Real-time traffic forecast by means of macroscopic models for Dynamic Traffic Assignment: theory and practice

Guido Gentile

DICEA, University of Rome “La Sapienza”
Let’s start with the use case: requirements and delivery

Use of Dynamic Traffic Assignment models in mobility management centres

Formulation and solution of Dynamic User Equilibrium to obtain route choice probabilities

Dynamic Network Loading via General Link Transmission Model for Rolling Horizon simulation in real-time

Towards more data and model integration

Some real world application

Open issues
A USE CASE:
REQUIREMENTS AND DELIVERY
Optima and HyperPath for the Wien Region

Regional Supervisor

<table>
<thead>
<tr>
<th>Extension</th>
<th>27,000 square km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand zones</td>
<td>1096</td>
</tr>
<tr>
<td>Demand matrices</td>
<td>Hourly O/D matrices, 3 day types</td>
</tr>
<tr>
<td>Network model</td>
<td>50,000 link, &gt; 70,000 km</td>
</tr>
<tr>
<td>Assignment model</td>
<td>Dynamic Network Loading 5 min, Dynamic User Equilibrium 20 min</td>
</tr>
</tbody>
</table>
Goal of the project traffic prediction and infomobility

- Real time traffic monitoring of flow and speed
- Real time traffic forecast
- Simulation of events
- Parallel simulation of interventions
- Provide current and forecasted speeds to the national journey planner of the VAO project -> HyperPath
Real-time feeds
FCD and loop detectors
Real time monitoring and event management

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Challenges and solutions

- Very large network
  - Half-automatic methods to build, update, simplify and calibrate
  - The DNL in 1 minute on the “assignment” network

- Traffic events received in standard EU format (DATEX2) and geo-referentiatied to the national graph called GIP
  - Automatic calculation of event impacts starting form the type of the event and its standardized description

- Data fusion of FCD coming from city cabs (about 3000) and loop detectors (about 1000)
Unexpected congestion detected on the bridge
Congestion downstream
15 min forecast
Congestion upstream
15 min forecast
Validation through comparison of detector measure and forecast 15m

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GEH statistics to monitor and evaluate the prediction

GEH < 5 = GOOD

5 < GEH < 10 = FAIR

GEH > 10 = NOT GOOD

Maximum Allowable Variation: 5% vs GEH=5

\[ GEH = \sqrt{\frac{(M-C)^2}{(M+C)/2}} \]
Forecast used by HyperPath in VAO to improve journey planning
USE OF DTA MODELS FOR TRAFFIC MANAGEMENT
An operative system for mobility management and traffic control

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Why models in a control room: from data to information

- Traffic data Amplifier
- Real time Decision Support

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Augmented infomobility in space and time

FORECASTING FOR 7:30 AM FROM DTA MODEL
Dynamic Traffic Assignment
to road networks

- Use cases of DTA models
  - transport planning and management through off-line equilibrium
  - traffic monitoring and control through real-time network loading

- Main advantage
  - explicitly reproduce vehicle queues along links and their spillback at intersections
    - thus overcoming the weak representation of congestion by volume delay functions in static assignment models
  - react to unpredicted events (accidents, road works) and control countermeasures (vms, traffic lights)
    - thus overcoming the weak sensitivity of pattern recognition models
DTA models for traffic forecast: DNL and DUE

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FORMULATION AND SOLUTION OF DUE BASED ON ARC PROBABILITIES
Fixed-Point schema of DTA model with implicit path enumeration

\[ w_{adg}(\tau) \rightarrow \text{RCM} \rightarrow c_{ag}(\tau) \]
\[ p_{adg}(\tau) \rightarrow \text{FPM} \rightarrow \text{DNL} \]
\[ d_{adg}(\tau) \rightarrow \text{FPM} \]
\[ q_{adg}(\tau) \rightarrow \text{NCM} \]
\[ q_a(\tau) \rightarrow \text{NCM} \]
\[ \delta_a(\tau) \]

DUE = NCM → ACM → RCM → FPM → [MSA] → NCM
DNL = NCM → FPM → [MSA] → NCM
Variables: functions of time

- \( p_{agd}(\tau) \) probability that, at time \( \tau \in T \), users of class \( g \in G \) directed toward \( d \in Z \) choose to enter arc \( a \in A \) conditional on being at its tail

- \( d_{odg}(\tau) \) demand flow of class \( g \in G \) travelling from origin \( o \in Z \) to destination \( d \in Z \) and departing at time \( \tau \in T \)

- \( \delta_a(\tau) \) characteristic vector of arc \( a \in A \) at time \( \tau \in T \)

- \( q_{agd}(\tau) \) flow of class \( g \in G \) users entering arc \( a \in A \) at time \( \tau \in T \) directed to destination \( d \in Z \)

- \( q_a(\tau) \) volume entering arc \( a \in A \) at time \( \tau \in T \)

- \( \theta_a(\tau) \) exit time of arc \( a \in A \) for users entering at time \( \tau \in T \)

- \( c_{ag}(\tau) \) cost of arc \( a \in A \) perceived by class \( g \in G \) users entering at \( \tau \in T \)

- \( w_{agd}(\tau) \) expected disutility perceived by users of class \( g \in G \) entering arc \( a \in A \) at time \( \tau \in T \) and directed toward destination \( d \in Z \)
Travel times and vehicle flows in dynamic macroscopic models

\[ t_a(\tau) = \theta_a(\tau) - \tau \]

FIFO

\[ q_{ag}^{\text{cout}}(\theta) = q_{ag}^{\text{cin}}(\tau), \quad \tau = \theta_a^{-1}(\theta) \]

derivatives (chain rule and inverse)
Sequential Route Choice Model based on random utility e.g. DSP

\[ W_{bdmg}(\tau) = c_{bg}(\tau) + W_{b-dmg}(\theta_b(\tau)) \]

\[ W_{bdmgt} = c_{bgt} + W_{b^+dmg} + (\theta_{bt} - \tau_e) \cdot \frac{W_{b^+dmg e+1} - W_{b^+dmg e}}{h_e} \]

\[ p_{admg} = \begin{cases} p_{bdmg}(W_{bdmg}, \forall b \in i^+ \cap A_m), & \text{if } a \in A_m \\ 0, & \text{otherwise} \end{cases} \]

\[ W_{idmg} = W_{idmg}(W_{bdmg}, \forall b \in i^+ \cap A_m) \]

solve system in reverse chronological order
Flow Propagation Model based on arc probabilities

\[ q_{idmg}(\theta) = d_{idmg}(\theta) + \sum_{a \in i} \frac{q_{a-dmg}(\tau_a)}{\partial \theta_a(\tau_a)} \cdot p_{adm}(\tau_a) \]

\[ q_{idmg} = d_{idmg} + \sum_{a \in i} \sum_{e \in i} q_{a-dmge} \frac{h_e}{h_t} m_{aet} \cdot p_{adm} + \sum_{a \in i} q_{a-dmgt} m_{aet} \cdot p_{adm} \]

\[ \tau_a = \theta_a^{-1}(\theta), \forall a \in i^- \]

BiCGstab with preconditioning by efficient triangularized solution

node flow conservation

entry/exit map

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Functionals of the fixed point problems

- ACM – Arc Cost Model
- RCM – Route Choice Model
- FPM – Flow Propagation Model
- NCM – Network Congestion Model
Variational Inequality problem for deterministic route choices

- Focus on local choices at each node \( i \in N \) among its forward star made by users of class \( g \in G \) directed toward each destination \( d \in Z \)
- VI problem defined on probabilities
- Feasible set is a simple polytope
- Cost functional does includes the solution of DNL

\[
\sum_{d \in Z} \sum_{g \in G} \sum_{i \in N - d} \sum_{a \in i^+} \int w_{adg} \left( \mathbf{p}_{ADGT}^*, \tau \right) \left( p_{adg}^* (\tau) - p_{adg} (\tau) \right) d\tau \leq 0, \quad \forall \mathbf{p}_{ADGT} \in S_{p}^{ADGT}
\]

\[
S_{p}^{ADGT} = \left\{ \mathbf{p}_{ADGT} \in \mathcal{R}^{ADGT} : p_{adg} (\tau) \geq 0, \forall a \in A, \forall d \in Z, \forall g \in G ; \sum_{a \in i^+} p_{adg} (\tau) = 1, \forall i \in N - d, \forall d \in Z, \forall g \in G \right\}
\]

proved to be equivalent to path based formulation of DUE

\[
\sum_{k \in K} \sum_{g \in G} \int c_{kg} \left( \mathbf{p}_{KGT}^*, \tau \right) \left( p_{kg}^* (\tau) - p_{kg} (\tau) \right) d\tau \leq 0, \quad \forall \mathbf{p}_{KGT} \in S_{p}^{KGT}
\]

\[
S_{p}^{KGT} = \left\{ \mathbf{p}_{KGT} \in \mathcal{R}^{KGT} : p_{kg} (\tau) \geq 0, \forall k \in K, \forall g \in G ; \sum_{k \in K_{ad}} p_{kg} (\tau) = 1, \forall od \in Z \times Z, \forall g \in G \right\}
\]
Gap function: revisit the classical convergence

- Measures how close we are from a dynamic user equilibrium
- Ranges from 1 to 0 (equilibrium)
- How much better users can do if they could choose again their local route without changing costs
- Small cost variations can imply large flow variations
- Local equilibrium implies global equilibrium

\[
\gamma(p_{ADGT}^*) = 1 - \frac{\sum \sum \sum \int w_{idg}(p_{ADGT}^*, \tau) \cdot d\tau}{\sum \sum \sum \sum \int w_{adg}(p_{ADGT}^*, \tau) \cdot p_{adg}(\tau) \cdot d\tau}
\]
Search probability direction with Gradien Projection

- If $c_1$ and $c_2$ are equal, then we have equilibrium and the search direction is null.
- When heading towards the equilibrium we do smaller moves.
- Proper scaling e.g. with $\sigma = 1/c_{\text{min}}$.
- No derivatives available for Quasi-Newton.
- The cost operator is a (macroscopic) simulator.

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GENERAL LINK TRANSMISSION MODEL FOR DNL

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Critical modelling choice: supply
How does traffic look like?

- Traffic model (types of congestion)
  - Under saturation - queues only in front of signals, but vanishing every cycle
  - Over saturation on the link - persistent queues
  - Spillback - queue spillovers to backward links

- Granularity (time and space)
  - Microsimulation, Mesoscopic, Macroscopic

- Several possible compromises can be useful depending on the use case to address
Link Transmission Model for DNL with fixed splitting rates

Link Model

Sending Flows
Receiving Flows

Node Model

OD demand

Exit Flows
Entry Flows

Splitting Rates
Node Model Merging

- Partition of scarce resource (receiving flow) among BS links, based on turn capacities and priorities
- If a sending flow does not fully exploit the assigned resource the rest is shared among hungry links
- Assuming FIFO
- Min ratio between receiving and splitted sending
- Splitting rates (not destination specific) come from
  - route choice, for each destination
  - demand flow propagation on the network

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Splitting Rates: aggregation of route choices
Necessary extensions of the node model for real applications

- Generalizations
  - Mixed merging and diversions
  - Lane intersection topology
  - Traffic signals

- Conflicting manoeuvres
  - Solved as merging plus diversion

- Partial FIFO violation at diversions to match microsimulator
  - Early lane change by blocking vehicles (smart polite)
  - Late lane change by blocked vehicles (sneaking)
  - Compressed virtual lanes
Fundamental diagrams with different shapes and parameters

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Forward wave propagation of hypocritical flow states

\[
\hat{H}(x, \tau) = F(\tau) + f(\tau) \cdot x \cdot \left( \frac{1}{w^o(f(\tau))} - \frac{1}{v^o(f(\tau))} \right) = F(\tau) - x \cdot \chi^o(f(\tau))
\]
Backward wave propagation of hypercritical flow states

\[ \hat{G}(x, \tau) = E(\tau) + (L - x) \cdot e(\tau) \cdot \left[ -\frac{1}{w^+(e(\tau))} + \frac{1}{v^+(e(\tau))} \right] = E(\tau) + (L - x) \cdot \chi^+(e(\tau)) \]

- Increasing flow
  - Fan of waves
  - Shockwave

- Decreasing flow
  - Fan of waves
  - Shockwave
Shockwave based algorithm for piecewise constant flows
Newell’s solution of Kinematic Wave theory

\[
R(\tau) = G(\tau) - F(\tau)
\]

Entry Flow

Vertical Storage

Spaces - Entry

Entry Capacity

\[
r(\tau) \cdot d\tau = \min \{ R(\tau) + dG(\tau), \mu(\tau) \cdot \Phi \cdot d\tau \}
\]

Exit Flow

Exit Capacity

Vertical Queue

Spaces

Exit back propagation

Vehicles

Entry forward propagation

Vehicles - Exit

Entry Flow

Exit Flow

hypocritical

hypercritical

spillback

queue

free flow

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Estimate of the queue length assuming a constant flow

\[ N(\tau) = F(\tau) - E(\tau) \]
\[ S(\tau) = H(\tau) - E(\tau) \]

\[ \alpha(\tau) = \frac{S(\tau)}{R(\tau) + S(\tau)} \]

\[ x = 0 \]

free flow density

\[ R(\tau) \]
vertical storage

\[ L \cdot \alpha(\tau) \cdot k^+(q) = S(\tau) + L \cdot \alpha(\tau) \cdot k^o(q) \]

\[ N(\tau) + R(\tau) = L \cdot k^+(q) \]
\[ N(\tau) - S(\tau) = L \cdot k^o(q) \]
HOW TO USE DUE AND DNL OFF-LINE AND IN REAL-TIME
Different simulations for Traffic Forecast and Management

- Sensors and probes
- Control devices
- Management strategies
- Traffic state forecast
- Rolling horizon DNL
- DUE for day types
- Equilibrium splitting rates
- Tactical splitting rates

Flowchart:
- On-line calibration
- Network & demand
- Injected traffic states
- Real-time
- Hystoric

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Rolling horizon approach with sequential simulations

Current simulation start time \( X - 5 \text{ min} \)

Current simulation end time \( X + 30 \text{ min} \)

Initial conditions of current simulation derived from corresponding conditions of previous simulation
NUMERICAL EXAMPLES
The first battery of tests is performed on the simple dipole network of Figure 4, where it is possible to have expectations on the solution. All links share the following characteristics: free flow speed of 90 km/h, link capacity of 1800 veh/h, jam density of 150 veh/km, jam wave speed of 30 km/h, parabolic hypocritical branch of the fundamental diagram, linear hypercritical branch. All links have a base length equal length of 1 km. Travel demand is constant for 40 min with entry: $d_{14} = 1500$ veh/h.

Figure 4. Topology of the dipole network.
Hypocritical congestion

Figure 5. Dipole network with hypocritical congestion. The links of the deviation 2-5 and 5-3 have length of 600 m each. The bottleneck 2-3 has exit capacity of 1200 veh/h.
Figure 6. Dipole network with queue. The links of the deviation 2-5 and 5-3 have length of 5 km each. The bottleneck 2-3 has an exit capacity of 500 veh/h.
Figure 7. Dipole network in spillback. The links of the deviation 2-5 and 5-3 have length of 15 km each. The bottleneck 2-3 has an exit capacity of 500 veh/h.
The effect of capacity drop

without

with (20%)
Convergence results for different congestion level

Figure 8. Convergence pattern for the dipole network – EGP outperforms MSA.
TOWARDS MORE DATA AND MODEL INTEGRATION
Key technology for ITS: GPS + Wireless TC $\rightarrow$ Map Matching

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Big Data (historical) on traffic

Computer Science
Operation Research

“statistical/machine learning” approach

Transportation Engineering

“modelling” approach + calibration

Modelling 2.0
Data driven model offline: 3 steps functional overview

1. **Map Matching**
   - Vehicle Trajectories
   - Traffic Zones
   - Road Network
   - Day Types
   - Observed OD Matrices
   - Splitting Rates by Destination

2. **Demand**
   - Flow Measures
   - OD Matrix correction
   - Updated OD Matrices
   - Observed OD Matrices
   - Existing OD Matrix

3. **Supply**
   - Road Network
   - DNL
   - Free Flow Speed, Capacity and Jam Density
   - Fundamental Diagrams
   - Splitting Rates
   - Link Speed Profiles

**ROUTE CHOICE**
- Splitting Rates by Destination
- Observed OD Matrices
- Link Speed Profiles
Calibration issue: why measured traffic states differ from estimates?

- What is going on here?

  there is a big queue

  estim. 800 veh/h, 70 km/h   meas. 1000 veh/h, 15 km/h

- We are reading the downstream capacity instead of demand flows

- To calibrate OD flows in DTA through an assignment matrix we shall use the number of vehicles on links

- Or we should re-run (at least) the DNL for each demand vector
  - Derivative free algorithms can help (SPSA, Nelder-Mead, ...)
  - Not many shots available (e.g. 1000)
Calibration of the DTA model in real-time: measure injection

- Static models
  - can be easily calibrated with respect to flows (not time)
  - have a hard time in simulating networks with heavy congestion

- In dynamic models
  - vehicle counts maybe almost uncorrelated with the demand flows
  - not really interested in a complete reconstruction back in time
  - want to forecast what happens next, for different scenarios

- We adopt a simpler approach
  - Measure injections in the network loading model
  - Modify flow, speed and density directly on links
Flow correction: injection and propagation

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Congestion propagation from model

Flow data

Flow propagation from field

Hypocritical flow only forward propagation

Hypercritical flow also backward propagation
Exit flow consistent with measure disregarding entry flow
Matching is not always possible e.g. due to spillback in the model
Speed correction: fundamental diagram distortion

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hypothetical state

hyper state
Shall model speed follow the measured speeds?
When spillback is simulated in front of a measure it is not possible
How to represent traffic lights and node delays

- **Explicit representation**
  - Arc splitting
  - Pulsing

- **Fundamental diagram distortion**
  - Include in the equation of the speed the additional travel time

- **Profile shifting**
  - Theory violation
Flow from harmonized speed on the urban fundamental diagram

- Consider only hypercritical flows
  - otherwise too unstable
- Urban FD distortion
  - Fixed delay
  - Signal delay
  - Max speed

![Graph showing flow vs density with gentile polynomial and gentile polynomial with delay]
Effects of traffic signals
lower speeds
Travel times via Bluetooth portals

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The presence of traffic lights in travel time measures

average speed

link speed
REAL WORLD APPLICATIONS

HISTORY OF OPTIMA
The Cooperative Navigator... simple only in principle

trajectories

wireless internet

paths

GPS
Calibration of LTM against VISSIM link with ending signal

- Average density (number of vehicles)

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- New phenomena were added in the DTA simulation

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Dusseldorf Test
validation of base functionalities

<table>
<thead>
<tr>
<th>Links</th>
<th>29000</th>
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<tbody>
<tr>
<td>Nodes</td>
<td>13000</td>
</tr>
<tr>
<td>Zones</td>
<td>560</td>
</tr>
<tr>
<td>OD components</td>
<td>2M</td>
</tr>
<tr>
<td>Count locations *</td>
<td>665</td>
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</tbody>
</table>

* with some counts
Realtime monitoring with loop detectors and FCD

- Fixed (and moving) probes
- Don’t cover the whole network
- Allow forecast only when easy
- They can be integrated with transport models
- For realtime data completion and traffic forecast
Day-type based forecast with Dynamic User Equilibrium

- Variables are functions of time
- Travel demand Origin-Destination matrices
- Road network with speeds and turn capacities
- Macroscopic flow model can reproduce queues and spillback
- Yields route choice as splitting rates
Realtime data completion

- Flow and queue corrections on monitored links wrt base forecast
- Propagate on the network based on daytype time varying splitting rates
- This allows to estimate congestion on all links
Real-time traffic forecast

- Rolling horizon simulation
- This allows for within day forecast
- Queues are persistent and last more than vehicle travel times
Event manual insertion

- Click on the link
- Insert
  - Event type
  - capacity reduction
  - from day and time
  - to day and time
- In this case, 30 minutes block
- Then click start simulation
Forecast the effects of events

- Evolution of the queue
  - forms
  - sticks
  - disappears
### Dusseldorf Test performance evaluation

- **Traffic state forecasts**
  - up to 1 hour ahead every ten minutes

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<tr>
<td>DB</td>
<td>4,7 Gb</td>
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<table>
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<th>Calculation times</th>
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<tbody>
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<tr>
<td>Import &amp; Process Vehicle Counts</td>
<td>10”</td>
</tr>
<tr>
<td>Perform Dynamic Network Loading</td>
<td>1’39”</td>
</tr>
<tr>
<td>Export results into DB</td>
<td>19”</td>
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<tr>
<td><strong>Total for a single run</strong></td>
<td><strong>2’08”</strong></td>
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## Dusseldorf Test
aggregated quality evaluation

### USED MEASURES

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<tr>
<th>forecast</th>
<th>ro square</th>
<th>0 min</th>
<th>0.95</th>
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<tbody>
<tr>
<td>10 min</td>
<td></td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>20 min</td>
<td></td>
<td>0.55</td>
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### UNUSED MEASURES

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<th>forecast</th>
<th>ro square</th>
<th>0 min</th>
<th>0.81</th>
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<tbody>
<tr>
<td>10 min</td>
<td></td>
<td>0.85</td>
<td></td>
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<tr>
<td>20 min</td>
<td></td>
<td>0.59</td>
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Dusseldorf Test
quality evaluation by link

Unmonitored location

Monitored location

link capacity
measured
forecast 0 min
forecast 10 min
forecast 20 min

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Traffic Information in Romania –
Data Fusion and Warehouse

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Map interface with GIS layer tree

- Static layers
  - Roads
  - Traffic signals
  - TMC locations ...
- Dynamic layers
  - FCD points
  - Events ...
- LOS layers
  - Harmonized Speeds
  - FCD speeds ...

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Road layer:
link attributes and speed chart

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Event processing

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Data exchange among different formats
5T Regione Piemonte
a comprehensive project
On a large network

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>Number of Navteq Links</td>
<td>795.000</td>
</tr>
<tr>
<td>Model Links</td>
<td>268.000 (80.000 after graph simplification)</td>
</tr>
<tr>
<td>Zones</td>
<td>2.000 internal zones 8 cordon zones</td>
</tr>
</tbody>
</table>

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Network Sensor Location Problem

COUNT LOCATION POSITION

DAILY TRAFFIC SIMULATION

- OnLine Count Locations
- Count Locations Scenario A
- Count Locations Scenario B
- Count Locations Scenario C

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## Network Sensor Location Problem

<table>
<thead>
<tr>
<th>Scenario</th>
<th>% monitored link flows</th>
<th>% monitored OD flows</th>
<th>% monitored OD relations</th>
</tr>
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<tbody>
<tr>
<td>Current</td>
<td>1.10%</td>
<td>24.21%</td>
<td>66.36%</td>
</tr>
<tr>
<td>A</td>
<td>1.20%</td>
<td>36.60%</td>
<td>78.60%</td>
</tr>
<tr>
<td>B</td>
<td>1.30%</td>
<td>44.20%</td>
<td>86.30%</td>
</tr>
<tr>
<td>C</td>
<td>1.37%</td>
<td>49.38%</td>
<td>90.62%</td>
</tr>
</tbody>
</table>

**CURRENT SCENARIO**

**SCENARIO A**

**SCENARIO B**

**SCENARIO C**
Transportation Model Builder with guided map updates

INPUT
ISTAT DATABASE

OUTPUT
DEMAND MODEL

O-D Matrix

OUTPUT
NAVSTREES DATABASE

SUPPLY MODEL

Assignment Graph

Assignment OUTPUT
Flow

Link Performance

LAST UPDATED 2019.07.20
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Edmonton Lab (VISSIM) OPTIMA + BALANCE

6 miles (10 km) 31 signals
London Pilot
OPTIMA to drive SCOOT

Comparison of KPIs

Short term forecast -> Scenario 1 -> Scenario 2 -> Scenario 3 -> ... -> Scenario N

Signal plan 1 -> Signal plan 2 -> Signal plan 3 -> ... -> Signal plan N

Signal plan sets selected by operator

Optima

Transportation Planning Model

Travel times

Signal data

Detector data

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Scenario evaluation and comparison with KPI

- Build alternative scenarios
- Run multiple simulations in real time
- And "do nothing" situation

- Evaluate KPI
- Compare and rank alternative solutions
- against "do nothing"
Hong Kong
Off-line Event Impacts

- **Real network**
  - 30,000 links, 2000 zones
- **Manual insertion of events**
  - link closure, capacity reduction, speed reduction
- **Simulation with drivers rerouting each 5 minutes**
- **Comparison of traffic situation with respect to**
  - no-incident situation
  - no-rerouting situation (drivers are unaware of the incident until they stuck in it!)
Infomobility portal
subscribe for alerts on forecast

Events reported
Nessun evento presente per le tipologie selezionate

Featured news
- 13 Feb 2015
  ❖ Test di prova
  Stiamo lavorando per voi

- 11 Feb 2015
  ❖ Calendari controlli Autovelox
  Febbraio 2015

- 7 Feb 2015
  ❖ Apertura Outlet Novi Ligure
  Articolo di prova di Daniele Tiddi.
Dynamic Journey Planning of Rome with HyperPaths

Los Angeles, 19.11.2015

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VAO Multimodal
Trip Planning of Austria
CONCLUSIONS
AND OPEN ISSUES
Some open issue in DTA applied to real-time forecast

- Many types of data and models are available
  - how to exploit big data in construction and calibration of offline models?
  - can the machine learning approach be used to also extend measures?
  - How to best integrate real-time data to correct the DNL model?
- DUE and DNL are robust paradigms
  - how much does traffic information play a role in elastic demand?
  - what actually happens in real time with rerouting?