Improving public transport decision making, planning and operations by using Big Data

Cases from Sweden and the Netherlands

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IEEE ITSC
Las Palmas 2015
Challenges in PT industry

Main challenges:
• Increasing cost efficiency
• Increasing customer experience
• Motivating new strategic investments

• Data and models enable achieving objectives
Approach

- New methodologies
- Proven in practice
Operations and feedback

- Real-time feedback loop
  Driver/Control room

- Strategic
  - Long term feedback loop
    - APC
    - AVL
    - Customer surveys

- Tactical
  - Short term feedback loop

- Operational
Applications

- Real-time information generation and dissemination
  - Real-time control strategies (e.g. holding, stop skipping)
  - Fleet management (e.g. short turning, deadheading)
  - Priority measures (e.g. traffic signal priority, dynamic lanes).

- Involve generating predictions on future system conditions

- Require instantaneous access to large amounts of online data and tools to assess and implement alternative measures in real-time

- Can be ultimately integrated into a decision support system
Applied examples

Monitoring and predicting passenger numbers: Whatif
Improving service reliability

Quantifying benefits of enhanced service reliability in public transport
Van Oort, N. (2012)., Proceedings of the 12th International Conference on Advanced Systems for Public Transport (CASPT12), Santiago, Chile.

Optimizing planning and real time control
Van Oort, N. and R. van Nes (2009), Control of public transport operations to improve reliability: theory and practice, Transportation research record, No. 2112, pp. 70-76.


Optimizing synchronization multimodal transfers
Lee, A. N. van Oort, R. van Nes (2014), Service reliability in a network context: impacts of synchronizing schedules in long headway services, Transportation Research Record, No. 2417, pp. 18-26

Improved scheduling

Case 1: The Hague, The Netherlands
Smartcard data (1/2)
The Netherlands
• OV Chipkaart
• Nationwide (since 2012)
• All modes: train, metro, tram, bus
• Tap in and tap out
• Bus and tram: devices are in the vehicle

Issues
• Privacy
• Data accessibility via operators

Data
• 19 million smartcards; 42 million transactions every week
• Several applications of smartcard data:
Smartcard data (2/2)

Our research focus:

**Connecting to transport model**
- Evaluating history
- Predicting the future
- Elasticity approach (quick and low cost)
Connecting data to transport model (1/4)

1) Importing PT networks (GTFS) (Open data)
Connecting data to transport model (2/4)

- 2) Importing smartcard data (Closed data)

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<th>Check in stop</th>
<th>Check out stop</th>
<th>Check in time</th>
<th>Check out time</th>
<th>Line number</th>
<th>(vehicle number)</th>
<th>(ticket type)</th>
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<td>4</td>
<td>..</td>
<td>Annual ticket</td>
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</tbody>
</table>
Connecting data to transport model (3/4)

3) Processing and matching

Processing smart card data
  - missing check outs
  - short trips
Connecting data to transport model (4/4)

4) Route choice and visualization options of transport model

- Boardings

- Fictitious data
Challenge the future - fictitious data
What if?
PT modelling

**Traditional (4-step) model**
- Multimodal (~PT)
- Network
- Complex
- Long calculation time
- Visualisation
- Much data
- Detailed results

**Simple calculation**
- PT only
- Line
- Transparent
- Short calculation time
- Only numbers
- Little data
- Assessments

**Short term predictions**

**Elasticity method based on smartcard data**
What if: elasticity approach (1/2)

\[ C_{ij} = \alpha_1 T_{ij} + \alpha_2 WT_{ij} + \alpha_3 NT_{ij} + \alpha_4 F_{ij} \]  

(1)

With:

- \( C_{ij} \): Generalized costs on OD pair \( i,j \)
- \( \alpha_1, \alpha_2, \alpha_3, \alpha_4 \): Weight coefficients in generalized costs calculation
- \( T_{ij} \): In-vehicle travel time on OD pair \( i,j \)
- \( WT_{ij} \): Waiting time on OD pair \( i,j \)
- \( NT_{ij} \): Number of transfers on OD pair \( i,j \)
- \( F_{ij} \): Fare to be paid by the traveler on OD pair \( i,j \)
What if: elasticity approach (2/2)

- Elasticities
- Literature (e.g. Balcombe)
- “Proven “ rules of thumb

- NOTE:
  - Simple changes
  - Short term
  - Only LOS changes
  - Accuracy
Whatif results: Flows rerouting
Whatif: increased speed
Case 2: Stockholm, Sweden
Stockholm trunk bus case study

- AVL for entire bus fleet used for:
  - Radio communication
  - Real-time monitoring
  - Fleet management strategies
  - Generation of real-time passenger information

- Ongoing work to make APC (10-15% buses) and AFC (90% users, check-in only) available in real-time
  - 5-7 min headway
  - Partially dedicated ROW
  - 58% of all bus pass-km in Stockholm inner-city
Primary problem: service unreliability

Line 1, 16:00-17:00

Challenge the future
Study objective and approach

- Developing and evaluating operational and control strategies to mitigate the bus bunching phenomenon

1. Analyzing reliability at the stop, line and network level
2. Investigate the underlying determinants of service reliability
3. Design and test – first in a simulation environment then in the field -
From Research to a Field Test

**Modeling** - Transit operations simulation model, BusMezzo

**Validation** - Tel-Aviv and Stockholm case studies

**Evaluation and Optimization** - Real-time holding strategies for Stockholm case study

**Series of experiments** – Field trials with lines 1,3 and 4 in Stockholm

**Implementation** – Full-scale operations and business model
More regular services
- Line 4, 7:00-19:00
Main outcomes from field experiments

- Excessive waiting time
- In-vehicle time
- Total travel time (1172->1056 sec)

- Annual savings of **4,5 million Euro** for weekdays 7am-7pm (underestimation of congestion effects)
Summary

- Major challenges in public transport
- Data supports optimization
- Evaluating and controlling -> predicting and optimizing

- Connecting data to transport models enables short term predictions
- Combining strengths of two approaches (complex <-> simple)

- Developing and evaluating operational and control strategies to mitigate the bus bunching phenomenon

Next steps
- Updating elasticities (using smartcard data)
- Additional factors in cost function (reliability, crowding, etc)
- Data fusion
Questions / Contact

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