Passenger Travel Time Reliability for Multi-Modal Public Transport Journeys

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Introduction

• Reliability: ‘Certainty of service aspects compared to the schedule as perceived by the user’ (van Oort, N., 2016)

• Reliability of travel time
  – Regularity
  – Punctuality
Motivation

- Urban transit networks typically multi-modal
- Reliability based on the whole journey experience including the transfers

Two leg journey with two transit modes

<table>
<thead>
<tr>
<th>Waiting time</th>
<th>In-vehicle time</th>
<th>Transfer time</th>
<th>Waiting time</th>
<th>In-vehicle time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode 2</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Motivation

• Urban transit networks typically multi-modal
• Reliability based on the whole journey experience including the transfers
• Existing indicators
  – Focus on one mode only, or
  – Fail to include all travel time components

Requires passenger travel data at the network-level
Objective

• To develop a metric that
  – measures reliability for multi-modal transit journeys;
  – is sensitive to all travel time components; and
  – enables comparison between different transit modes and routes.

• Demonstrate its application to a real life network (Amsterdam)
Methodology - RBT

- **Reliability buffer time (RBT)** (Chan, 2007; Uniman et al, 2010)

  Difference between the 95\textsuperscript{th} and 50\textsuperscript{th} percentile travel time experienced by travelers between a stop-stop pair using a specific route*

  \[
  RBT_{o,d,r} = t_{95}^{o,d,r} - t_{50}^{o,d,r}
  \]

  Interpreted as the additional time passengers have to budget for their travel to ensure on-time arrival one out of twenty times

*Route : A combination of public transport services a passenger may choose, where each route may or may not include a transfer.
Data sources

• Smartcard data
  – Tap-in and tap-out location and times

• Automatic Vehicle Location (AVL) data
  – Vehicle number, stop location and time stamps
Data pre-processing

- Smartcard data
- AVL data

Data Cleaning + Fusion

Transfer Inference

Journeys Database

Gordon et al. (2013), Yap et. al (2017)
Travel time using smartcard data

- Where first tap-in at station (e.g., Amsterdam Metro)
  - Total travel time ($t_5-t_0$)

- Where first tap-in inside vehicle (e.g., Amsterdam buses & trams)
  - Total travel time minus waiting time at origin ($t_5-t_1$)
Waiting time at origin

- For journeys where first tap-in is inside the vehicle
  - Time passenger arrived at stop is not known
  - Headway of services known (from AVL data)
  - For short headway services – passengers assumed to arrive randomly
  - Continuous random variables generated and sampled over uniform distribution $[0, \text{observed headway}]$ to estimate waiting time for each journey
Travel time reliability for multi-modal journeys

- RBT calculated for each stop-stop (OD) pair and route

\[ RBT_{o,d,r} = tt_{95}^{o,d,r} - tt_{50}^{o,d,r} \]

- Weighted average calculated for each mode/line/stop
Case study: Amsterdam

- ~850,000 inhabitants
- 4 metro lines
- 15 tram lines
- 25 bus lines
- ~800,000 transactions/day

- Two weekdays (1\textsuperscript{st} and 2\textsuperscript{nd} March 2018) used for analysis
Results
## Reliability per mode

<table>
<thead>
<tr>
<th>Mode(s) used</th>
<th>Number of journeys</th>
<th>Median travel time (mins)</th>
<th>RBT (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unimodal Journeys</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro (incl. Metro-Metro)</td>
<td>235,287</td>
<td>14.7</td>
<td>5.9</td>
</tr>
<tr>
<td>Tram</td>
<td>315,410</td>
<td>15.4</td>
<td>6.6</td>
</tr>
<tr>
<td>Bus</td>
<td>104,495</td>
<td>14.8</td>
<td>6.2</td>
</tr>
<tr>
<td>Tram-Tram</td>
<td>1,755</td>
<td>23.2</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Multimodal Journeys</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metro-Tram</td>
<td>7,588</td>
<td>25.0</td>
<td>7.6</td>
</tr>
<tr>
<td>Metro-Bus</td>
<td>747</td>
<td>28.8</td>
<td>7.8</td>
</tr>
<tr>
<td>Tram-Metro</td>
<td>6,665</td>
<td>26.3</td>
<td>8.3</td>
</tr>
<tr>
<td>Bus-Metro</td>
<td>1,336</td>
<td>28.7</td>
<td>8.5</td>
</tr>
</tbody>
</table>
Reliability of accessing transit hubs
Reliability by route used - Station Sloterdijk to Boelelaan
Reliability by route used - Station Sloterdijk to Boelelaan
Conclusion

• New metric proposed for travel time reliability measurement
  – considering multimodal transit journeys
  – including waiting and transfer times for all legs of the journey
  – consistent for all journeys - comparable across modes and routes
• Demonstrated application to Amsterdam data but can be applied to other networks
• Can provide reliability at a very disaggregate level
  – flexibility of aggregation (eg. mode, transit stop and route level)
  – can be used as an input to behavioral models
Limitations and future work

- Assumed that passengers boarded the first vehicle (no denied boarding)
- Did not consider the impacts of availability of real-time information
- Low sample size
  - to be applied to a larger dataset
- Part of the ‘Impact of North-South Metro Line’ project
  - Reliability comparison of previous versus current network design
Thank you!

Questions?

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