benefit of information provision. The scale parameter θ is equal to 1.5 in SUE calculation. After the reduction of total travel time is estimated for all cases, the results for top five cases are summarized in **Table 1**. It is known from the results in case S and case 1 that about 70% of travel time is increased with the events. The reductions of travel time for these cases are shown with effective combination of Information. The distribution of information as (A, B, C, D)=(E-3, E-3, E-1, E-2) is recommended in this example. Particularly, it is known from the results that the event, E-3 should be displayed on the information board B. If the combinational optimization technique such as Genetic Algorithm (GA) is introduced, the same evaluation approach may be applied in the real scale network.

Table 1 Evaluation Results for Top Five Cases

Case	Assumption				Total Travel Time	Reduction
S	Normal Condition				6,918,022	
0	Events without Information				11,700,398	
	Information Boards					
	A	B	C	D		
1	E-3	E-3	E-1	E-2	10,432,768	1,267,630
2	E-3	E-3	E-2	E-1	10,463,584	1,236,814
3	E-1	E-3	E-1	E-2	10,597,187	1,103,211
4	E-2	E-3	E-2	E-1	10,614,453	1,085,945
5	E-1	E-3	E-2	E-1	10,737,837	962,561

4. Concluding Remarks

Efficient Information provision is an important subject in ITS. The fundamental idea is formulated to evaluate the distribution of the information is proposed. As the approach can be applied with particular assumption in traffic flow, the following further studies are strongly recommended to extend the method for the real scale information provision.

1. The route choice of the driver is strongly influenced by the perceived traffic information. Therefore, the display of information should be investigated to express the physical change of the road conditions causing by the events.
2. As many pieces of information are provided to the driver at the same time in the real road system, the route choice should be formulated under the mixed and complicate distribution of information.
3. The dynamic change of traffic and different personalities of the drivers should be considered to estimate the traffic flow realistically. The network simulator would be introduced to describe the situation of dynamic SUE.

References

1) Hanshin Expressway Public Corporation, Traffic Control System For Safe and Comfortable Driving, 1999.
2) Sheffi, Y., Urban Transportation Networks, Prentice-Hall, 1985.