Modernization of the RATP Railway Network

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The RATP group problematic

16 M, 2 RER and 8 T
≈ 3 billions passengers/year
One of the most dense in the world

Increase of passengers number ⇒ maximum productivity, reach system intrinsic capacity

A small disturbance can impact dramatically the traffic performance

Operating studies help determine strategies optimizing KPY such as punctuality, robustness etc…
Two operating strategies considered

- Classical operation (Headway = 90s)
- Classical operation + intermediate terminus (Headway = 90s/180s)

Which one is the best?

- Punctuality
- Robustness
Simulation of an incident

• Damage train can’t move for 15 min
• Localization: Gare de Lyon Station Track 2
• Delay before first turn around: 5 min
Implementation of regulation methods in OpenTrack (1/2)

**Anti-stacking (using trains connections)**

- Two trains (2 & 3) can’t be in the same interstation if another train (1) is still waiting in the next station (A).
- Train 3 has to wait in station B until train 1 leaves station A.

**Ahead regulation (using trains connections)**

- Limit huge headway creation by adding delay to trains ahead of the incident.
- Delay added:
  - Train 1 : 0
  - Train 2 : \( \frac{X}{(n-1)} \)
  - Train 3 : \( 2\frac{X}{(n-1)} \)
  - Train n-1 : \( (n-2)\frac{X}{(n-1)} \)
  - Max headway : \( H_w + \frac{X}{(n-1)} \)

**Implementation of turn around (modification of itineraries)**

- After 5 min, trains are turned around using the switch in the stations juxtaposing the incident.
Implementation of regulation methods in OpenTrack (2/2)

Terminus margins (Timetable management)

- Trains can reduce their delay using the margins set up in each position of a terminus
- Margin = DwT_{timetable} – DwT_{mini}
- Total Margins = ∑Margins = 100s
- Departure delay = Arrival delay - 100s

Faster speed profile (Train category management)

- When a train is late, it can change its speed profile to reduce its running time in the interstation up to 4% of the “normal” running time

Train Parking/Injection (Courses management)

- When a train delay is too important, it’s possible to park this train and inject another one in the correct corridor to reduce its delay instantly
Simulations results and analyze

Simulation during morning peak hours

Classical operation

Classical operation + intermediate terminus

- Trains coming from Terminus 2
- Trains coming from Terminus 1
- Trains turned around
- Trains parked/injected
- Trains running on the Spiral
- Trains departing from the intermediate terminus Track 2
- Trains going to the intermediate terminus Track 1
- Trains turned around
- Trains parked/injected
Simulations results and analyze

Localisation

Anti-staking

Ahead regulation
Simulations results and analyze
Simulations results and analyze

Delay comparison: Arrival in terminus 2

Classical operation

1 : Increase of delay due to the ahead regulation
2 : Maximum delay -> First train turned
3 : Homogeneous delay
4 : Decrease of delay (anti-staking)

Classical operation + intermediate terminus

1 : Increase of delay due to the ahead regulation
2 : Homogeneous delay
3 : Decrease of delay (anti-staking)
Simulations results and analyze

Departure delay from the intermediate terminus

Classical operation + Intermediate terminus

1 : Increase of delay due to the ahead regulation
2 : Homogeneous delay
3 : Decrease of delay
Simulations results and analyze

<table>
<thead>
<tr>
<th>Performance indicators</th>
<th>Classical operation</th>
<th>Classical operation + Intermediate terminus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of turn around</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Number of injection</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Number of parking</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Maximum headway</td>
<td>422</td>
<td>318</td>
</tr>
<tr>
<td>Maximum delay</td>
<td>312</td>
<td>208</td>
</tr>
<tr>
<td>Time for recovery</td>
<td>58min33s</td>
<td>51min45</td>
</tr>
</tbody>
</table>
Calibration of the junction model on Line B/D

Infrastructure between Chatelet and Gare du Nord stations.

Gare du Nord

Chatelet

Headway B Line : 180s
Headway D Line : 180s/360s/360s
Circulation cycle : B-D-B-D-B-D-B-B-D-B
Circulation Feedback/Simulation – Gare du Nord Station Dwell Time

Dwell time at Gare du Nord station as a function of the dynamic headway

Feedback

Simulation

Mean Dwell Time: B = 68 s et D = 83 s

Mean Dwell Time: B = 68 s et D = 82 s
Less than 10% of the trains manage to achieve the theoretical running time
However 90% of the trains only see green aspects

➔ Drivers slow their speed to avoid yellow aspects
Circulation Feedback/Simulation – Tunnel Running Time (2/2)

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Simulation</th>
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<tr>
<td>Running time in the tunnel as a function of the spatial headway</td>
<td></td>
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</table>

Mean Running Time: B = 215 s et D = 222 s

Mean Running Time: B = 217 s et D = 220 s
Circulation Feedback/Simulation – Châtelet Station Dwell Time

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</table>

Mean Dwell Time: B = 68 s et D = 109 s

Mean Dwell Time: B = 77 s et D = 110 s

Difficulty to mix junction regulation and dwell time distribution
Circulation Feedback/Simulation AP – Tunnel Running Time

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<tr>
<td>Running time in the tunnel as a function of the spatial headway</td>
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</table>

**Mean Running Time:**

- Feedback: $B = 215 \text{ s} \text{ et } D = 222 \text{ s}$
- Simulation AP: $B = 176 \text{ s} \text{ et } D = 173 \text{ s}$
- Mean Running Time: $B = -40\text{ s} / D = -60\text{ s}$
Thank you for your attention