(Towards) Agent Computing for **Intelligent Transport Systems**

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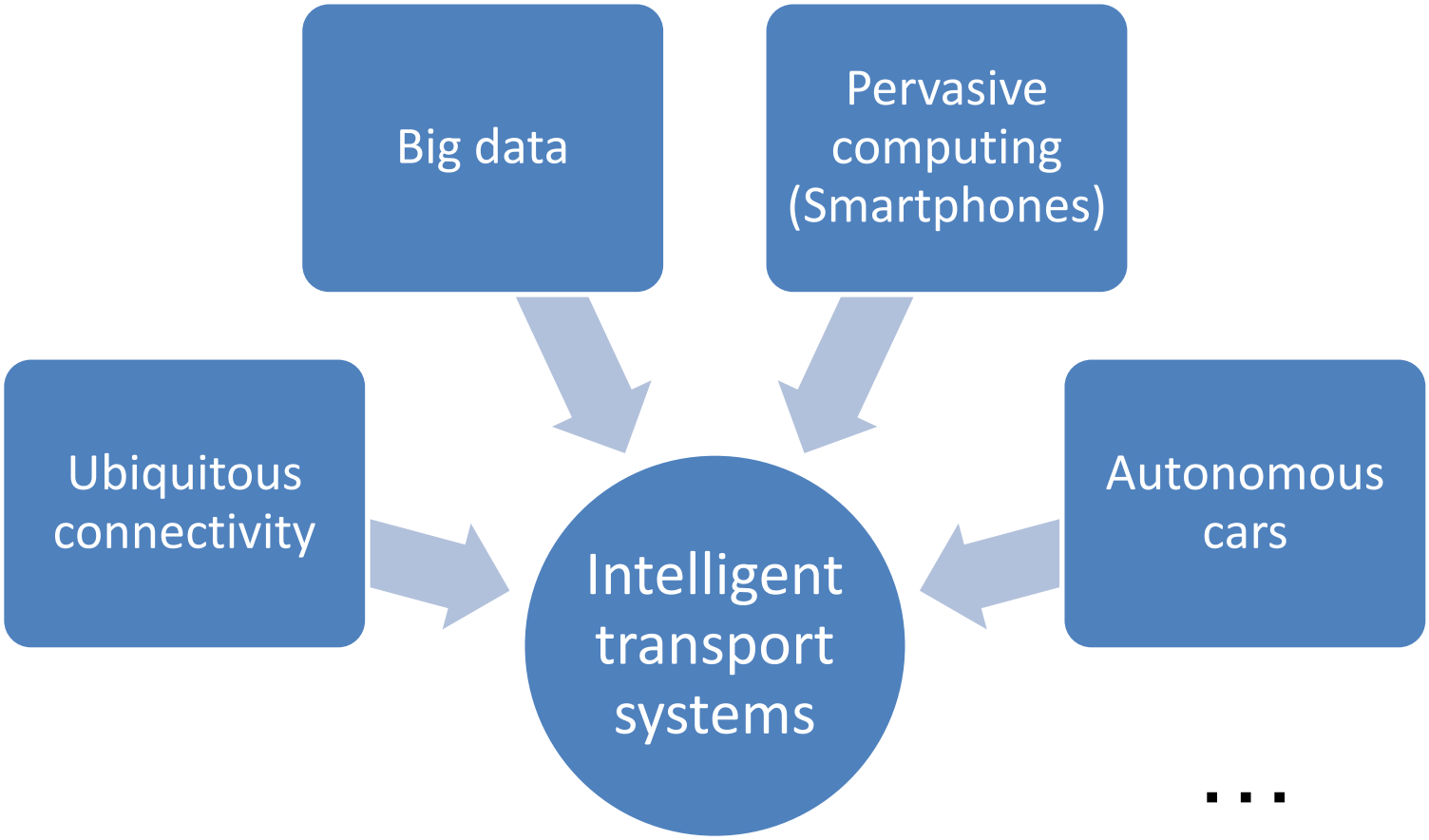
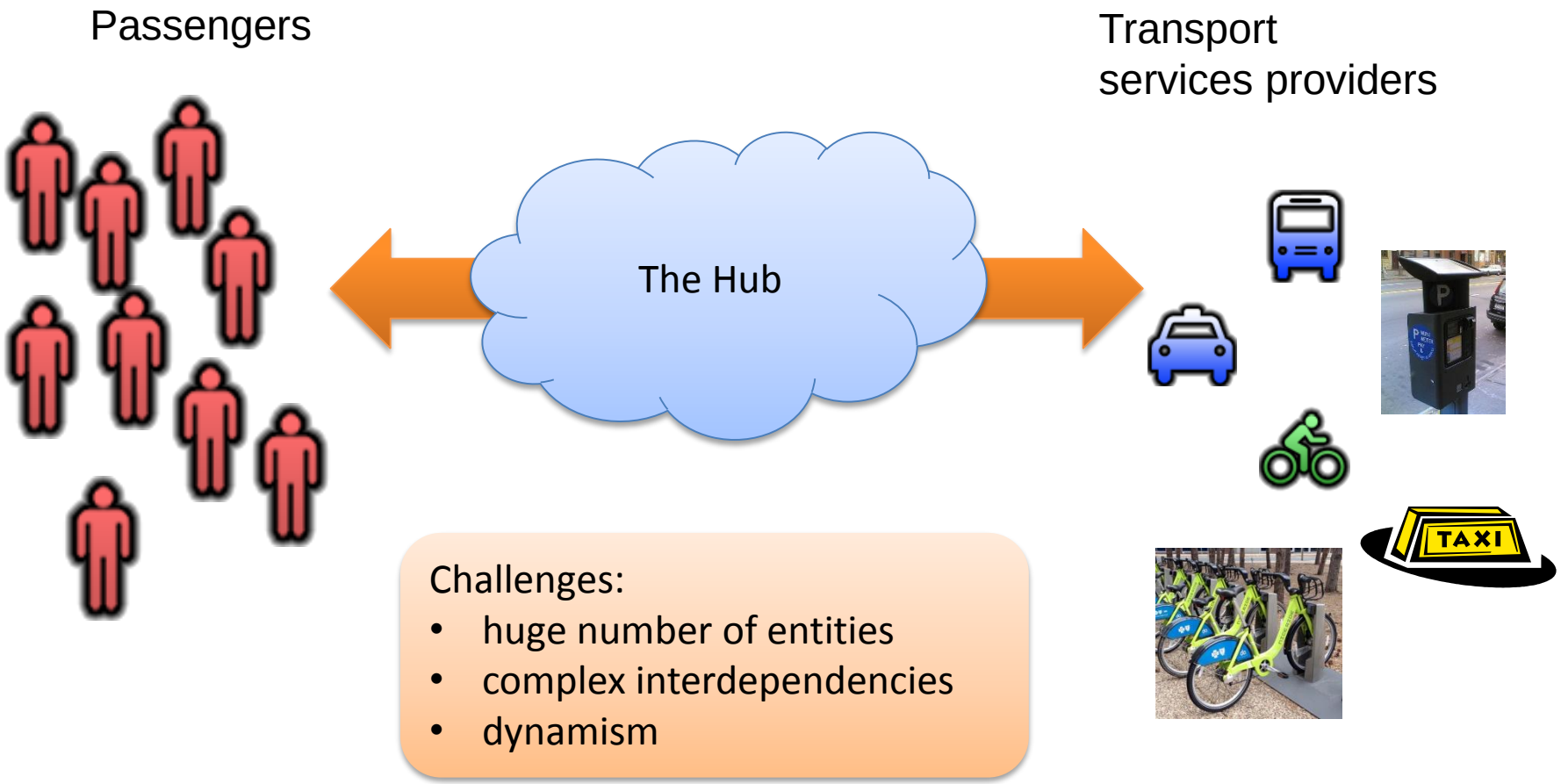
http://agents.fel.cvut.cz/topics/intelligent_transport_systems

Trends/Vision



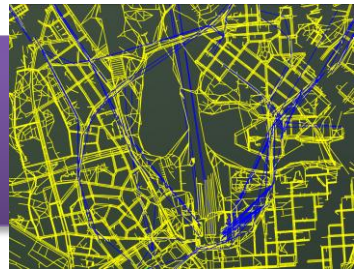
Flexible Transport Markets

- Real-time matchmaking between demand and supply => **mobility as a service**

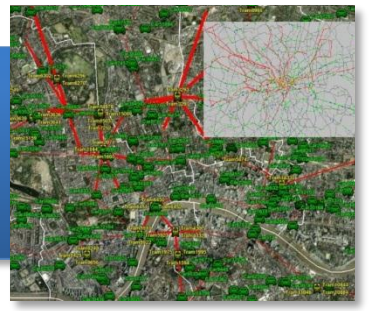


Layered Approach

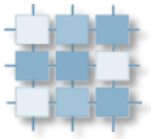
Data Integration, Visualization and Analysis



Agent-based Simulation (What-if)



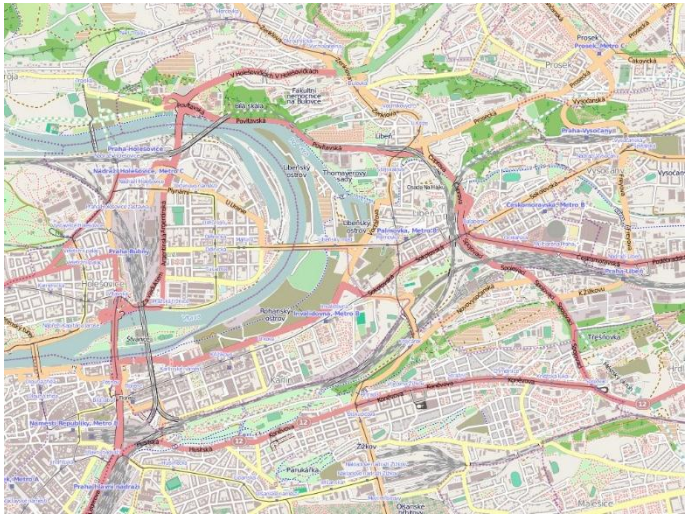
Planning, Coordination and Optimization



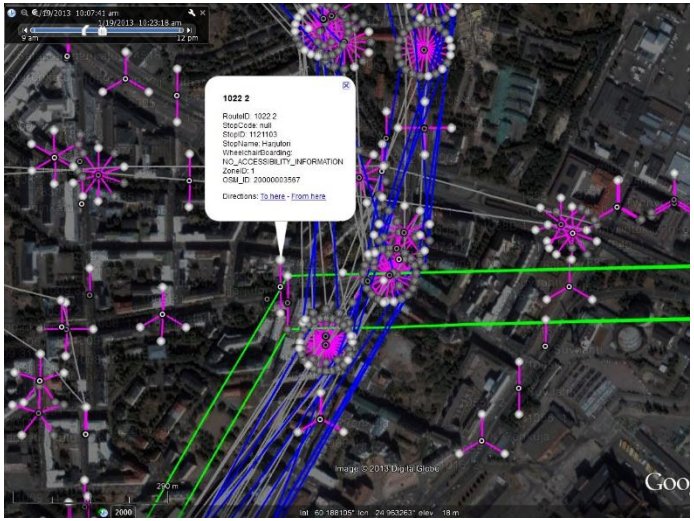
Data Integration and Analysis

Main Data Sources

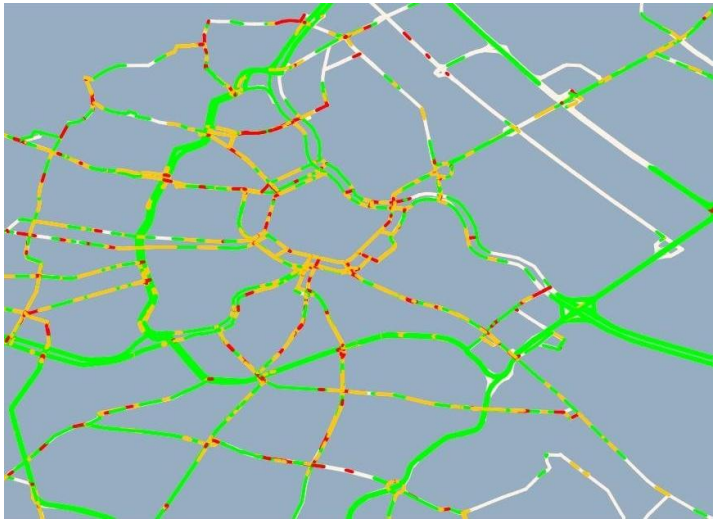
OSM road networks



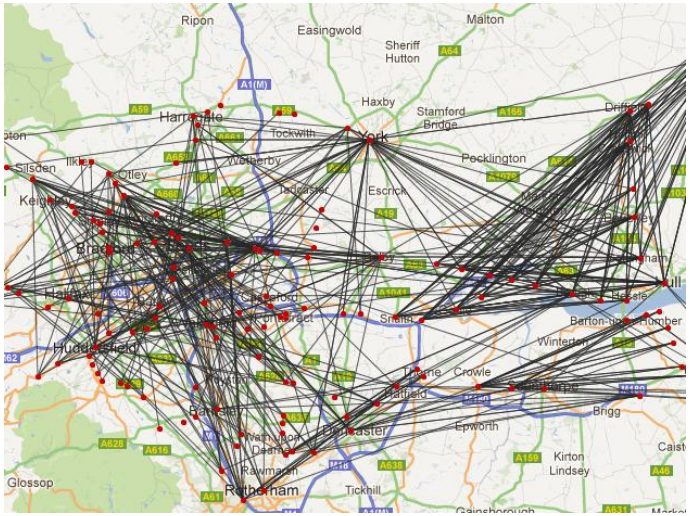
GTFS / JDF Timetables



Real-time Level of Service (FCD)



Real-time Origin-Destination Matrices

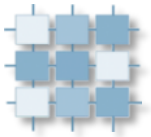


Transport Network Analysis

(BP Jan Nykl)

- Input: Timetables & stops of the PTN
- Output: Various PTN metrics
  - (duration of journey, number of interchanges, harness, PTN area and length etc.)
- Two modes of analysis
  - Many-to-many
  - One-to-others
- Time-expanded graph & Dijkstra used for finding a route in the PT

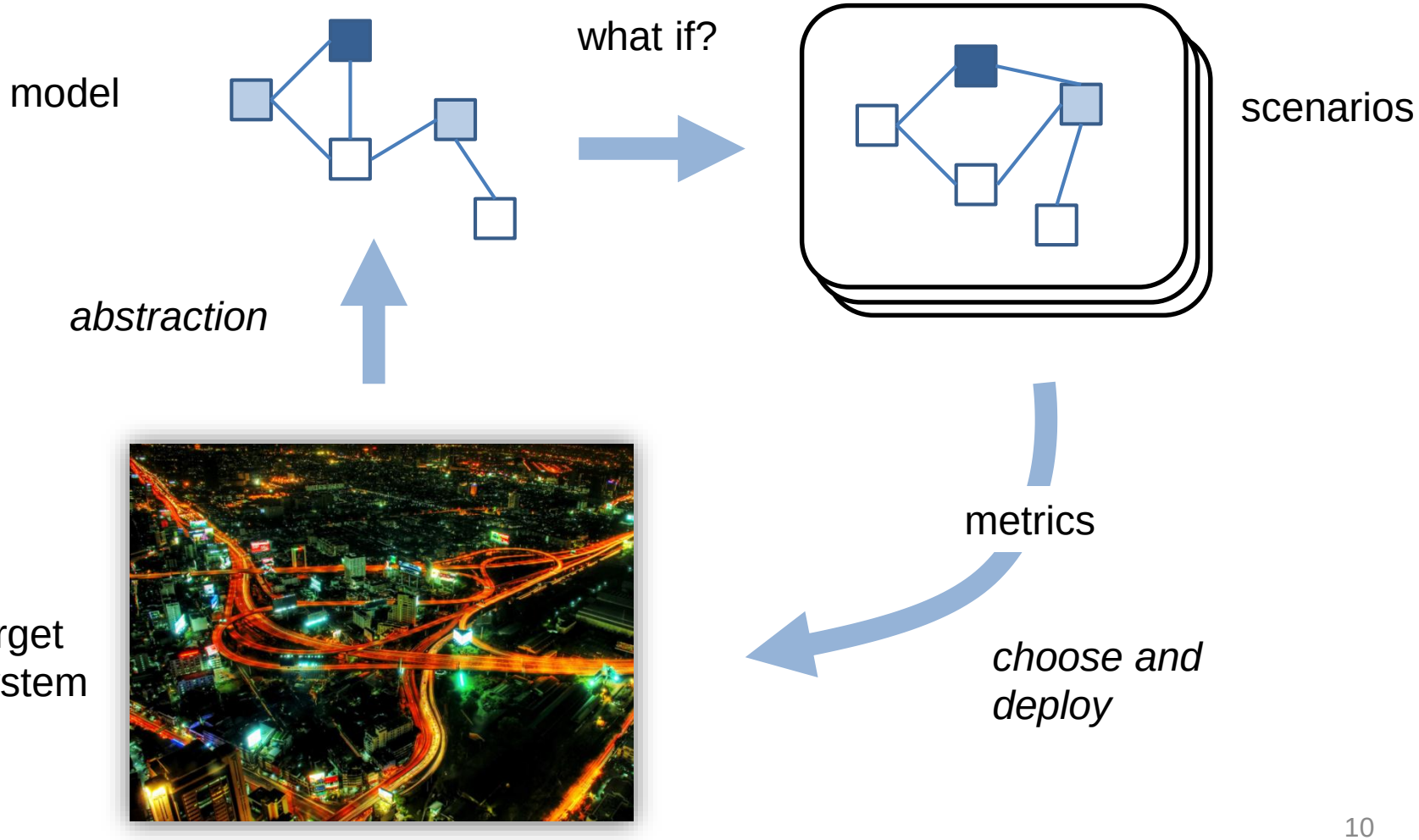
(Image from OpenTripPlanner Analyst)



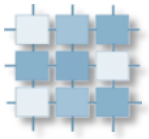
Simulation

What-If: Simulation Modeling

Estimate the behavior of the transport system under different circumstances



Simulation Inputs and Outputs



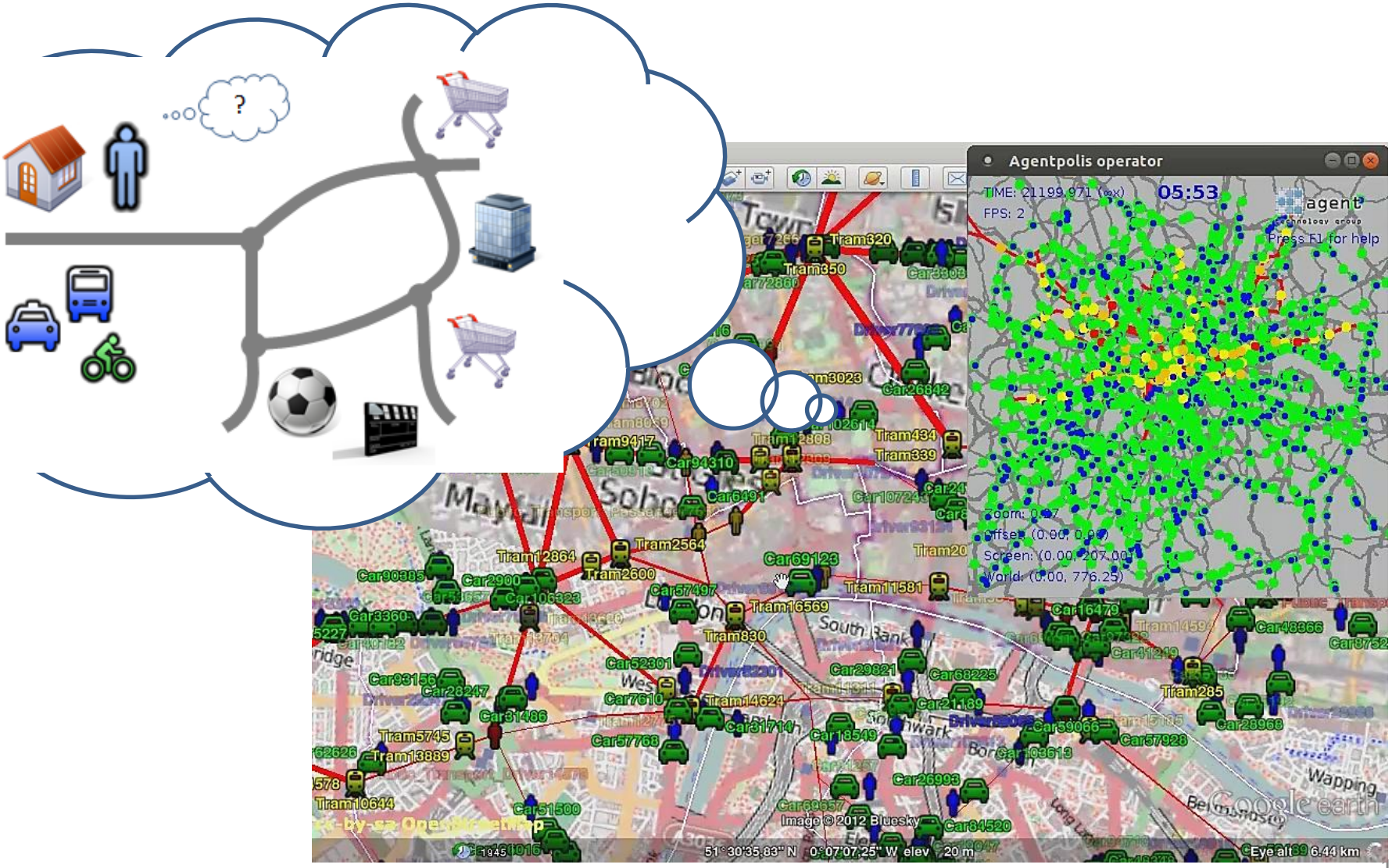
Scenarios

- Policies: congestion charge, parking regulation, ..
- Public transport: routes and schedules, ticket prices
- Planned events: big concerts, football matches
- Unexpected disruptions: accidents, bad weather
- Novel transport schemes: ridesharing, car sharing, bike sharing

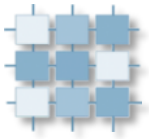
Metrics

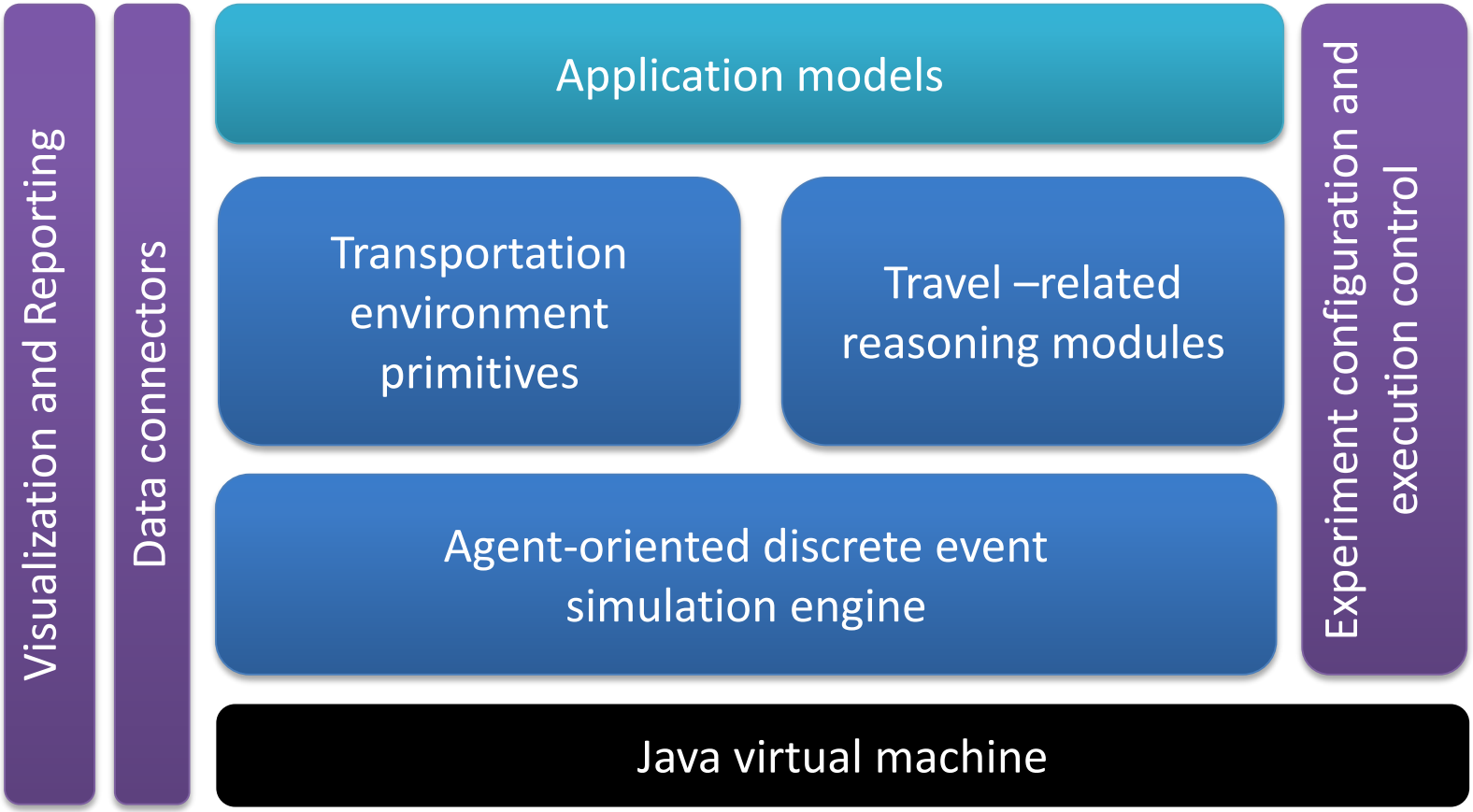
- Travel: travel times, costs, modal split, …
- Efficiency: utilization, energy consumption, congestion
- Environmental impact: emissions, noise,…

Agent-based Approach

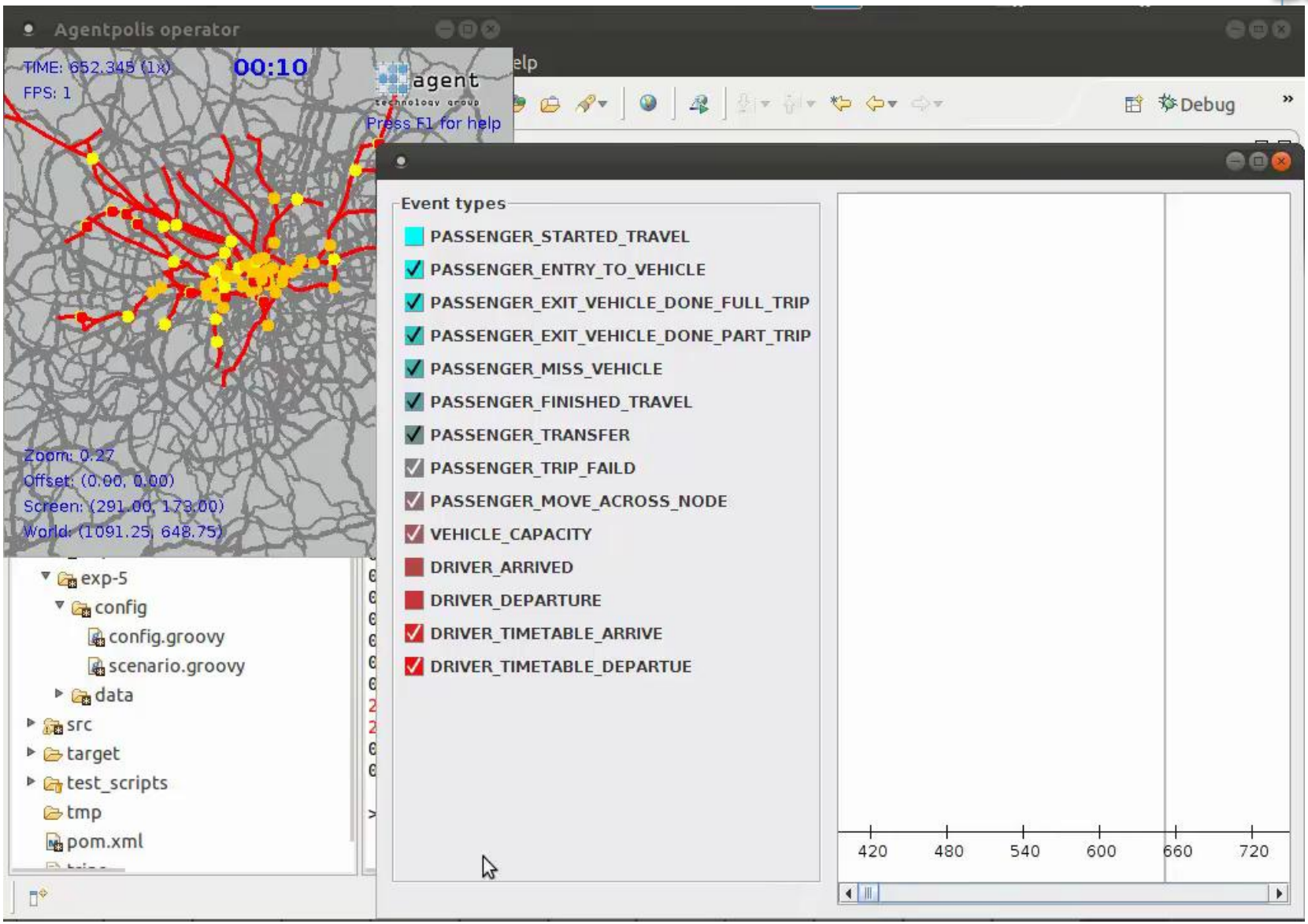


AgentPolis Framework: *Fully* Agent-Based Mobility Modelling

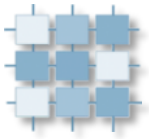




AgentPolis Framework - Demo

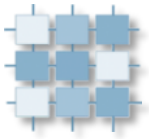


Research Areas



- Simulating transport environments (physics of transport)
  - abstractions for transport system models
  - efficient execution via discrete-event simulation
  - massively repeated journey planning (caching)
- Modeling human decision making (psychology of transport)
  - activity scheduling
  - plausible decision models
  - plausible memory models
  - cooperation with Centrum dopravniho vyzkumu (CDV)
- *Simulation-aided Design of ITS*

AgentPolis Models



- Multi-modal Urban Mobility
- Fare Inspection
- Real-time Ridesharing
- Auction-based Dynamic Taxi Pricing
- (Urban Parcel Delivery Logistics)

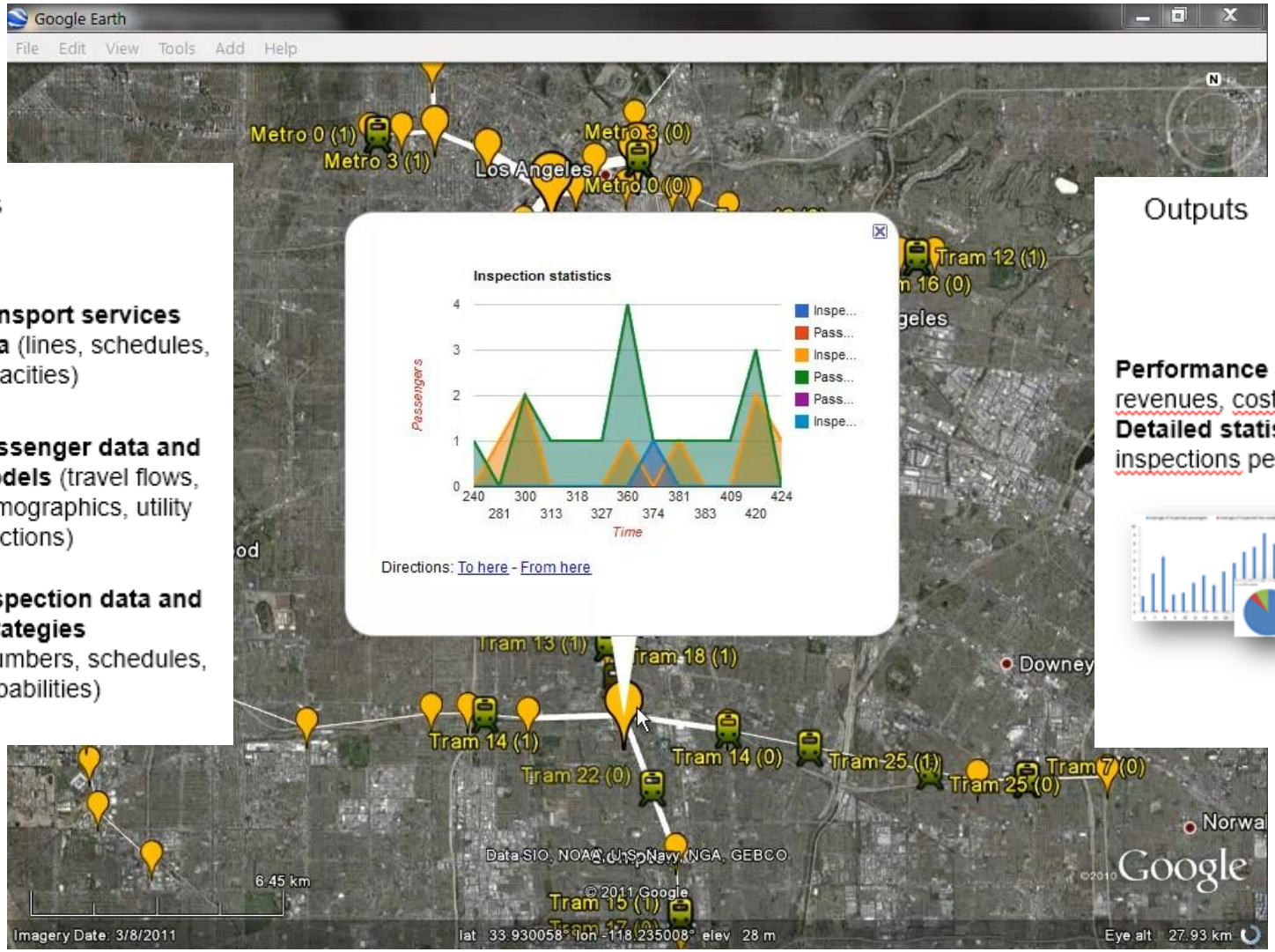
Fare Inspection Model

Inputs

Transport services data (lines, schedules, capacities)

Passenger data and models (travel flows, demographics, utility functions)

Inspection data and strategies (numbers, schedules, capabilities)

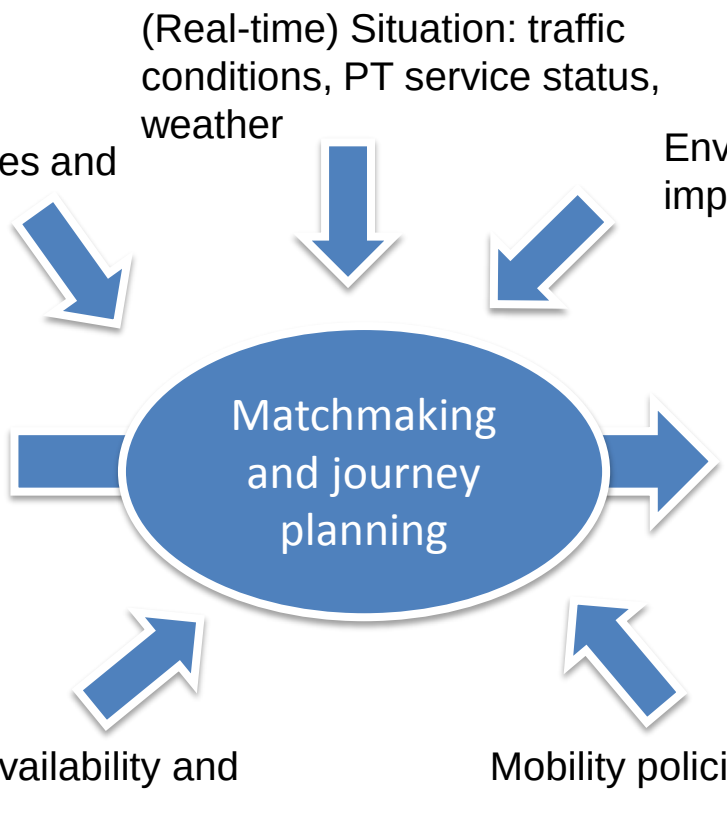


Outputs

Performance indicators (e.g. revenues, costs)
Detailed statistics (e.g. inspections per station0

Transport Planning, Coordination and Optimization

Multi-Criteria Multi-Modal Journey Planning



Journey request
(origin, destination, time)

(Near-) optimum
journey plan

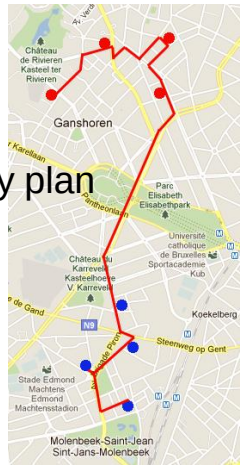
Multi-Critics Journey Planning

- Separates **plan search control** from **plan evaluation**

generate and test cycle

implement standard critic interface

Candidate (partial) journey plan



Critics

- User satisfaction
- Resources availability
- Emissions
- Physical effort
- Policy compliancy

Planner core

1. generate (partial) journey plan

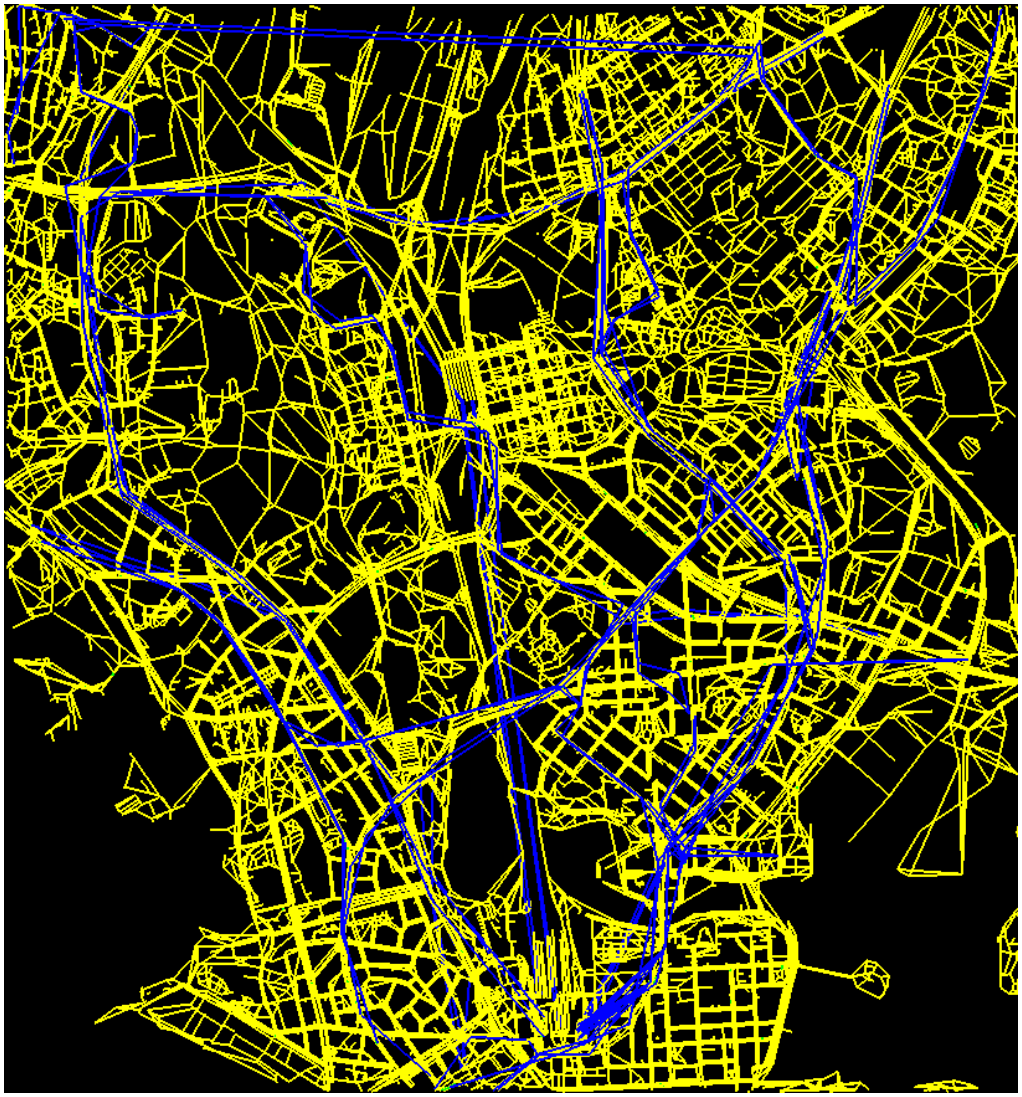
2. evaluate plan

3. aggregate feedback

search control built-in critics

➔ promotes **parallelism** (development and execution) and **extensibility**

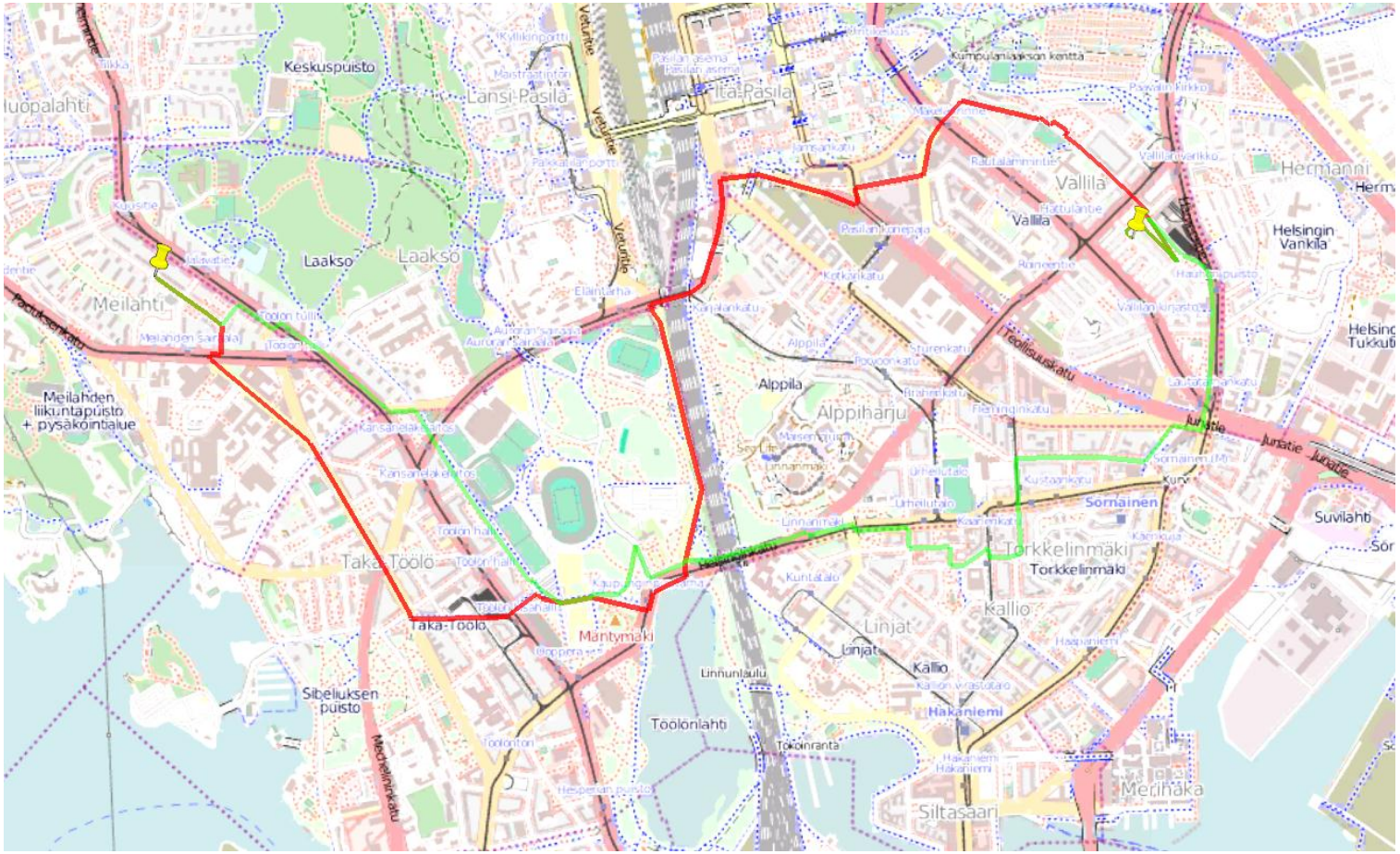
Example: Planning Graph



Helsinki statistics:

Graph	Nodes	Edges
PT	50320	764306
Road	87752	190822
Walk	160947	371637
Bike	156016	403750
R+B+w	404715	966209
Time dependent	256840	1401838

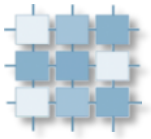
Example: Journey Response



Open Bicycle Route Planner

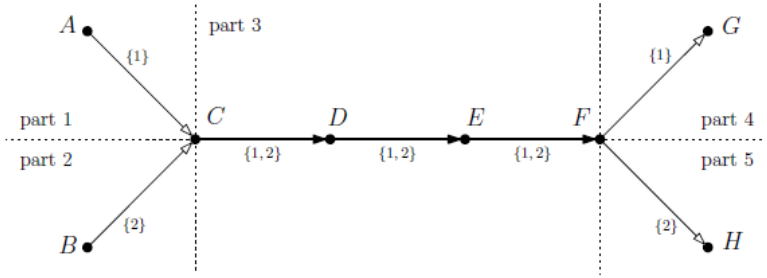
(BP Marcel Nemet)

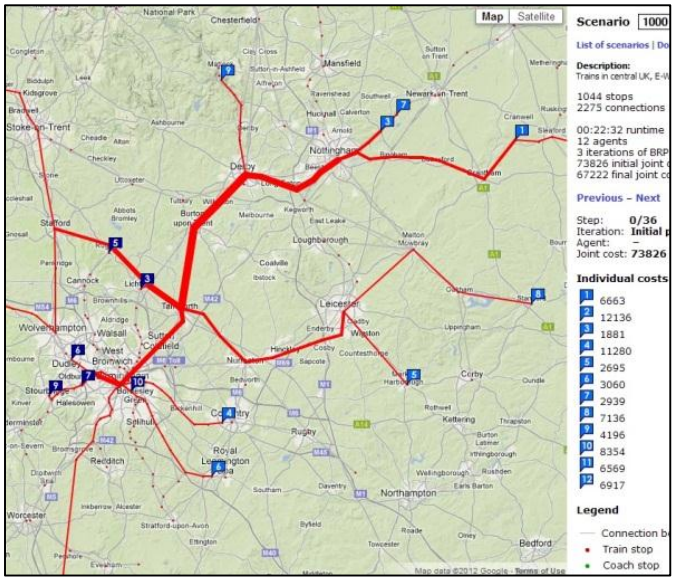
- Problem: Find a bicycle-friendly trip from origin to destination
  - Take into account trip duration & elevation
- Data
  - OSM maps
  - recommended routes for cyclists (by Auto*mat)
  - SRTM elevation data
- Solution approach: A*

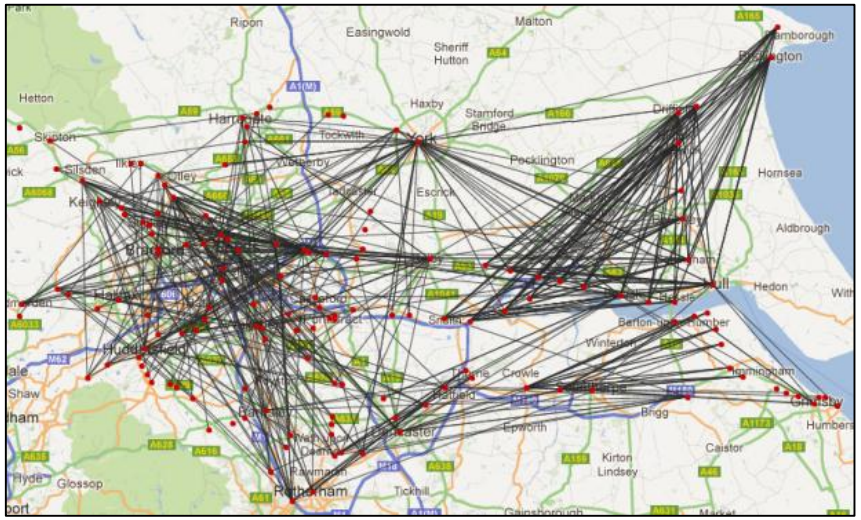


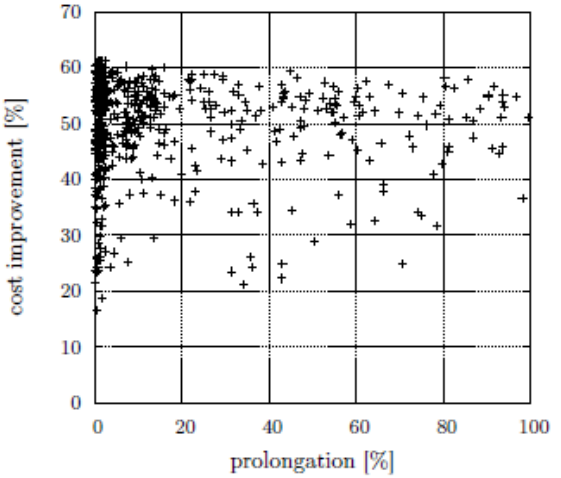
Multi-Agent Transport Coordination

Ride Sharing on Timetabled Services



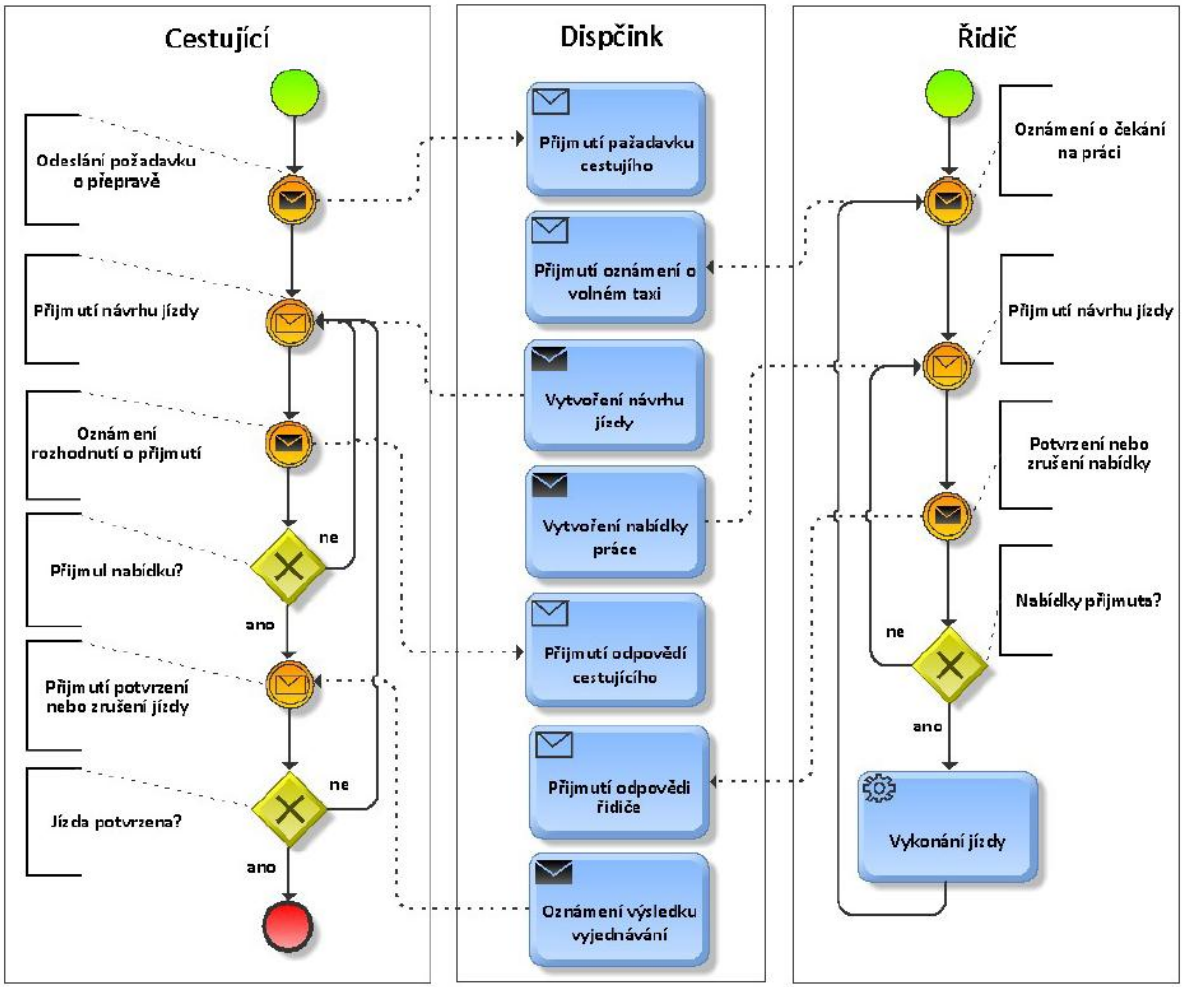


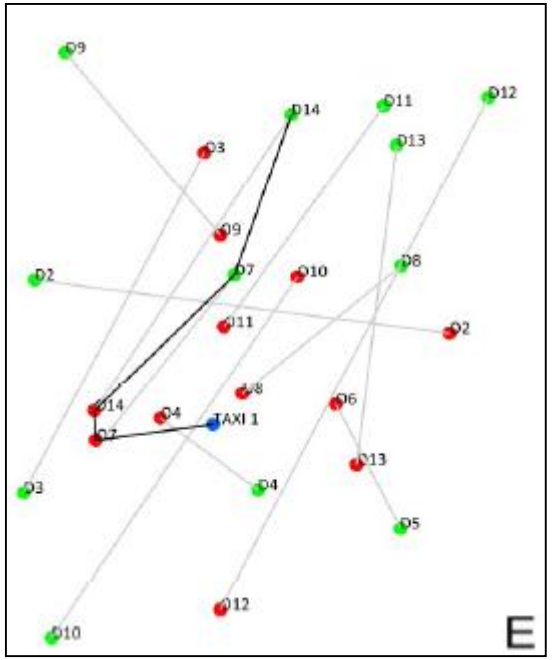




Taxi Ridesharing
(BP Petr Mezek)

- Real-time coordination of shared taxi rides

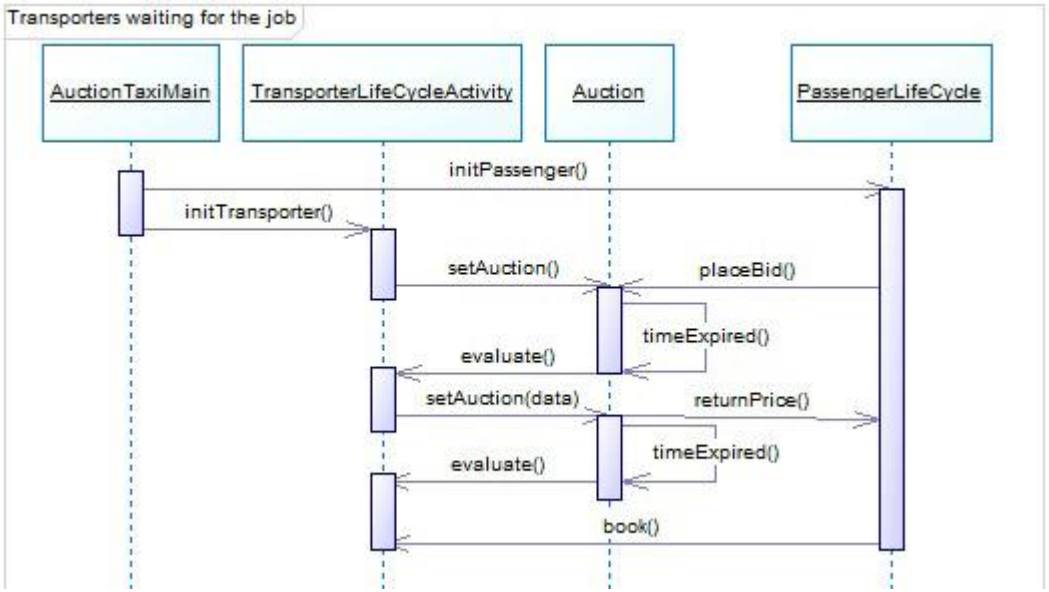


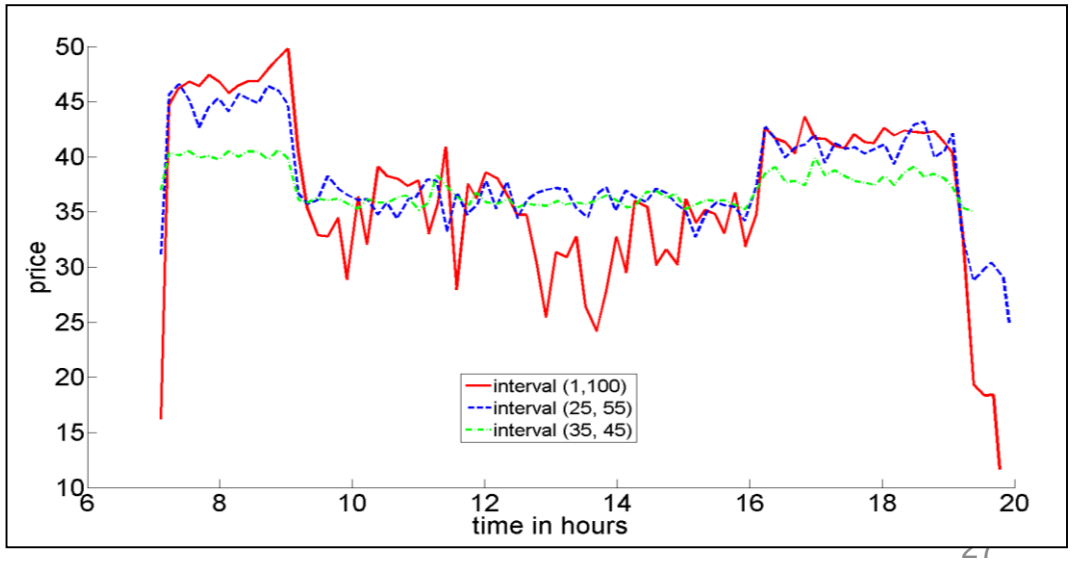


Auction-based Dynamic Pricing

(BP Jan Zikeš)

- Auction-based taxi allocation
- Passengers willing to pay more travel first in the peak time
- Passengers willing to wait travel cheapers

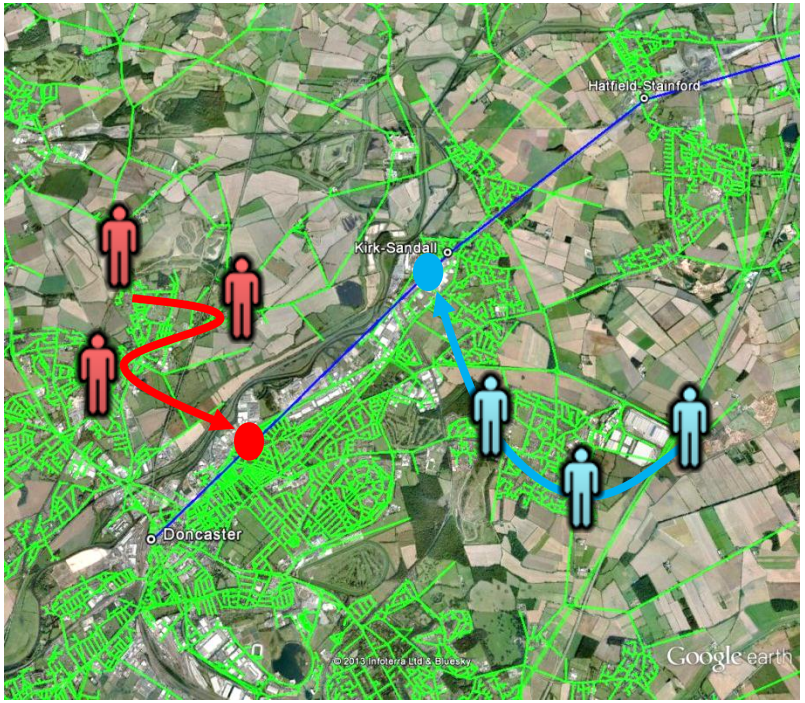


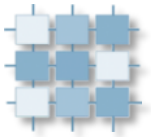


Flexible feeder services

(BP Tomáš Grubhoffer)

- Find feeder shared rides connecting to scheduled train service
- Solution approach
  - Find a single-agent plan for each agent
  - Cluster agents into groups for the first mile according to (First PT stop, Departure time, Location of origin)
- Find a joint plan for each group of agents

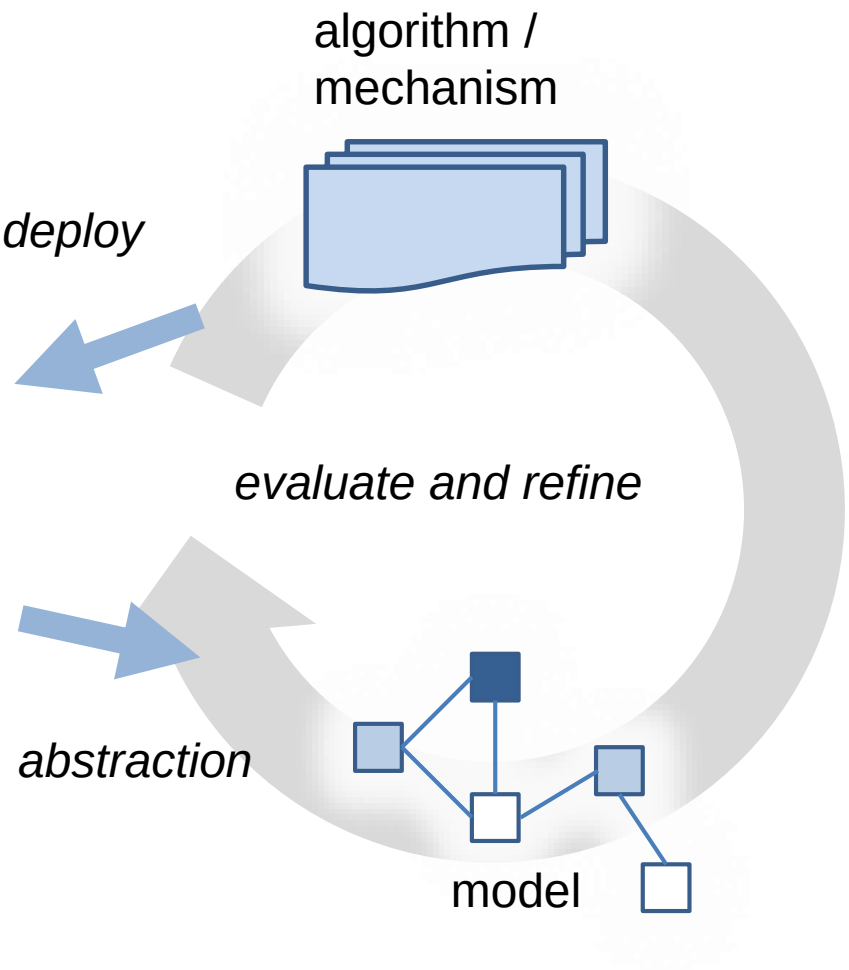




Conclusions

Simulation-aided Design of ITS

target system



SUPERHUB

SUstainable and PERsuasive Human Users moBility in future cities

- 2011-2014
- 20 partners
- FP7 Low-carbon multi-modal mobility and freight transport Future and Emerging Technologies (ICT-2011.6.6)
- Our role
  - Dynamic mobility matchmaking and Ecoplanner
  - Policy-aware mobility simulator

RODOS

Rozvoj dopravních systémů

- Projekt Centra competence TAČR 2012-2016
- Spolupráce: 3 univerzit, 1 výzkumného centra 6 firem
- ČVUT FEL vede pracovní balíček 6: Metody modelování a optimalizace multimodální mobility