Applications of Smart Card Data for Rail-oriented Transit System

Jin Ki Eom  
Senior Researcher  
Department of Transport&Logistics  
Korea Railroad Research Institute  
360-1, Uiwang, Korea  
Fax: +82-31-460-5467  
E-mail: jkom00@krri.re.kr

Dae-Seop Moon  
Research fellow  
Department of Transport&Logistics  
Korea Railroad Research Institute  
360-1, Uiwang, Korea  
Fax: +82-31-460-5477  
E-mail: dsmoon@krri.re.kr

Suk-Mun Oh  
Senior Researcher  
Department of Transport&Logistics  
Korea Railroad Research Institute  
360-1, Uiwang, Korea  
Fax: +82-31-460-5484  
E-mail: smoh@krri.re.kr

Abstract: The city of Seoul introduced a smart-card-based transit fare scheme in 2004. Interest in travel patterns of the passengers, particularly with regard to daily transit use, increased with the introduction of the smart card system. We are focusing on how to use this information extracted from the transit DB system and apply the data to transit system for better planning and operating of railway system. The study introduces the development of NxTIS (Next generation Transport Information System) and Real OD DB from the transit smart card data. The NxTIS consists of three functional parts: 1) Advanced Transit Demand Analysis System, 2) Optimizing Railway Scheduling System, and 3) Multimodal Transit Network Analysis System. This system will be beneficial to transit agencies and land use planners for promoting more transit-friendly communities.

Key Words: Transit Smart Card, Real OD, Transit DB, NxTIS

1. INTRODUCTION

The city of Seoul introduced transit smart card system in 2004 and this boosts the expansion of national wide transit card system. Introduction of transit smart card system gives a lot of benefits to passengers and transit agencies as it provides valuable information for analyzing travel behavior of transit users. The potential use of transit card data in the field of transit system planning and transit vehicle operation was reported many times. Bagchi and White (2005) reported that transit card data allow transit operators to estimate the cycle of card use and the ratio of trips and transfers per card. Further the data will improve existing processes and models for travel behavior analysis. Chu and Chapleau (2008) analyzed the archived transit smart card data for transit demand planning and provided methodologies to evaluate bus service level. The transit smart card system in Seoul is known as one of the most advanced and expanded systems in the countries. With the advanced smart card technologies, the development of next generation transport information system (NxTIS) based on real OD (origin-destination) DB is under developing for enhancing transit system which minimize transit transfer time and waiting time by optimizing transit schedules, and for planning effective transit route planning that attract more transit passengers by shifting travel mode.
This paper introduces the general ideas and the contents of NxTIS which consists of three main sub systems: 1) Advanced Transit Demand Analysis System, 2) Optimizing Transit Scheduling System, and 3) Combined Transit Assignment System.

2. Next Generation Transit Information System (NxTIS)

2.1 Real OD DB system

Real OD DB is obtained from the card data representing individual whole travel records from origin to destination. The origin and destination represents any bus stops and railway stations where passenger’s boarding and alighting happens. Hence, the DB system provides the trip chains of each transit users until their travel is complete. Table 1 shows the contents of the recorded information on smart card data. The actual number of recorded fields was more than 30, but we only 17 fields as listed in the table are used in DB system. Similar to other transit smart card systems, this includes individual card ID, boarding and alighting time, transit mode, type of user, location of boarding and alighting, etc. One interesting record is the transaction ID, which identifies transfer trips between modes with a maximum of four transfers. In 2009, the transit smart card system collected data associated with 490 metro stations and more than 36,000 bus stops in Seoul and Kyeonggi province.

<table>
<thead>
<tr>
<th>Information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Card ID</td>
<td>Card number for each smart card</td>
</tr>
<tr>
<td>Departure time</td>
<td>Bus departure time</td>
</tr>
<tr>
<td>Transaction ID</td>
<td>Distinguished ID for Transfer</td>
</tr>
<tr>
<td>Type of mode</td>
<td>Bus(local/main/feeder/metropolitan/circle bus), Metro</td>
</tr>
<tr>
<td>Number of transfers</td>
<td>Number of transfers (from 0 to 4)</td>
</tr>
<tr>
<td>ID of bus route</td>
<td>Given number of every bus route</td>
</tr>
<tr>
<td>ID of bus company</td>
<td>Given number of every bus company</td>
</tr>
<tr>
<td>ID of vehicle</td>
<td>Given number of every operated bus</td>
</tr>
<tr>
<td>Type of user</td>
<td>Adult, Student, Children or Elderly</td>
</tr>
<tr>
<td>Boarding time</td>
<td>Boarding time (year/month/day/hour/minute/second)</td>
</tr>
<tr>
<td>ID of boarding location</td>
<td>Given number of boarding bus/metro stop</td>
</tr>
<tr>
<td>Alighting time</td>
<td>Alighting time (year/month/day/hour/minute/second)</td>
</tr>
<tr>
<td>ID of alighting location</td>
<td>Given number of alighting bus/metro stop</td>
</tr>
<tr>
<td>Number of passenger</td>
<td>Number of passenger</td>
</tr>
<tr>
<td>Basic fare</td>
<td>Starting(base) fare</td>
</tr>
<tr>
<td>Additional fare</td>
<td>Additional fare with distance</td>
</tr>
<tr>
<td>Travel Distance</td>
<td>Distance from origin stop to destination stop</td>
</tr>
</tbody>
</table>

Figure 1 shows the example of a transit route connecting origin to destination that user choose based on transit card data. Also the real OD DB system provides OD table of the number of passengers by time of day and transit mode.
2.2 Advanced Transit Demand Analysis System
The Real OD DB provides observed travel distance by each transit mode from origin to destination which will be critical information for modifying and calibrating the existed trip distribution of zonal based OD tables estimated by using traditional travel survey method in Seoul. Another benefit from the Real OD DB is that the x-y coordinates of each bus stop and station are obtained. Based on the observed x-y coordinates, a mode choice model considering spatial effect among the passenger boarding locations will be developed. The spatial mode choice model allows to estimate transit mode share not only the observed places, but also the unobserved places where the card data are not recorded. The advanced transit demand analysis system will include these functions for better representing of travel demand.

2.3 Optimizing Train Schedule & Passenger Loading System
In order to minimize the waiting time and transfer time between train lines, the optimized train schedule will be obtained based on the transit smart card data. Further, the rail and bus schedule are able to be synchronized by multi-modal scheduling simulation that coordinates two mode schedules for ease transfers. This system is also expected to handle the unexpected situations like an accident by suggesting an alternative schedule. This system may improve railway capacity and attract more passengers to transit.
2.4 Combined Transit Assignment System

The combined transit assignment system has a role that it does predict the travel demand as an estimated number of passengers for all transit modes in case a new railway or bus route is introduced. The output of the estimated travel demand will be sent to train schedule system for rescheduling transit modes to enhance transit ridership and optimize transit operation. This feedback procedure will be required to get the final output settled.

3. CONCLUSIONS

This paper briefly introduces the purpose of development of next generation transport information system and its components. The NxTIS will provide reliable estimates of passenger travel patterns and transit schedule which are expected to be much better in terms of accuracy and reliability compared to traditional approaches. This is because the data obtained transit smart card system is almost one-hundred percent real. Therefore, the NxTIS will be
informative to transit agencies and planners for making better decisions on transit operation and new route alternatives. This meets the goal of new paradigms on public transportation policies such as transit-oriented development (TOD) and development of green-growth and low-carbonized communities.

REFERENCES


