A decision support system based on transport modelling for events management in Public Transport Networks

Laboratorio Mobilità e Trasporti - Politecnico di Milano
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Objectives

Development of a model and tool to analyse and manage the events causing the interruption or the reduction of a Local Public Transport service.

- Interventions on the transport supply

  Dimensioning of the replacement service, increase in the number of vehicles on the lines near the event, etc.

- Strategic indications to manage the demand

  Providing users with focused, timely and effective information so they can choose more appropriate routes and means
Approach and operating procedures

The implemented model and its tool, developed with Citilabs CUBE, consists in two separate simulations

- **Simulation 1**
  It allows a comparison between users’ flows as expected in the basic scenario and in the disrupted scenario. By evaluating the results of the first comparison, the model user may define the main parameters governing the following simulation.

- **Simulation 2**
  Enhancements for the offer system and users information are processed.
Main features of the transport model

A simulation model to describe the transport system was implemented by using data which define the supply (surban railways, undergrounds, tramways, trolleybuses and buses) and demand system.
Main features of the transport model

The model is based on a assignment that considers a generalized cost perceived by users for their transfers, i.e. the journey time:

\[ T^k = \beta_p t^k_p + \beta_a t^k_a + \beta_b t^k_b + \beta_{inc} \sum_{i \in I} (n^k_i t^i_{inc}) + \beta_{tras} \sum_{i,j \in I,J} (m^k_{ij} t^ij_{tras}) \]

- \( t^k_p \) is the total time on foot for the \( k \)-th route
- \( t^k_a \) is the total waiting for the \( k \)-th route
- \( t^k_b \) is the total time spent on the means for the \( k \)-th route
- \( \sum_{i \in I} (n^k_i t^i_{inc}) \) penalty for time necessary to get on certain means along the route
- \( \sum_{i,j \in I,J} (m^k_{ij} t^ij_{tras}) \) penalty for time necessary for the transfer from the \( i \)-th means of transport to the \( j \)-th means of transport
- \( \beta_p, \beta_a, \beta_b, \beta_{inc}, \beta_{tras} \) weighting coefficients of the components of the journey time

Affected by congestion
Output and results

The assignment carried for the disrupted (Disrupted Scenario) and non-disrupted condition (Basic Scenario), allows to compare the configurations that network flows assume in both situations.

- the variation of the average flow/capacity ratio on the whole route for each LPT line
- the maximum variation along the link that is mostly affected by the disruption

Quantification of the effects of the disruption on the public transport system and the priorities of any intervention
Definition of critical lines

Criticality thresholds can be defined to set the minimum limit of variation of flow/capacity ratio, below which a line can be defined as critical. For the critical lines, the model will suggest enhancements.

- Absolute minimum value of the flow/capacity ratio along the several line links
- Minimum percentage increase of the flow/capacity ratio along the several line links
- Extension of criticalities along the line

The possibility to dynamically and freely set crowding thresholds allows to concentrate the resources where they are most needed.

Useful feature in case of particularly disrupted situations (i.e. underground disruption)
Interventions on the offer: definition of enhancements

For critical lines, the number of additional means required is defined; the enhancement will be such as to bring the crowding condition on the line below the threshold value that first determined the condition of criticality.

**Intervention Scenario**

- Enhancements directly implemented in the offer graph
- Graph loaded with the flows based on the final configuration defining users’ optimum distribution on the network
- Real time use requires adequate sensitivity in use on the part of operators
- Operational limits prevent model enhancements to be implemented
- Set of Intervention scenarios prepared in peace time
- Implementation of each enhancement can be excluded
Management of the demand: information to users. Aggregate information

### Scenario Comparison

<table>
<thead>
<tr>
<th>Basic Scenario</th>
<th>Intervetion Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flows with no disruption</td>
<td>Flows with disruption + enhancements</td>
</tr>
</tbody>
</table>

**Identification of significative “diversion points” (i.e. stop-node) exceeding both these thresholds:**

- Threshold minimum percentage increase and decrease in the number of users getting on and off at the node for each LPT line
- Threshold minimum absolute increase and decrease in the number of users getting on and off at the node for each LPT line

**Possibility to dynamically and freely set value of thresholds to adapt the operation of the model to the single case under analysis**

- List of aggregate information to provide users
- Strategic network nodes where to provide information
Management of the demand: information to users. Disaggregate information

Specific files are provided reporting all the users’ routes as forecast in the optimum configuration of the intervention scenario, meant as a succession of lines from one’s origin to one’s destination.

For operators being present on the network to address individuals to their best route.

For single users to send specific information via smartphone or other mobile devices.
Case study

Interruption subway Line 1, between the stops of Pagano and Cadorna

<table>
<thead>
<tr>
<th>Nodo</th>
<th>Punto_destinazione</th>
<th>Destinazione</th>
<th>PAX</th>
<th>PAX_cum</th>
<th>Perc_cum</th>
<th>Azione</th>
<th>Mezzo_1</th>
<th>Mezzo_2</th>
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REPORT INFORMAZIONI - EVENTO M1-PAGANO-CADORNA

- Alla Stazione di PAGANO per raggiungere i quartieri DUOMO, GUASTALLA, MAGENTA - S. VITTORE, XXII MARZO, UMBRIA - MOLISE, ORTOMERCATO Scendere dalla linea M1 e successivamente Prendere le linee TRAM16
- Alla Stazione di PAGANO per raggiungere i quartieri DUOMO, GUASTALLA, GRECO, VIALE MONZA, PADOVA, LORETO, BUENOS AIRES - VENEZIA, esterne_9 Scendere dalla linea M1 e successivamente Prendere le linee Bus61 + M1
- Alla Stazione di PAGANO per raggiungere i quartieri BRERA, PARCO SEMPIANCHE, BUENOS AIRES - VENEZIA, CITTÀ STUDI, XXII MARZO Scendere dalla linea M1 e successivamente Prendere le linee Bus61
- Alla Stazione di PAGANO per raggiungere i quartieri BRERA, GARIBALDI REPUBLICA, CENTRALE, ADRIANO, PARCO LAMBRO - CIMIANO, PADOVA, CITTÀ STUDI, LAMBRATE, est Scendere dalla linea M1 e successivamente Prendere le linee Bus61 + M2
- Alla Stazione di CADORNA per raggiungere i quartieri BANDE NERE, LORENTEGGIO, FORZE ARMATE, DE ANGELI - MONTE ROSA, S. SIRO, TRENNO, GALLARATESE, QT S, CASCINA Scendere dalla linea M1 e successivamente Prendere le linee Bus61 + M1
Case study

Interruption subway Line 2, between the stops of Loreto and Cascina Gobba

Suggested Enhancements

<table>
<thead>
<tr>
<th>Line to enhance</th>
<th>No. of necessary means</th>
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</thead>
<tbody>
<tr>
<td>Bus 44</td>
<td>8</td>
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<tr>
<td>Bus 965</td>
<td>7</td>
</tr>
<tr>
<td>Bus 75</td>
<td>5</td>
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</tbody>
</table>
Case study

Interruption subway Line 2, between the stops of Loreto and Cascina Gobba

- **Loreto M1-M2:**
  - Prendere linea **Bus 39** proseguendo fino a **Lambrate M2**
  - Prendere linea **Bus 55** proseguendo fino a **Udine M2**

- **Pioltello:**
  - Prendere linea **Bus 965** proseguendo fino a **Loreto M1-M2**

- **Cascina Gobba M2:**
  - Prendere linea **Bus 44** proseguendo fino a **Gorla M1**
  - Prendere linea **Bus 75** proseguendo fino a **Udine M2**

- **Romolo M2:**
  - Prendere linea **S9** proseguendo fino a **MI Lambrate**

- **MI Lambrate:**
  - Non scendere dalla linea **R-Bergamo** ma proseguire fino a **MI Centrale**
  - **Lambrate M2:**
    - Prendere linea **Tram 23** proseguendo fino a **Via Bassini – Via Ponzio**
    - Prendere linea **Bus 93** proseguendo fino a **Via Celoria – Via Ponzio**
    - Prendere linea **Bus 39** proseguendo fino a **Loreto M1-M2**

- **MI Gobba:**
  - Prendere linea **Bus 71** proseguendo fino a **Gorla M1**
  - Prendere linea **Bus 75** proseguendo fino a **Udine M2**

- **Pioltello:**
  - Prendere linea **Bus 965** proseguendo fino a **Loreto M1-M2**

- **Romolo M2:**
  - Prendere linea **S9** proseguendo fino a **MI Lambrate**
Conclusions

• Definition of clear intervention solutions when a disruptive event occurs on a public transport system

• Results suitable and reliable for the set of case studies tested

• Results provided in a quick and ready-for-use format suitable for LPT companies

• Need to develop the integration with means of communication to provide customized information (twitter, app, VMS, …)
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