Technische Universität Berlin

Using real-world traffic incident data in transport modeling

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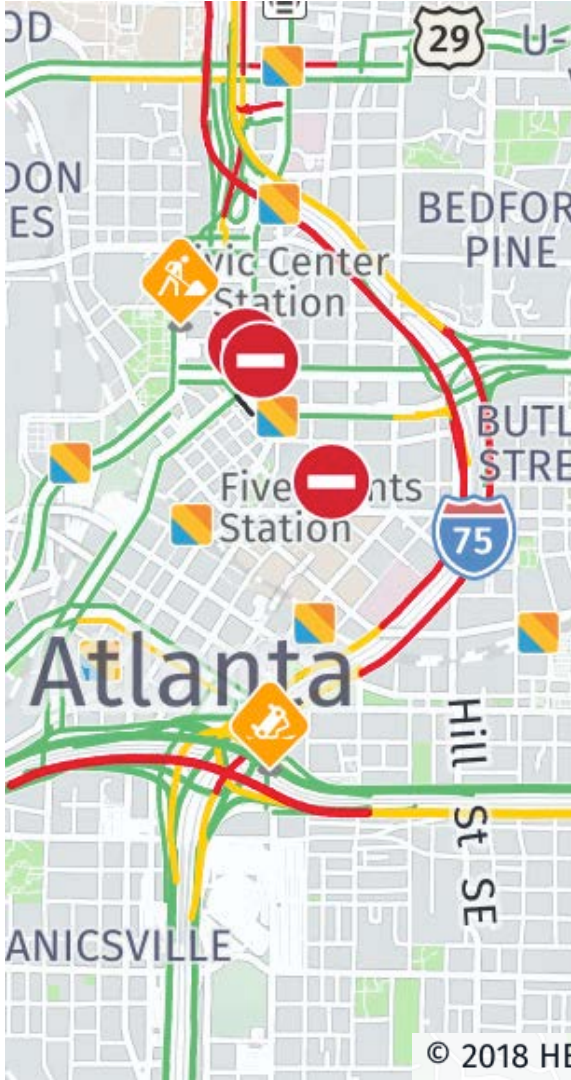
Motivation

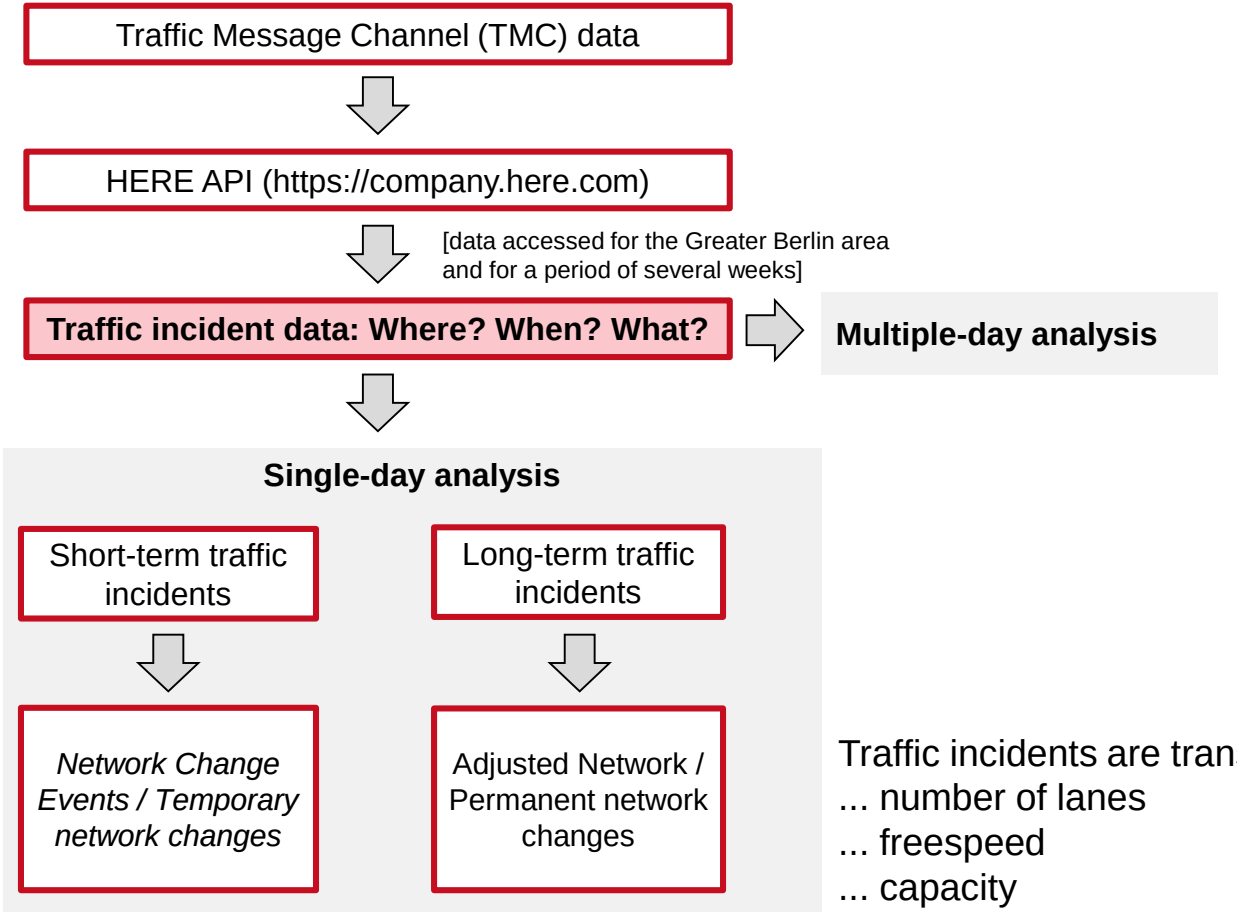
- In most real-world oriented transport models, traffic incidents and variations in transport supply are neglected.
- Transport policies are investigated in a synthetic environment assuming ideal network conditions.

Objectives

- Incorporate traffic incidents into an existing agent-based simulation framework and model the agents' short- and long-term reactions.
- Improve an existing agent-based simulation framework's level of realism



Incorporating real-world traffic incident data into MATSim



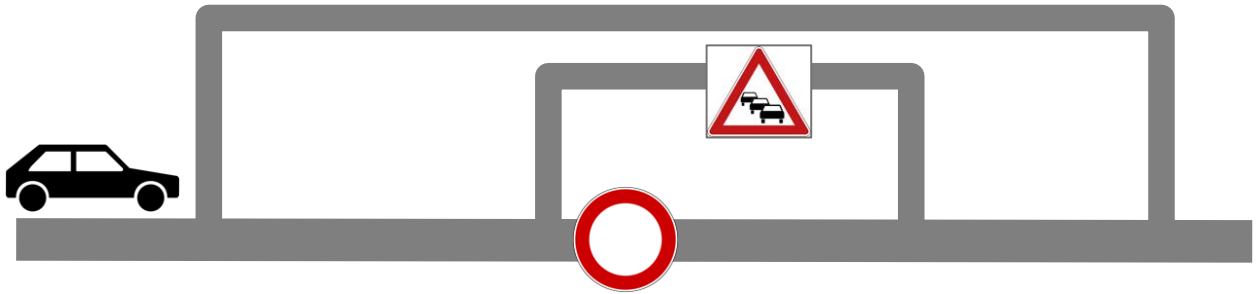
Traffic incidents are translated into an adjusted...
... number of lanes
... freespeed
... capacity

The agents' reaction to **long-term** traffic incidents

Long-term traffic incidents → Adjusted Network / Permanent network changes

MATSim
Multi-Agent Transport Simulation

- Assumption: The traffic incidents are **known** before starting a trip
- Day-to-day replanning: Compute the least-cost path based on the adjusted network **at the beginning of the day**.
- Run the simulation for several iterations; every iteration a certain number of agents is randomly selected for re-routing.

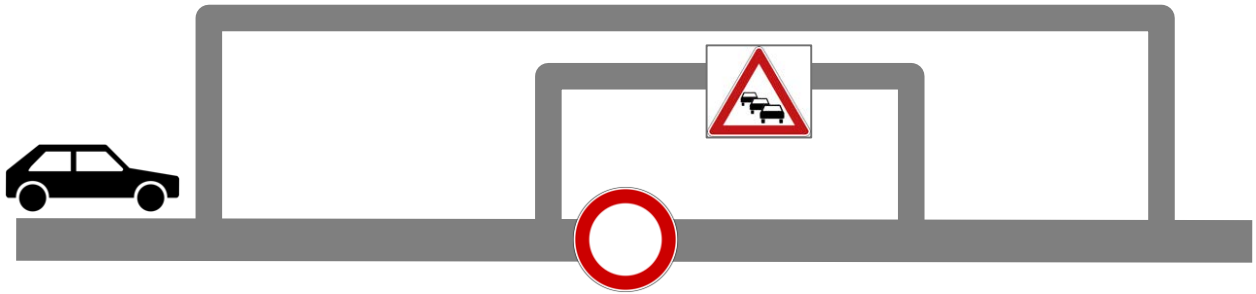


The agents' reaction to **short-term** traffic incidents

Short-term traffic incidents → *Network Change Events* / Temporary network changes

MATSim Multi-Agent Transport Simulation

- Assumption: The traffic incidents are **unknown** before starting a trip
- Within-day replanning: Compute the least-cost path based on the adjusted network **during the day.**
- Run the simulation for a single iteration; re-adjust the transport route for all agents after departing and then every 5 minutes during the trip.



Simulation experiments

1) What is the effect of **long-term traffic incidents** on the transport system?

- Exp. 1a: Assume ideal network conditions.
- Exp. 1b: Incorporate the long-term traffic incidents.

[day-to-day replanning, 300 iterations, 30% replanning rate]

2) What is the effect of **short-term traffic incidents** on the transport system?

- Exp. 2a: Only account for the long-term traffic incidents.
- Exp. 2b: Additionally, incorporate the day-specific short-term traffic incidents.

[input demand from Exp. 1b, within-day replanning, 1 iteration, 100% replanning rate]

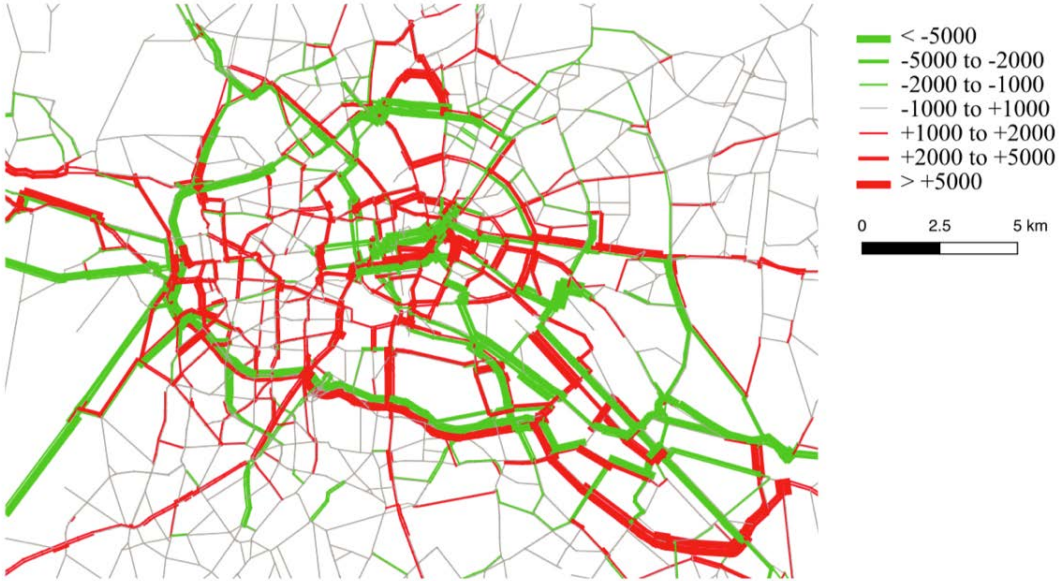
3) What is the effect of long-term traffic incidents on the **policy sensitivity**?

- Exp. 3a: Implement the pricing scheme and assume ideal network contidtions.
- Exp. 3b: Implement the pricing scheme and incorporate the long-term traffic incidents.

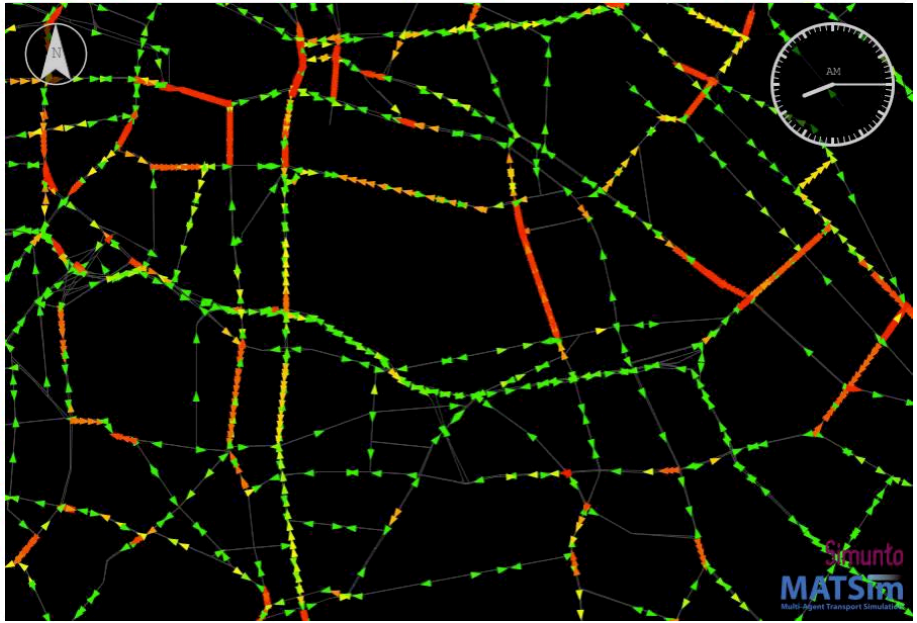
[day-to-day replanning, 300 iterations, 30% replanning rate]

The effect of **long-term** traffic incidents

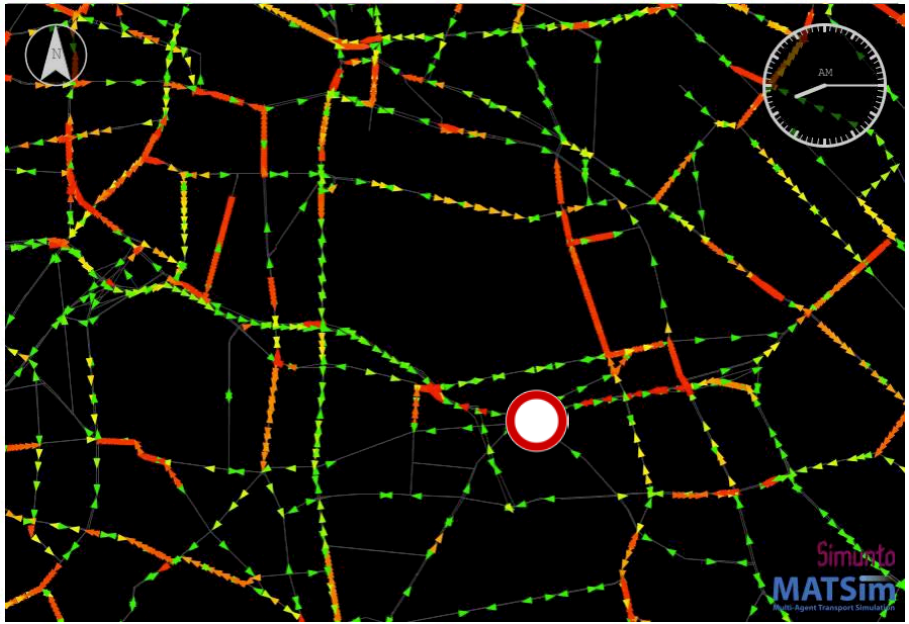
- Long-term traffic incidents increase the overall level of traffic congestion; the average **car travel time increases by 313 sec (+18%) per trip**.
- Reduction in traffic volume on road segments for which traffic incidents are reported; the same applies for upstream and downstream road segments.
- Overall, the daily traffic volume increases on smaller road segments.



The effect of **short-term** traffic incidents



Experiment 2a: without short-term traffic incidents



Experiment 2b: with short-term traffic incidents

→ Increase in **average car travel time by 136 sec (+8%) per trip**
(in addition to the effect of long-term traffic incidents)

The effect of traffic incidents on the **policy sensitivity**

Transport policy: Road- and time-specific **congestion pricing** (Proportional-Integral-Derivative Controller)

Impact of the pricing policy under **ideal network conditi**ons
→ Reduction in average travel time per car trip by 254 sec (-17%)

Impact of the pricing policy under **realistic network conditions** (accounting for long-term traffic incidents)
→ Reduction in average travel time per car trip by 527 sec (-27%)

→ Accounting for traffic incidents increases the gains of the pricing policy compared to assuming ideal network conditions.

→ Models that neglect traffic incidents may underestimate the potential of transport policies.

Conclusion

- The simulation experiments indicate that long- and short-term traffic incidents have a significant effect on the…
  - … transport system (average travel time per car trip: +5 min / +7 min)
  - … policy recommendations (travel time reduction per trip: -17% → -27%).

- The multiple-day data analysis reveals that also over a long period of time, traffic incidents may have a significant effect on the transport system.

- Overall, incorporating traffic incidents in transport modeling allows to…
  - … quantify the effects from roadworks, accidents and other incidents on the transport system
  - … improve the model's level of realism and policy sensitivity.

Thank you!

Questions, comments, …?

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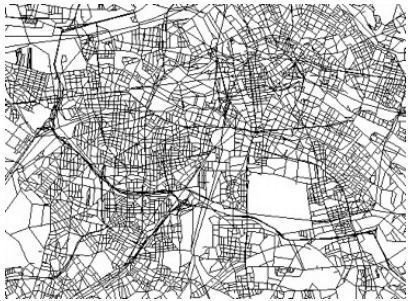
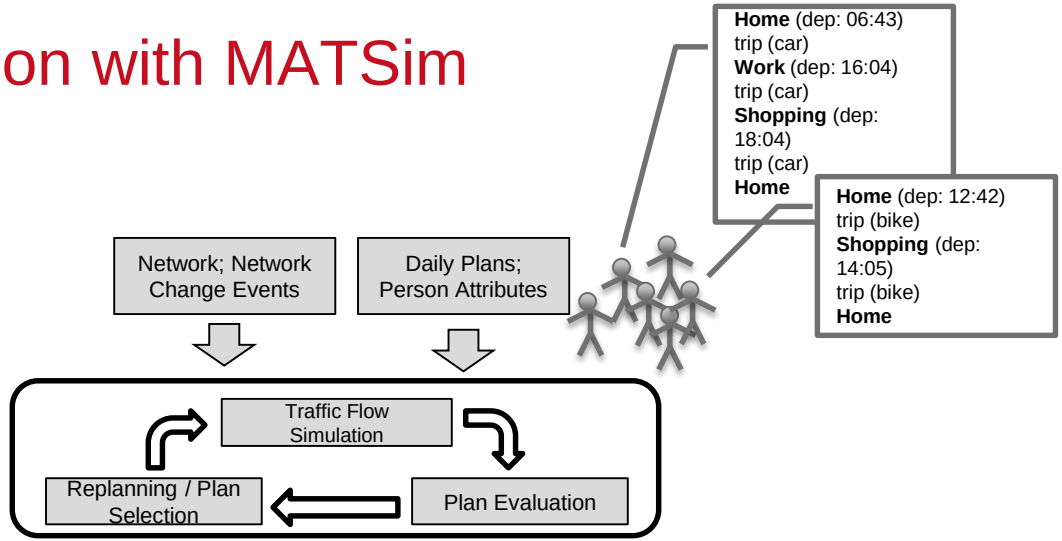
Backup

Transport Simulation with MATSim



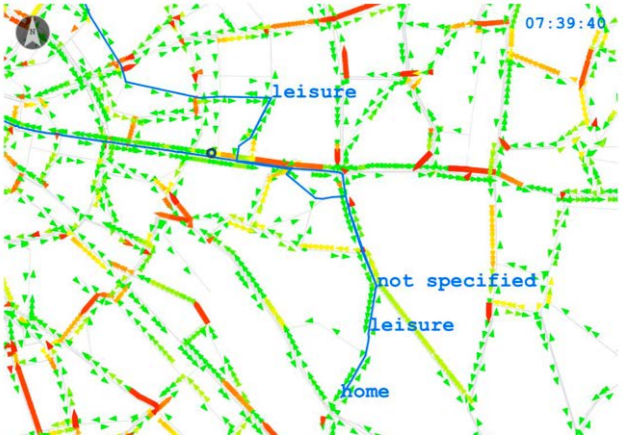


MATSim
Multi-Agent Transport Simulation

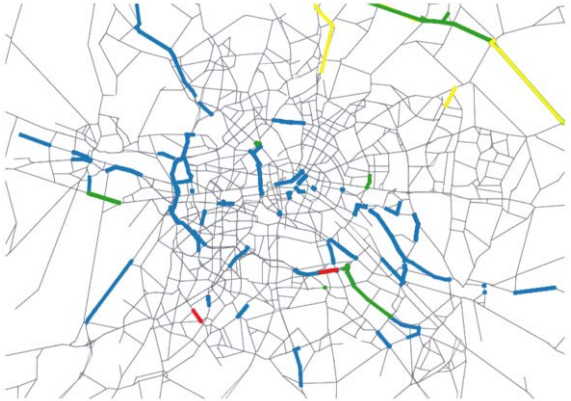
Traffic Flow Simulation:
agents' interaction in the network
→ dynamic congestion (queue model)

Plan Evaluation:
based on executed activities and trips

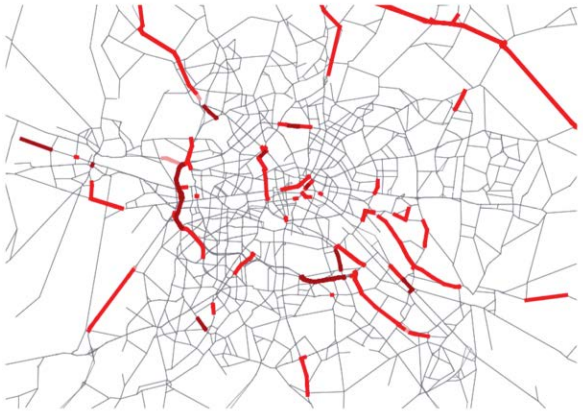
Replanning / Plan Selection:
plan modification according to choice dimensions (choice set generation); plan selection based on a MNL model



Translating traffic incidents into network parameters



Traffic incidents
- Accident
- Obstruction
- Construction
- Dangerous situation



Relative capacity reduction
- 0.75 - 1.00
- 0.50 - 0.75
- 0.25 - 0.50

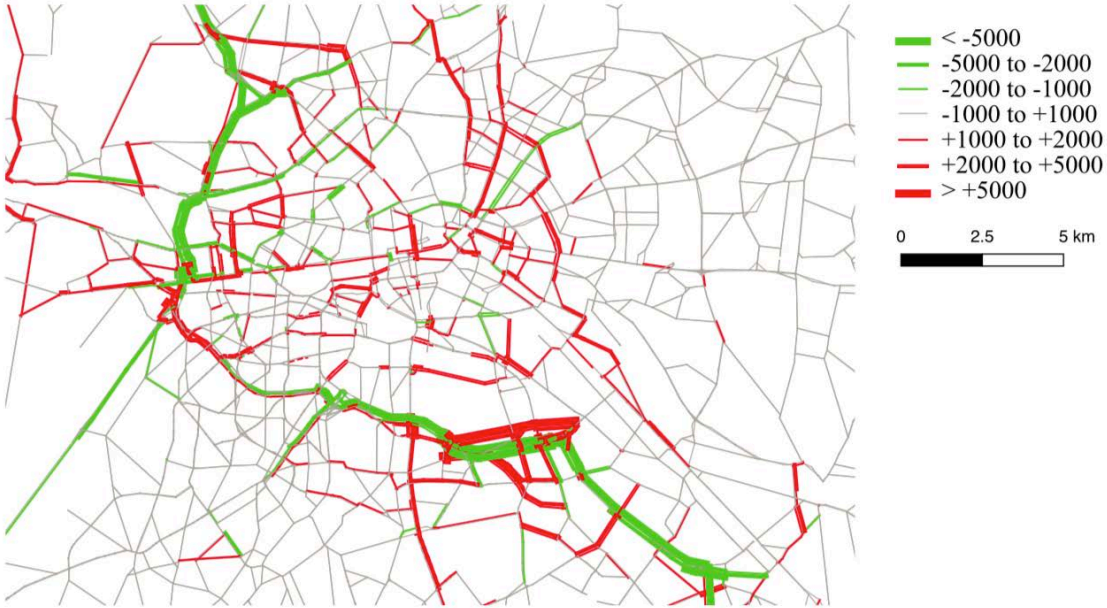
Traffic incidents mapped on the Berlin network (11 Feb 2016)

Multiple-day traffic incident analysis

- Analyzed traffic incident data: Greater Berlin area, average working day, 12 Feb 2016 – 18 May 2016
- Depending on the time of day, 3-4% of all road-km are affected by traffic incidents (and resulting changes in transport supply).
- Taking into consideration the agents' daily trip routes from the base case (Exp. 1a) allows to estimate how many people may directly affected by traffic incidents:
  - For 44% of all car trips, the agent's transport route contains at least one road segment for which the capacity or speed limit is reduced because of an incident (doesn't necessary mean the agent is affected).
  - This corresponds to 25% of the entire population in the Greater Berlin area; not included: agents that are indirectly affected (e.g. increase in congestion on other roads).

The effect of **short-term** traffic incidents

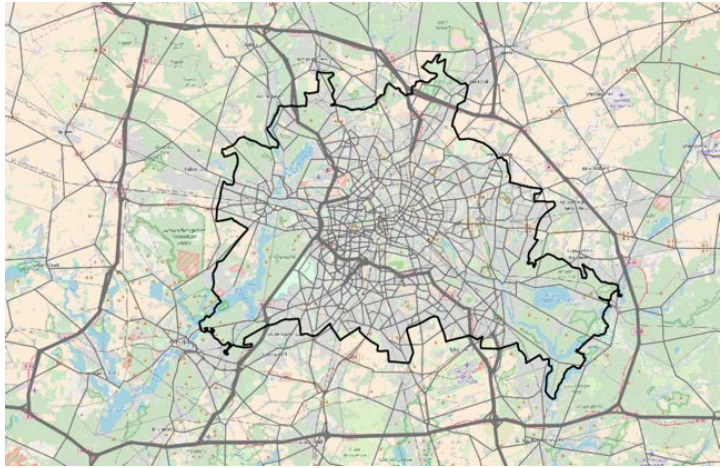
- Short-term traffic incidents further increase the overall level of traffic congestion; the average car travel time increases by 136 sec (+8%) per trip (in addition to the effect of long-term traffic incidents).
- Decrease in daily traffic volume on the southern and north-western inner-city motorway (full road closure caused by an accident); Increase in traffic on parallel road stretches.



Real-world case study

Greater Berlin Area, Germany

- **Transport network**: all major roads, generated based on OpenStreetMap
- **Travel demand**:
  - Generated based on survey data (Zensus 2011, Statistische Ämter des Bundes und der Länder) and the commuter statistics (Bundesagentur für Arbeit; German Federal Employment Office, 2010)
  - Contains commuters and non-commuters
  - Included modes: car, bicycle, public transit
  - Calibrated against real-world traffic data (counts, modal share, trip-distance, ...)

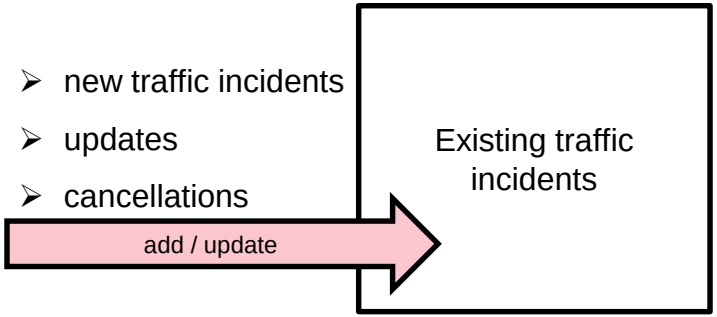


Ziemke, D.; Nagel, K. & Bhat, C.; Integrating CEMDAP and MATSim to increase the transferability of transport demand models; *Transportation Research Record,* 2015*, 2493*, 117-125.

Ziemke, D. and K. Nagel. Development of a fully synthetic and open scenario for agent-based transport simulations – The MATSim Open Berlin Scenario. VSP Working Paper 17-12, TU Berlin, Transport Systems Planning and Transport Telematics, 2017. URL http://www.vsp. tu-berlin.de/publications.

Data processing

Temporal processing:



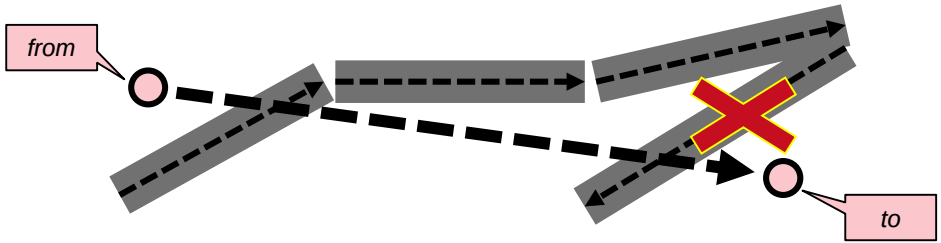
Spatial processing:

Identify affected network links between *from* and *to* coordinates

1) *from* / *to* coordinate → get nearest link

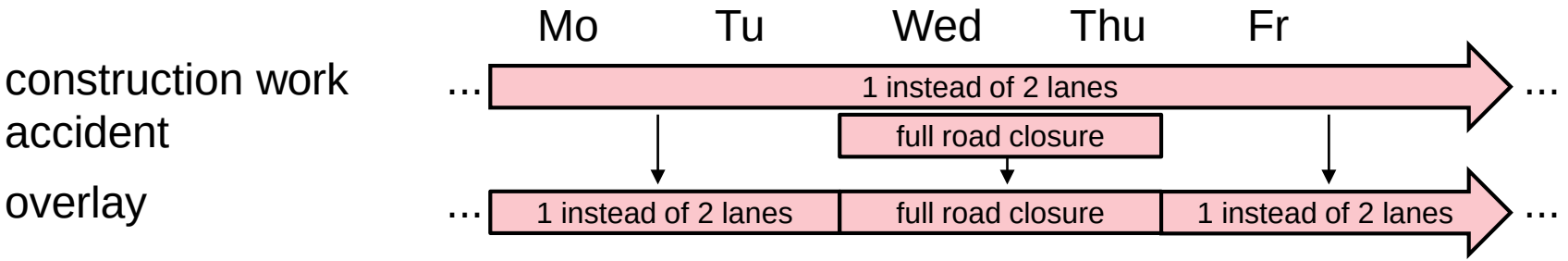
2) get the fastest route between these two links (simple freespeed based routing)

3) to account for minor inaccuracies of the network's geometry: go through route and only consider the link if the scalar product of the incident's and link's from-to-vector is > 0 (= acute angle)



Data processing

Overlay of traffic incidents: use the more restrictive network parameters:



- Most traffic messages specify the changes in transport supply, i.e. the number of closed lanes, the reduced speed level, vehicle-specific restrictions...
- Some traffic messages do not specify the changes in transport supply, mainly warnings such as “animals on road”, “broken vehicle”. In this case, the capacity is assumed to be halved and the speed is reduced to the typical lower level (80 km/h → 60 km/h; 50 km/h → 30 km/h; ...)