EVALUATION TOOLS FOR THE EFFECTS OF ETC TOLL PLAZA ON ROAD NETWORKS

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ABSTRACT

This research purposes to develop practical tools to evaluate the effects of ETC (Electric Toll Collection) system on road networks. In this paper, the analytical methodology to evaluate the capacity of toll plaza with ETC is proposed at first. Subsequently, two exiting simulation models, AVENUE and SOUND, are extended to estimate the total effects of ETC on road networks. After these two models are verified by comparing the analytical methodology, they are applied to the case studies with real network.

INTRODUCTION

This paper purposes to develop practical tools to evaluate the effects of ETC (Electric Toll Collection) system on road networks. ETC is rapidly installed at the expressway interchange in Japan. As ETC in Japan is based on road-vehicle communication technology, the improvement on the capacity of toll plaza apparently depends on the diffusion of on-vehicle equipment. In this paper, the analytical methodology to evaluate the capacity of toll plaza with ETC is proposed at first. The methodology considers not only the proportion of the equipped vehicles to the demand but also the usage of

upstream lanes for the toll plaza, such as ETC exclusive use or shared use. It is also considered the situation described in Figure 1, which the queue of non-equipped vehicles spills over the toll plaza and obstructs the equipped vehicles to enter the exclusive lanes. In such case, the capacity of toll plaza will get worse than the former plaza before ETC installed.

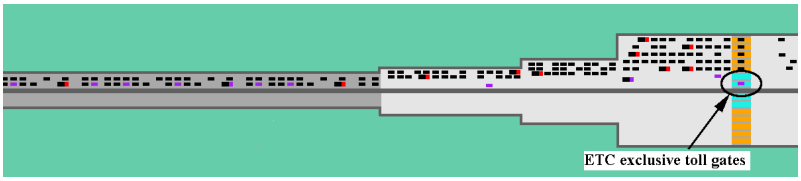

Figure 1. Image of ETC toll plaza where the queue of non-equipped vehicles obstructs the way of equipped vehicles.

EXTENSION OF EXISTING SIMULATION MODELS FOR ETC EVALUATION

For the practical applications, it is obviously insufficient only to consider the improvement on the capacity of ETC toll plaza, because there must be some up/downstream bottleneck sections adjacent to the toll plaza. An increase of the capacity of one bottleneck will change the demand profile to the downstream bottleneck. Sometimes, the queue heading to the downstream bottleneck may set back and drops the throughput of the upstream section. When a network becomes complicated, only the dynamic traffic simulations are available to estimate the total performance of the network for practical use. Consequently, in this paper, two exiting simulation models, AVENUE (Horiguchi, *et al*, 1996) and SOUND (Yoshii, *et al*, 1995), are extended to estimate the total effects of ETC on road networks. AVENUE is normally applied to surface street networks that may include toll plaza at an interchange. It involves microscopic traffic flow features such as vehicles, lanes, signal control devices, etc. On the other hand, SOUND can be applied to the road networks widely spreading over large city. It treats traffic with meso-scopic flow expression and reasonably reproduces shockwave propagation.

VERIFICATION OF ETC EXTENSION OF THE SIMULATION MODELS

Simulation approach, however, always faces to criticism that the casual relationship between model parameter settings and the results is unclear like black box, so that it is required to verify the model behavior by comparing with the result of theoretical analysis (Horiguchi, *et al*, 2000). For the subject of this paper, the extension of ETC toll plaza should be verified by comparing the reproduced capacity with the values calculated with the analytical method proposed here.

Figure 2 shows one of the simulation results of AVENUE in the verification of the extension for ETC toll plaza. In this case, the simulation result achieves the toll plaza capacity at 748[veh./hr] against the theoretical capacity value of 778[veh./hr]. Although there are slight differences coming from the randomness in arrival reproduced by the simulation models, the results support that they reasonably follows theoretical values.

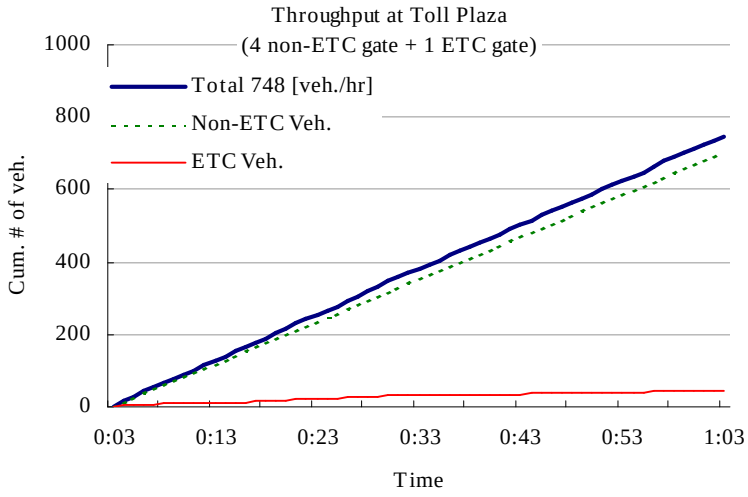

Figure 2. Throughput of the simulation result for the verification of ETC toll plaza of which theoretical capacity is 778[veh./hr]. (AVENUE)

CASE STUDIES OF ETC EVALUATION

In order to demonstrate the evaluation using two simulation models, two case studies are included at the end of this paper. First case applies AVENUE to the section from Tokorozawa interchange to Nerima exit on Kan-Etsu expressway illustrated in Figure 3. In this section, heavy congestions heading to Niiza toll barrier are frequently seen on holidays. It is expected that the queue will disappear when ETC is installed at the toll barrier, but the simulation result shows that half of the congestion will remain with newly heading to Nerima exit, where a signalized intersection stands close.

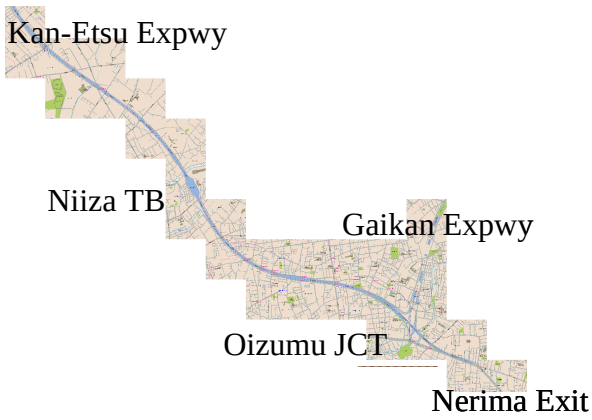

Figure 3. Study area 1 ~ Kan-Etsu expressway

Another case study uses SOUND to estimate the dispersion effects on congestion by additionally constructing low-cost exclusive interchange to serve ETC equipped vehicles. Figure 4 shows the study area along Tomei expressway, of which section from Atsugi interchange to Yokohama interchange. In the middle of this section, there exists a remarkable bottleneck besides Ayase bus stop. The distance between two interchange is now approximately 16 kilometers, and if the distance will be shortened into approximately 5 kilometers even for the equipped vehicles, the result of the study shows

significant improvement for the congestion.

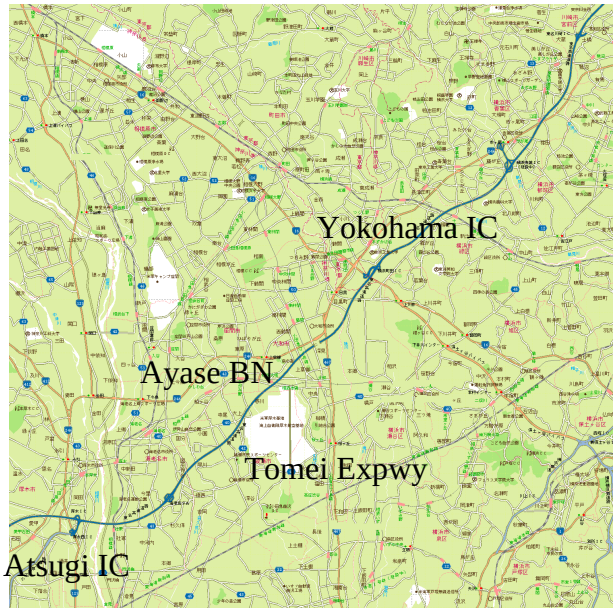

Figure 4. Study area 2 ~ Tomei expressway

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