Punctuality analysis using a microscopic simulation in which drivers’ behavior is considered

Y. Ochiai
Odakyu Electric Railway Co., Ltd

N. Tomii
Chiba Institute of Technology, Japan
Our Aim

- Delays at terminal < 2 minutes during rush hours
- Establish an approach to increase punctuality

Microscopic simulation in which drivers’ behavior is considered

Application

- Track relocation

Conclusions
Our Aim - 1

Background

- A lot of complaints about delays from passengers
  - Several minutes delay very often happen during rush hours
  - Regaining punctuality is necessary

Our Target

- Arrival delays at the terminal station must be less than two minutes everyday even during rush hours
  - This target is not realized yet.
  - At present: 59.0%
Our Aim-2

- Trains are running very densely
- Only a part is quadruple track
- Knock on delays very often occur

Diagram:

Higashi-kitazawa
Shimo-kitazawa
Setagaya-daita
Umegaoka

Double
Quadruple

6' 40"
Our Aim-3

- We would like to establish an approach of punctuality analysis
  - Analysis of current situation
  - Estimation of future
- Detailed analysis is necessary
  - Microscopic simulation
  - Signaling system + Train operation
    - Drivers’ behavior has to be explicitly considered
Outline

- **Our Aim**
  - Delays at terminal < 2 minutes during rush hours
  - Establish an approach to increase punctuality

- Microscopic simulation in which drivers’ behavior is considered

- **Application**
  - Track relocation

- **Conclusions**
Drivers’ behavior -1

Without consideration

① This train suddenly takes a brake when it is accelerating.
② It is impossible to continue driving a train exactly with the same speed of the speed limit.
Drivers’ behavior -1

With consideration

① The train has to coast before it takes brake.
② The train will repeat acceleration, coasting and braking if there is a speed limit.
There exist a slight difference between these two curves and we think the blue line is more natural and similar to actual ones.
Consider Drivers’ behavior

- In order to obtain precise and practical results of simulation, we need to consider drivers’ behavior explicitly.

- Microscopic simulation is widely used for punctuality analysis.
  - But drivers’ behaviors have not been considered explicitly!
Algorithm

- When we calculate the (technically) minimum running time, we use “backtracking”
Algorithm

- When we calculate the (technically) minimum running time, we use “backtracking”
- But drivers cannot backtrack!
  - We have to decide where the driver takes brake without using “backtracking.”

```
Speed Limit

[Graph showing speed limit and speed]
```
Comparison - 2

Real World

Simulation without considering Drivers’ behavior

Simulation in which Drivers’ behavior is considered

Succeeded to obtain more realistic results!
Outline

- **Our Aim**
  - Delays at terminal < 2 minutes during rush hours
  - Establish an approach to increase punctuality

- **Microscopic simulation in which drivers’ behavior is considered**

- **Application**
  - Track relocation

- **Conclusions**
Application

- Track relocation - outline
  - Some parts of the tracks were moved to underground
  - To remove level crossings
Application

- **Track relocation - outline**
  - Some parts of the tracks were moved to underground
  - To remove level crossings
  - Preparation phase to make the track quadruple

- **Possible disadvantages for punctuality**
  - Analyzed countermeasures to prevent delays from increasing
◆ If the dwell time at Station Shimo-Kitazawa is 65 sec, …

◆ If the dwell time at Station Shimo-Kitazawa is 75 sec, …

◆ Where does a train have to stop, if the signal is Red?
  • 30 m outside of the signal?
  • 50 m outside of the signal?
Results of simulation

Arrival Delay at Terminal (min.)

Dwell time at Station Shimo-kitazawa (sec)

- Plan 30m
- Plan 50m

=> Plan 50m is better!
Before and After

**Before**

(An average value of the specified 19 days between 2012/12 – 2013/02)

**After**

(An average value of the specified 32 days between 2013/04 – 2013/07)
## Before and After

### The number of days (delay less than 2min.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>8</td>
<td>8</td>
<td>7</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>13</td>
<td>13</td>
<td>127/245</td>
<td>51.8%</td>
</tr>
<tr>
<td>2013</td>
<td>9</td>
<td>9</td>
<td>13</td>
<td>16</td>
<td>19</td>
<td>13</td>
<td>11</td>
<td>12</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>16</td>
<td>144/244</td>
<td>59.0% (+7.2%)</td>
</tr>
</tbody>
</table>

Below is a chart showing the number of days with delays less than 2 minutes for each month in 2012 and 2013. The chart compares the total number of days with delays in each year and shows a slight increase in the total number of days with delays in 2013 compared to 2012.
Conclusion

- Introduced a microscopic simulator in which drivers’ behavior is considered
- Validated accuracy by comparing the results with real world data
- Introduced examples to which we applied the simulator
  - The results show our approach worked very well