Information System for Predicted Arrival Time of Expressway Bus

ITS R&D Division
National Institute for Land and Infrastructure Management
Ministry of Land, Infrastructure and Transport

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Today’s Topics

1. Needs for travel time prediction information
2. Rationale for travel time predictions
3. Route selection and subject sections for applying the methods
4. Study of macro-simulation approach
5. Study on method of statistic using bus probe
6. Conclusion
1. The needs for bus travel time prediction information

Expressway Bus Operational Status

Increasing bus ridership year by year

Revision of Road Transport Act (Feb. 2002) enacted
- allows operators to establish a new bus operation business on new routes
- with a new fare system
- increased routes with higher frequency
- lower fare system than those of air or rail

Incremental ridership
Inherent flaw in transit bus

- delays due to congestion → uncertainty in travel time

In one case, a route requiring a 14 minute minimum run time requires a maximum 41 minutes (an example on Metropolitan Expressway)

Travel time prediction information is required for expressway bus uses
## 2. Rationale for travel time prediction

**Milestone in the Course of System Development**

1. To configure a system on the premise of effective operations on the real routes
2. To offer information services on travel time prediction to meet the needs of users
3. To offer information services on travel time prediction provided an hour in advance
4. To establish a prediction method applicable to those in other regions
5. To utilize traffic counters and probe systems for prediction
6. To disclose the rationale for the prediction method and calculation processes to the public
Rationale for Travel Time Prediction

Instantaneous value and time slice value

<table>
<thead>
<tr>
<th>Current time</th>
<th>section 1</th>
<th>section 2</th>
<th>section 3</th>
<th>section 4</th>
<th>section 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00</td>
<td>5min</td>
<td>3min</td>
<td>2min</td>
<td>4min</td>
<td>4min</td>
</tr>
<tr>
<td>10:05</td>
<td>5min</td>
<td>3min</td>
<td>4min</td>
<td>6min</td>
<td>7min</td>
</tr>
<tr>
<td>10:10</td>
<td>5min</td>
<td>4min</td>
<td>5min</td>
<td>7min</td>
<td>7min</td>
</tr>
<tr>
<td>10:15</td>
<td>? A vehicle operating at a real site</td>
<td>8min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:20</td>
<td>8min</td>
<td>6min</td>
<td>7min</td>
<td>8min</td>
<td>9min</td>
</tr>
</tbody>
</table>

To predict travel time, both a prediction of travel time for each section, and the ‘time slice value’ are required

(1) Macro-simulation approach: uses traffic data from traffic counters
(2) Statistic method using bus probe data: uses travel time data from probe cars
3. Route selection and subject section for applying the methods

**Route Selection**

Selects the course of Central Japan International Airport - Sakae bus terminal (center of Nagoya)
### Subject Section of Travel Time Prediction

#### Macro-simulation approach

<table>
<thead>
<tr>
<th>(1) Outline</th>
<th>(2) Required data</th>
<th>(3) Subject section</th>
</tr>
</thead>
</table>
| Traffic volume, density, and capacity is used for traffic simulation to predict travel time ahead | • traffic volume in 5 min. intervals  
• average speed in 5 min. intervals  
Traffic counters are used | **Nagoya Expressway section**  
(a section between Ohtaka ramp and Marunouchi ramp) |

#### Statistic approach using bus probe data

<table>
<thead>
<tr>
<th>(1) Outline</th>
<th>(2) Required data</th>
<th>(3) Subject section</th>
</tr>
</thead>
</table>
| **The past travel time data** provides a basis for travel time predictions | • traffic time in the past  
Probe data is used | **Other than Nagoya Expressway**  
• Central Japan International Airport  
• Chita road  
• Chita peninsula road  
• general road |
4. Study of Macro-simulation Approach

Study Subject of Macro-simulation Approach

I/O rule

- Road network formation
- An initial set value

Upstream calculation
(1) identifies inflow volume, demerge ratios
(2) calculates traffic volume and checks demand volume

Downstream calculation
(1) calculates backup traffic volume
(2) calculates passing volume, number of vehicle at present

Prediction terminate?

No
- Calculates traffic volume by time
- Calculates accumulated traffic volume
- Calculates travel time

Yes

*calculation in 5 min

QK-pattern / Traffic capacity set
(1) Precision test on the current conditions

Inflow volume

Demerge ratios

Past traffic data (traffic counter)

Traffic data in real time (traffic counter)

Basic pattern creation
(2) Shift analysis during days of week
(3) Shift analysis during peak period

Modification of a basic pattern
(4) Study of modification approach by real time data

: input parameter (a basic pattern)
(1) Precision Test on the Current Conditions

Conducts simulations to calculate travel time using volume data as an input values

→ Compared to the true travel time

<table>
<thead>
<tr>
<th>gap</th>
<th>Oct. 11th (Fri), 2002</th>
<th>Nov. 7th (Thurs), 2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accumulation frequency</td>
<td>Accumulation %</td>
</tr>
<tr>
<td>Less than 1 min</td>
<td>113</td>
<td>67%</td>
</tr>
<tr>
<td>Less than 2 min</td>
<td>145</td>
<td>86%</td>
</tr>
<tr>
<td>Less than 3 min</td>
<td>160</td>
<td>95%</td>
</tr>
<tr>
<td>Less than 4 min</td>
<td>164</td>
<td>98%</td>
</tr>
<tr>
<td>Less than 5 min</td>
<td>168</td>
<td>100% %</td>
</tr>
</tbody>
</table>

96% are within a 3 minute gap → Verifies QK-pattern and traffic capacity
(2) Shift Analysis during Days of Week

Creates a basic pattern reflecting traffic shifts during days of week

- Weekday (Mon – Fri)
- Saturday
- Sunday, holiday

Traffic volume varies with time

Creates each basic pattern

Traffic volume varies with time (Meishi ingress)
(3) Shift Analysis during Peak Period

Creates a basic pattern reflecting traffic shifts during peak periods

- Off days in summer
- New Year’s holidays

differs greatly from a general pattern (weekday, Sat, Sun, holiday)

• Difficult to generalize the peak traffic into a basic pattern
• Copes with modifications using real time data (of traffic counter)

Time sequential traffic volume shifts
(summer holidays)

Time sequential traffic volume shifts
(New Year’s holidays)
(4) Study of Modification Approach by Real Time Data

The true traffic volume varies with day of week, and it does not converge on a basic pattern.

Using **real time data from traffic counters**, a basic pattern is modified and used as an input parameter.

As time passes, the ratio decreases.

Inflow volume

- True value
- Prediction input value

Basic pattern

- Present
- 1 hour
- 2 hours
- 3 hours

time \( t_0 \)

‘Modification coefficient’ for inflow volume

‘Modification coefficient’ for demerge ratio
Predictions from 5 minutes to 30 minutes in advance fall within 5-minute gap.

Simulation calculation for 60 minutes in advance sometimes exhibits more than a 5-minute gap, but its shift pattern is all but converge.

<table>
<thead>
<tr>
<th>Departure time</th>
<th>Travel time (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00</td>
<td>5:00</td>
</tr>
<tr>
<td>7:00</td>
<td>4:00</td>
</tr>
<tr>
<td>8:00</td>
<td>2:00</td>
</tr>
<tr>
<td>9:00</td>
<td>0:90</td>
</tr>
<tr>
<td>10:00</td>
<td>0:00</td>
</tr>
<tr>
<td>11:00</td>
<td>3:00</td>
</tr>
<tr>
<td>12:00</td>
<td>4:00</td>
</tr>
<tr>
<td>13:00</td>
<td>5:00</td>
</tr>
<tr>
<td>14:00</td>
<td>6:00</td>
</tr>
<tr>
<td>15:00</td>
<td>7:00</td>
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<tr>
<td>16:00</td>
<td>8:00</td>
</tr>
<tr>
<td>17:00</td>
<td>9:00</td>
</tr>
<tr>
<td>18:00</td>
<td>10:00</td>
</tr>
<tr>
<td>19:00</td>
<td>11:00</td>
</tr>
</tbody>
</table>

Outcome for 5 min in advance
Outcome for 15 min in advance
Outcome for 30 min in advance
Outcome for 60 min in advance
The true travel time

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Nagoya Expressway: Ohtaka ramp – Marunouchi ramp
Test day: Oct. 11th (Fri), 2002

<table>
<thead>
<tr>
<th>Advance Time</th>
<th>Gap: 95 percentile</th>
<th>Less than 5-min gap%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 min advance</td>
<td>3.0 min</td>
<td>100.0%</td>
</tr>
<tr>
<td>15 min advance</td>
<td>4.1 min</td>
<td>98.8%</td>
</tr>
<tr>
<td>30 min advance</td>
<td>5.0 min</td>
<td>95.2%</td>
</tr>
<tr>
<td>60 min advance</td>
<td>7.3 min</td>
<td>82.7%</td>
</tr>
</tbody>
</table>
5. Method of Statistics by Bus Probe

Data from probe cars
- Vehicle position data
- Passing time data at checkpoint
  ...

Data from traffic counters
- Traffic volume
- Average speed
  ...

(1) Creates basic statistical pattern for travel time

(2) Predicts a travel time through modification approach using real time data (from traffic counters)
6. Conclusion

1. We have forged the travel time prediction system using the existing traffic counters and a bus probe system.

2. We have proposed the ways to modify and to set traffic volume in order to replicate future traffic conditions.

3. Further specifications of the system have yet to be completed.