Bevorzugter Zitierstil für diesen Vortrag

Axhausen, K.W. (2012) An agent-based model of travel demand and traffic flow: Recent results with MATSim, presentation at the *University of Illinois - Chicago*, Chicago, July 2012.

An agent-based model of travel demand and traffic flow: Recent results with MATSim.

KW Axhausen

IVT
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July 2012

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Institute for Transport Planning and Systems

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Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Thinking about equilibrium

DUE, SO & SUE

Wardrop (1952):

1. The journey times on all the routes actually used are equal, and less than those which would be experienced by a single vehicle on any unused route.
2. The average journey time is **a** minimum.

Daganzo and Sheffi's (1977) define SUE for the aggregate case:

> "In a SUE network, no user believes he can improve his travel time by unilaterally changing routes."

Packing problem of the DUE, SO & SUE

Given the

Agent's daily schedules of predetermined detail

Subject to some

Max F

upto the resolution of the agents, links and facilities

Matching the

Expected elasticities with respect to the generalized costs

Known correlations between the details of the plans

Capacity constraints on the link and facilities

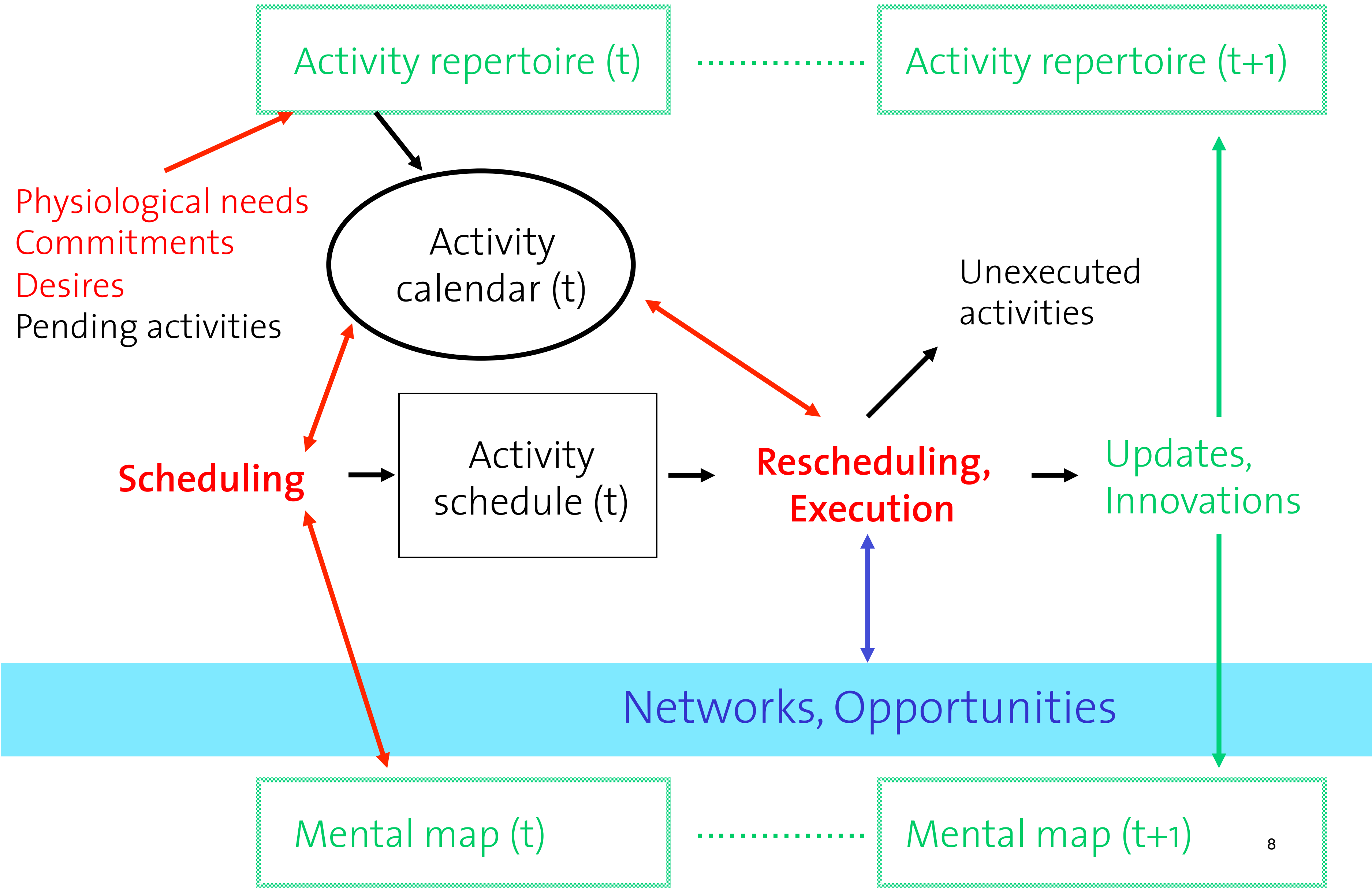
Minimum loads for some of the facilities

“Activity based approach”

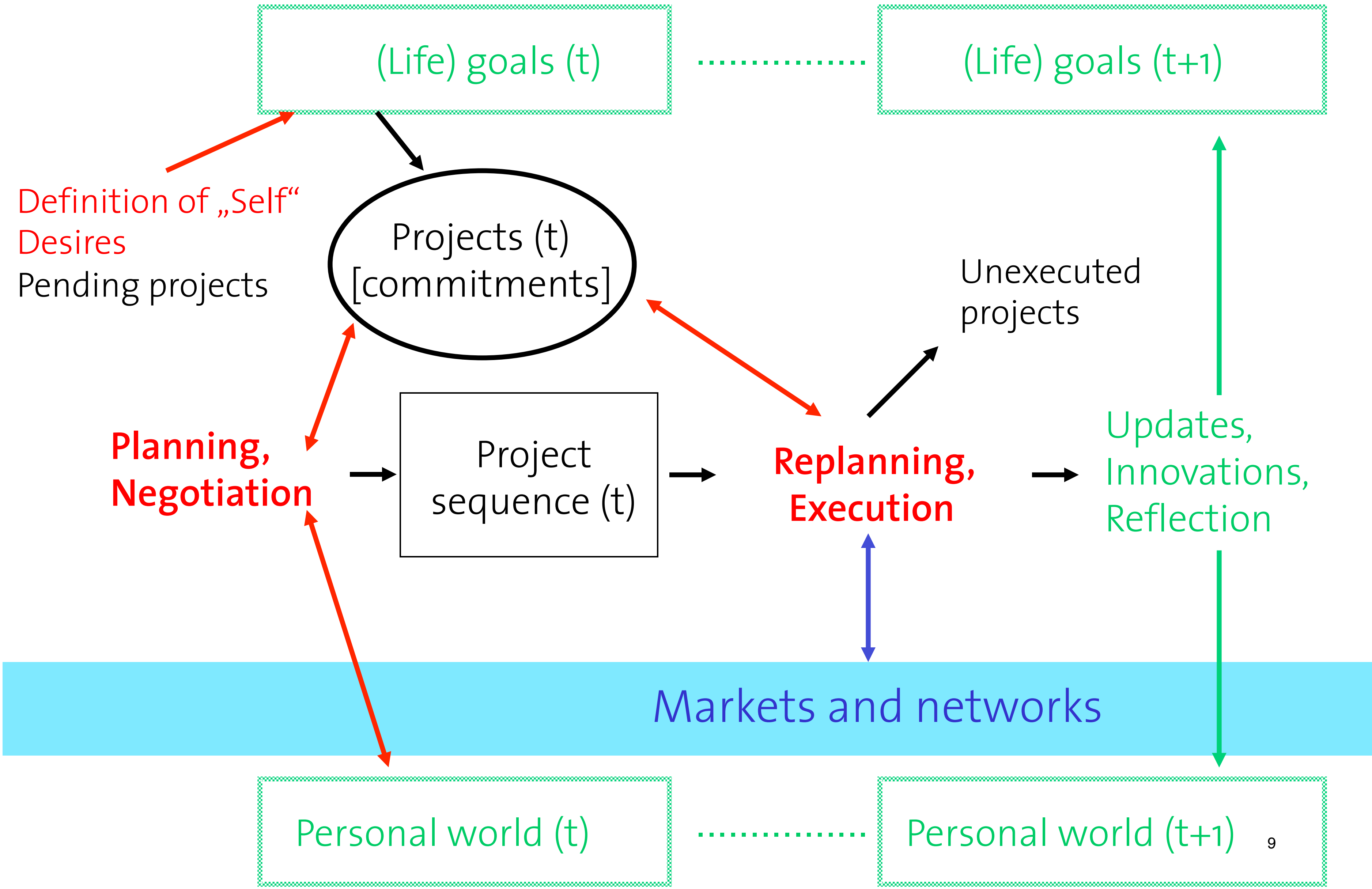
Key points of the critique of equilibrium approaches

- Travel is derived demand, with some exceptions
- The travellers are constrained by their commitments and tool ownership
- Travellers aren’t in equilibrium
- Travellers don’t know all alternatives
- Travellers don’t plan their whole day (week) in advance

Processes suggested tpo model personal daily dynamics

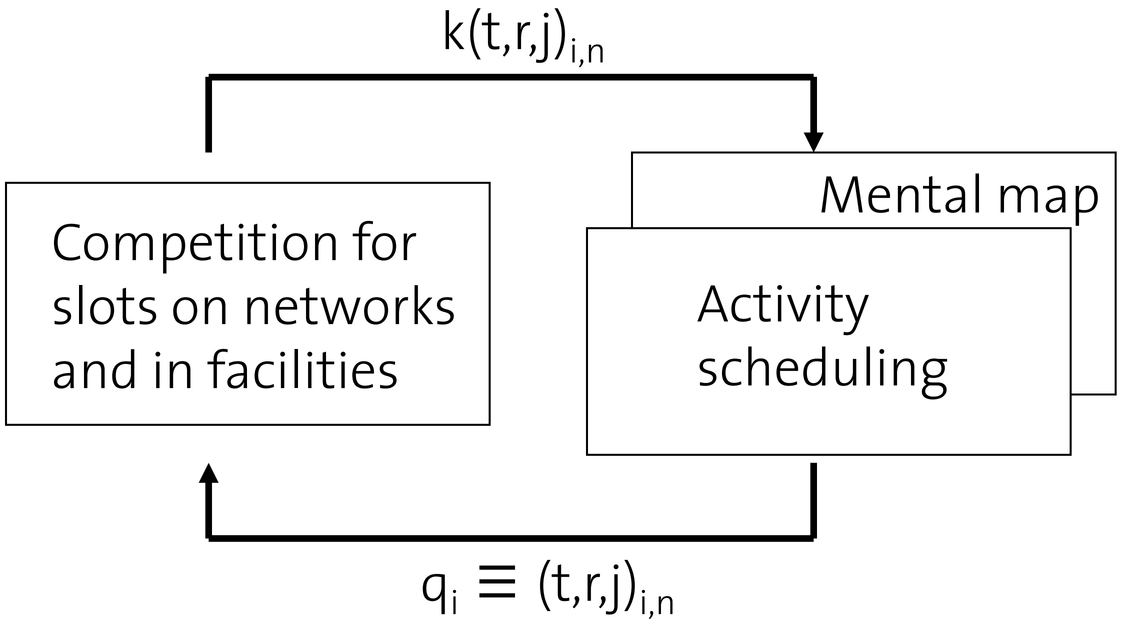


Processes suggested for personal long-term dynamics

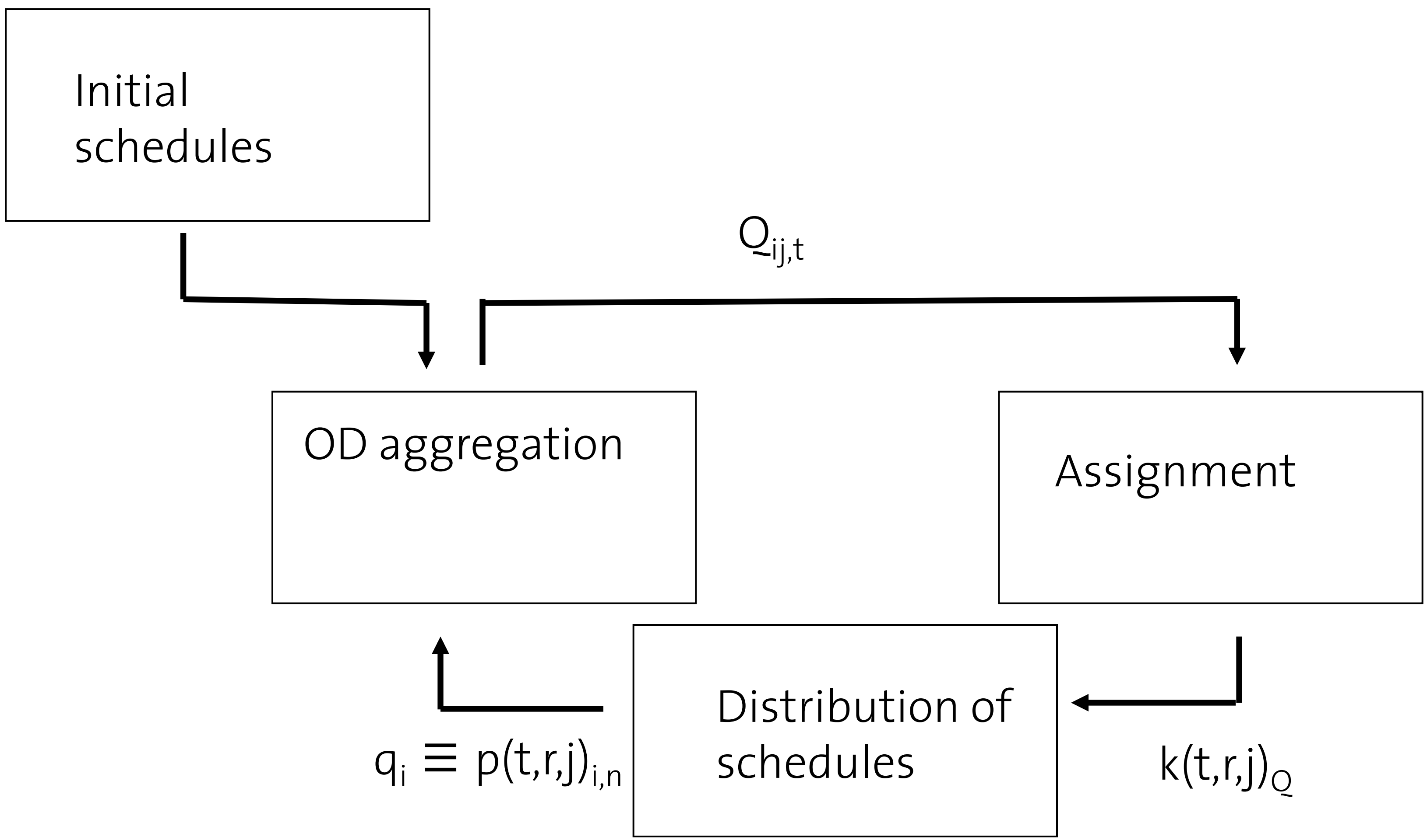


Thinking about SUE and best response

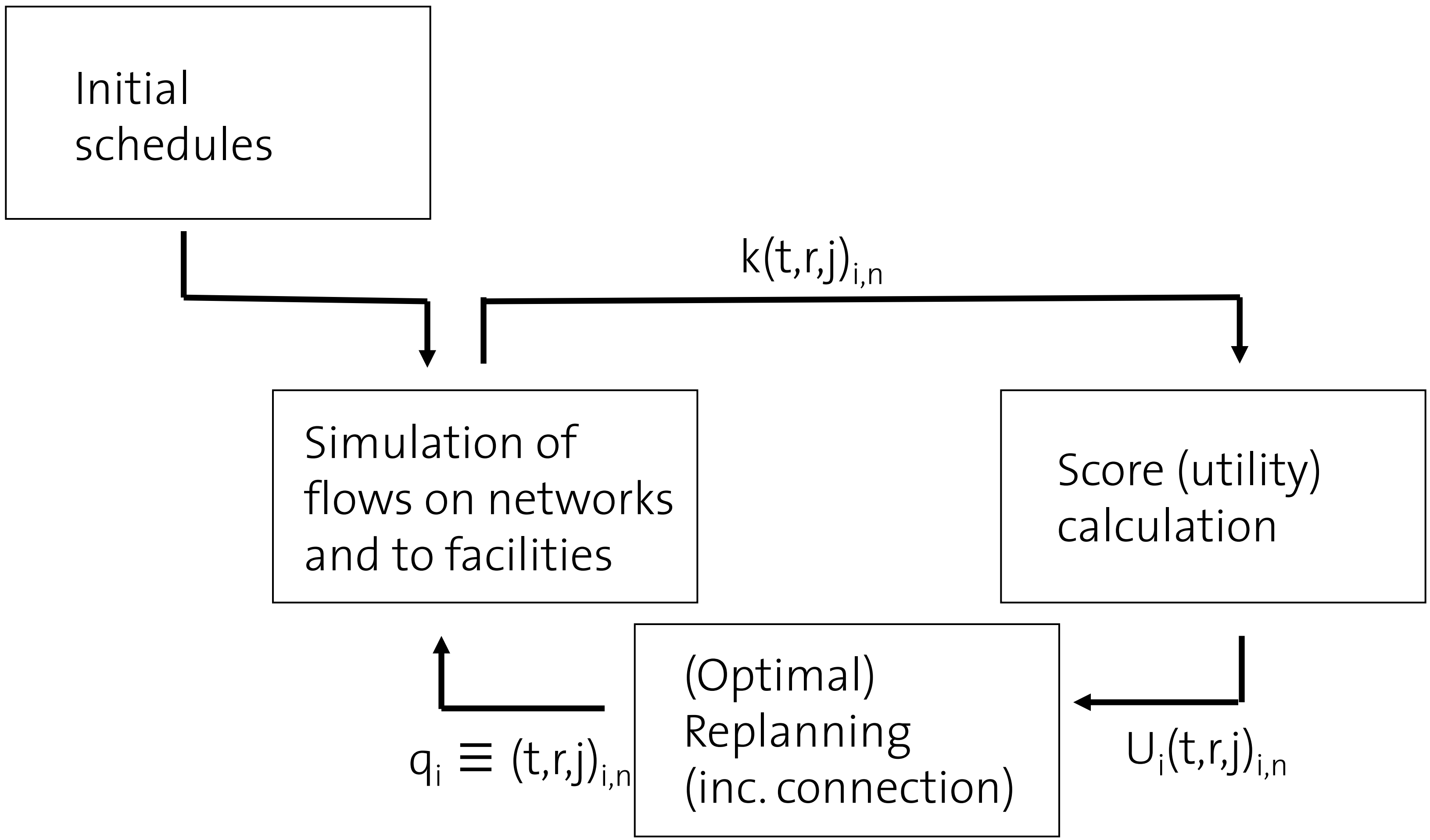
Learning approach of the generic one-day transport model



Equilibrium search in „ABM“ & assignment combinations

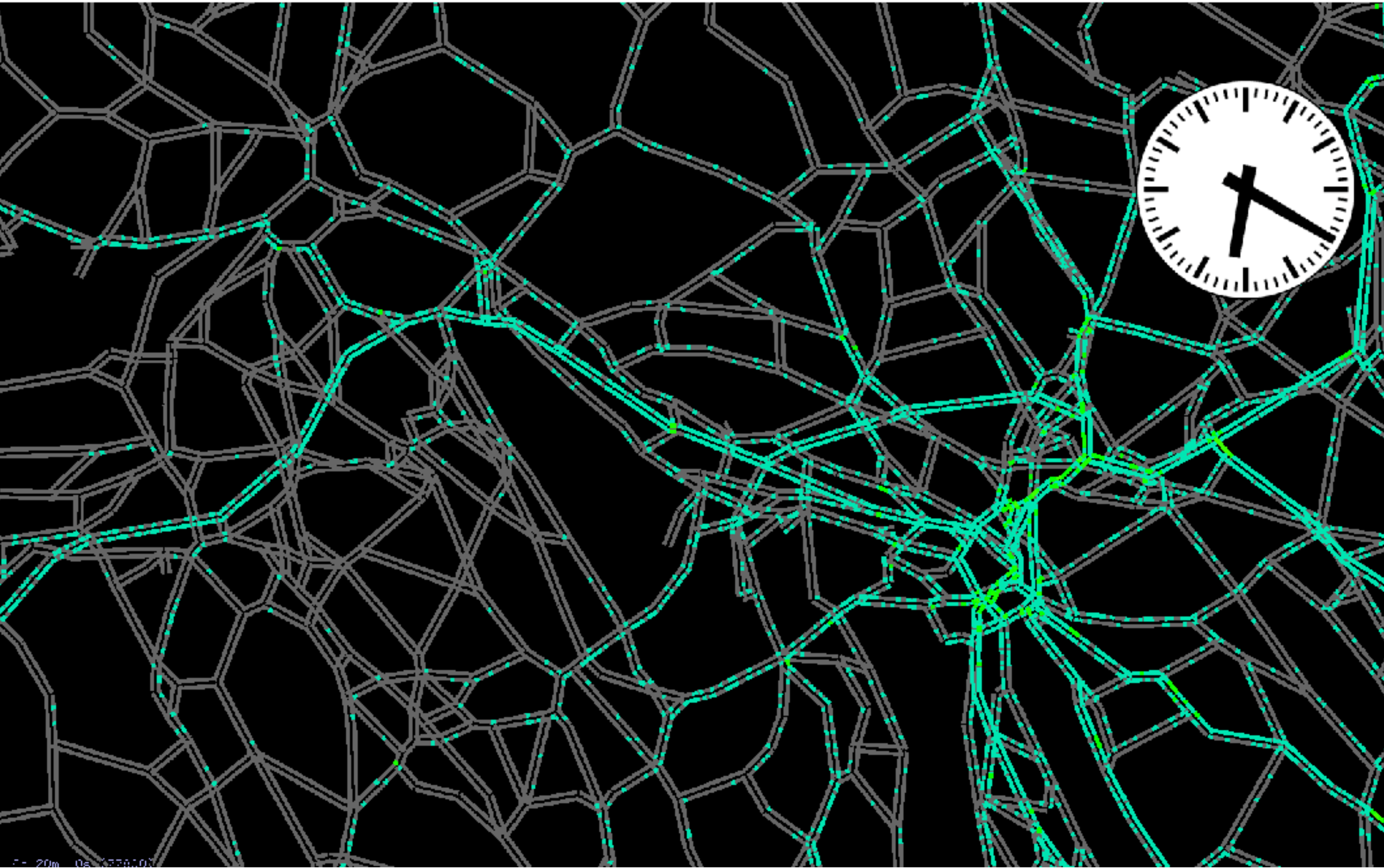


Equilibrium search in MATSim



MATSim today

Following the agents



MATSim: Logic of the event-based simulation – Step 1

Initial plan of agent 1:

• Home	8:00		
• Leg	0.20	Car	Link 1, 2
• Work	8:00		
• Leg	0:20	Car	Link 2,1
• Home	7:40		

Agent 2

• Home	8:00		
• Leg	0.20	Car	Link 3, 2
• Work	8:00		
• Leg	0:20	Car	Link 2, 3
• Home	7:40		

MATSim: Logic of the event-based simulation – Step 2

List of scheduled events at 8:00

Agent 1 Enter link 1 8:00

Calculate free flow time on link 1 dt = 0.15

Agent 2 Enter link 3 8:00

Calculate free flow time on link 3 dt = 0.16

MATSim: Logic of the event-based simulation – Step 3

List of scheduled events at 8:01

Agent 1	Join queue at end of link 1	8:15
Agent 2	Join queue at end of link 3	8:16

MATSim: Logic of the event-based simulation – Step 4

List of scheduled events at 8:15

Agent 1	Check queue at end of link 1	8:15

Can agent 1 leave the link ?

If yes, add

Agent 1 Leaves link 1 8:15

If no, add

Agent 1 At end of queue 8:16

Agent 2	Join queue at end of link 3	8:16

MATSim: A GNU public licence software project

Main partners

- TU Berlin (Prof. Nagel)
- ETH Zürich
- senezon (Dr. Balmer, Dr. Rieser)

Coordination via:

- User meeting
- Design meeting
- Developer meeting

- Code committee
- Regular releases of the code

Known implementations

Location	Scale (agents)	Schedules	DTA	Equilibrium
Switzerland	10^6	MATSim	MATSim	Yes
Berlin	10^6	MATSim	MATSim	Yes
München	10^6	MATSim	MATSim	Yes
Singapore	10^6	MATSim	MATSim	Yes
Gauteng	10^6	MATSim	MATSim	Yes
Cape Town	10^6	MATSim	MATSim	Yes
(Seoul)	10^7	MATSim	MATSim	Yes
(Shanghai)	10^7	MATSim	MATSim	Yes
Tel Aviv	10^6	ABM	MATSim	-
Toronto	10^7	Tasha	MATSim	-
Los Angeles	10^7	CEMDAP	MATSim	-
Netherlands	10^7	Albatross	MATSim	-
Dublin	10^6	-	MATSim	-
(London)	10^7	ABM	MATSim	-

Activity scheduling with Vickrey-style utility function

Number and type of activities
Sequence of activities

- Start and duration of activity
- Composition of the group undertaking the activity
- Expenditure division
- Location of the activity
  - Movement between sequential locations
    - Location of access and egress from the mean of transport
      - Parking type
    - Vehicle/means of transport
    - Route/service
    - Group travelling together
    - Expenditure division

Current Vickrey-type utility function

$$U_{plan} = \sum_{i=1}^{n} U_{act,i} + \sum_{i=2}^{n} U_{trav,i-1,i}$$

$$U_{act,i} = U_{dur,i} + U_{late.ar,i}$$

2010 MATSim: Initial demand

Population: Census-based (sample); Through traffic from surveys

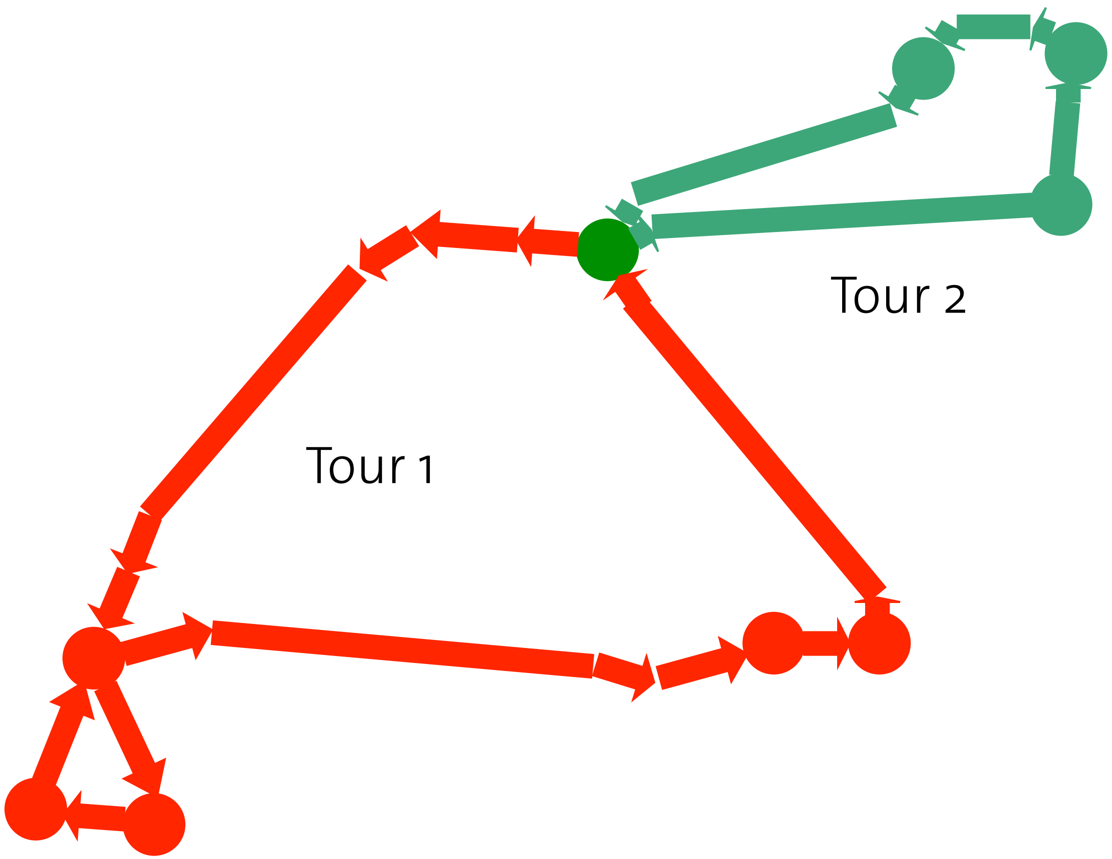
Number, type, sequence and duration of activities:

- Conditional random draw from observed categorised MZ 2000-2005 distributions by person type

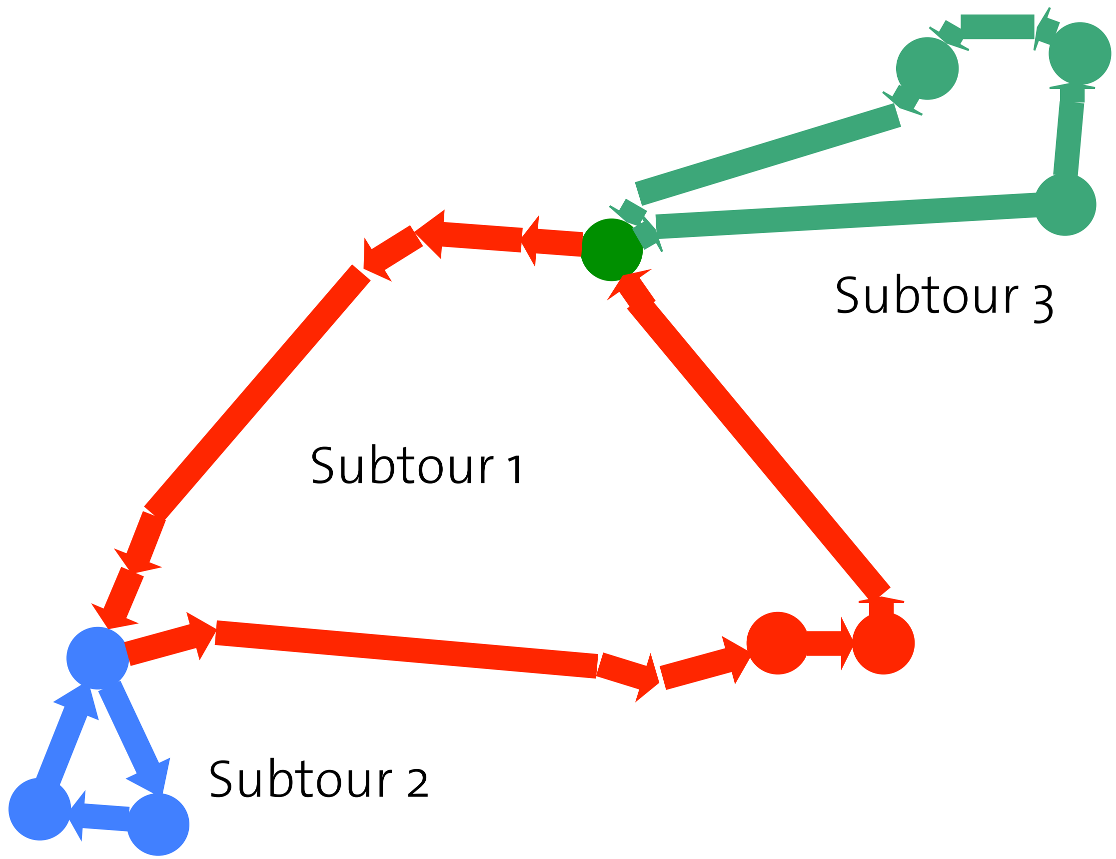
- Location of work/school activity:
  - Census commuter matrix
- Location of secondary activities:
  - Random constrained selection or
  - Capacity-constrained MNL within a time-space prism

  - Mode choice:
    - MZ-based subtour MNL
  - Route choice:
    - Improved A* shortest path

Mode choice: Tour (journey)



Mode choice: Subtour



2010 MATSim configuration: Iteration

Number and type of activities
Sequence of activities

- Start and duration of activity
  - Random mutation
  - Planomat: GA optimiser
- Composition of the group undertaking the activity
- Expenditure division
- Location of the activity

  - Location of access and egress from the mean of transport
    - Parking type
  - Vehicle/means of transport
  - Route/service
  - Group travelling together
  - Expenditure division

Modelling Switzerland 2009

2009 MATSim Switzerland: Configuration

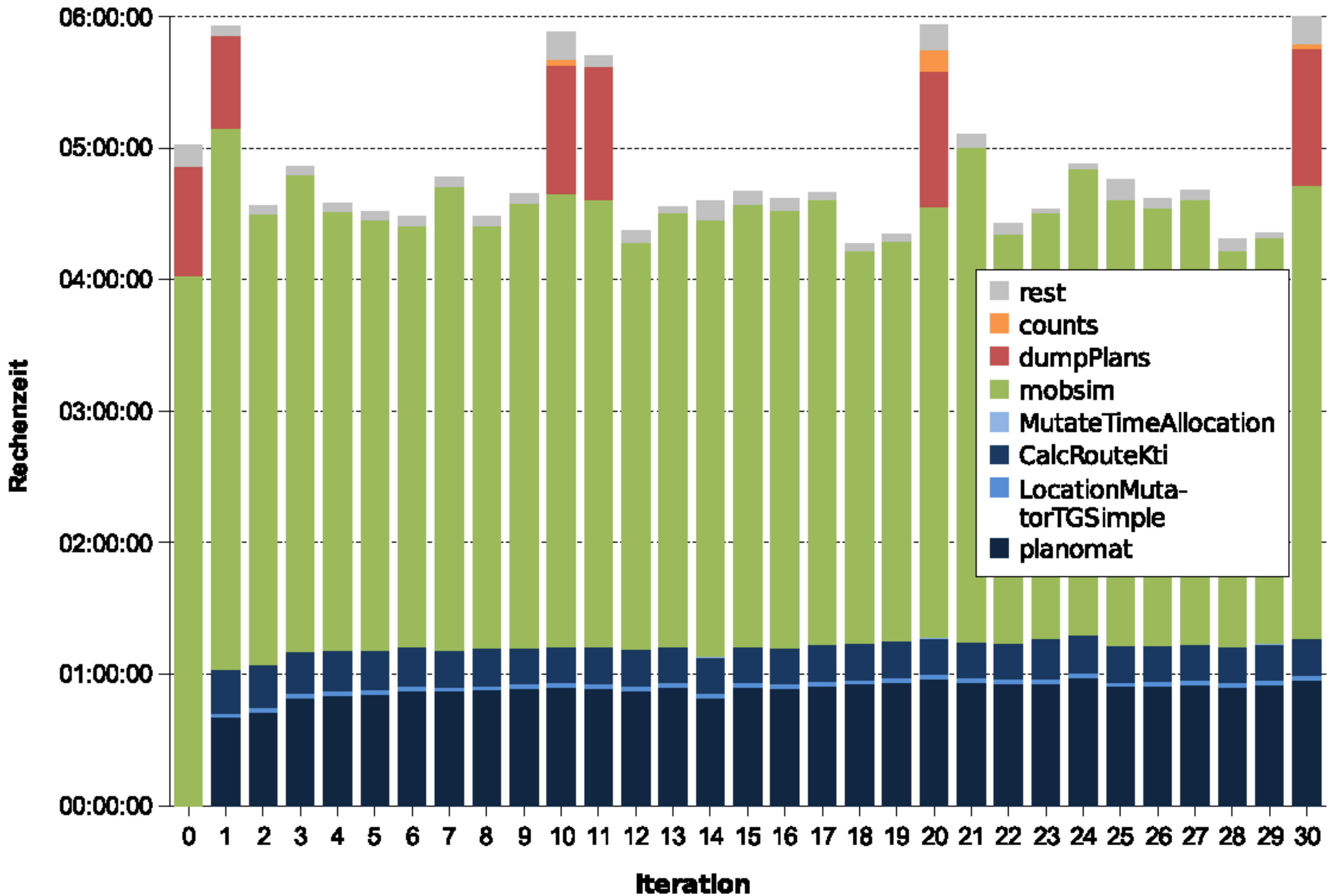
During the iterations:

- Optimisation of start time and duration of the activities
- Random location of the activity (with capacity constraint)
- Vehicle/means of transport at sub-tour level
- Optimal routes
- Event-oriented queue-based traffic flow simulation

For a search space of:

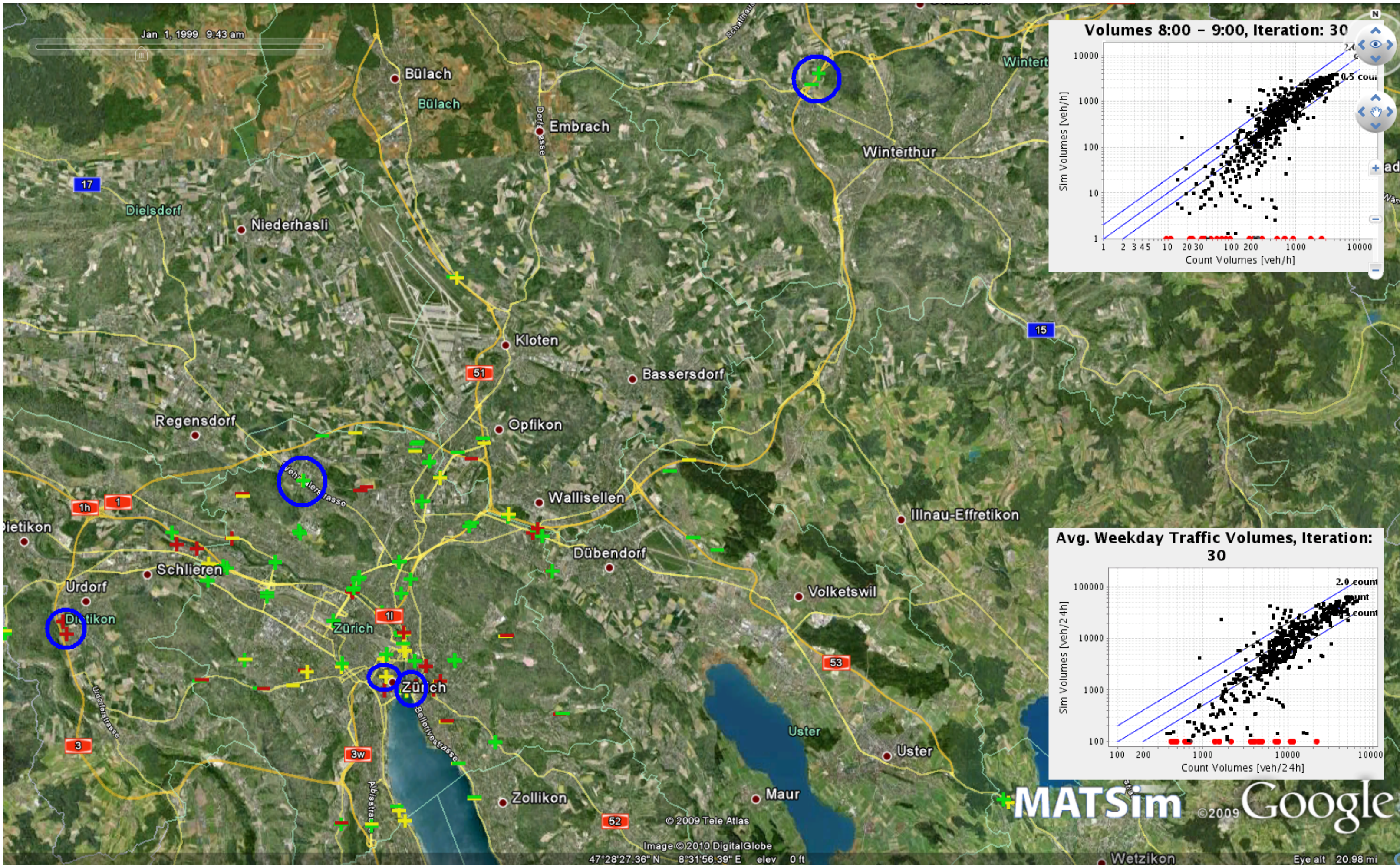
- $6.0 * 10^6$ agents with 11 activity types
- $1.6 * 10^6$ facilities
- $0.8 * 10^6$ links
- 24 * 60 * 60 seconds

2009 MATSim Switzerland: Computing time

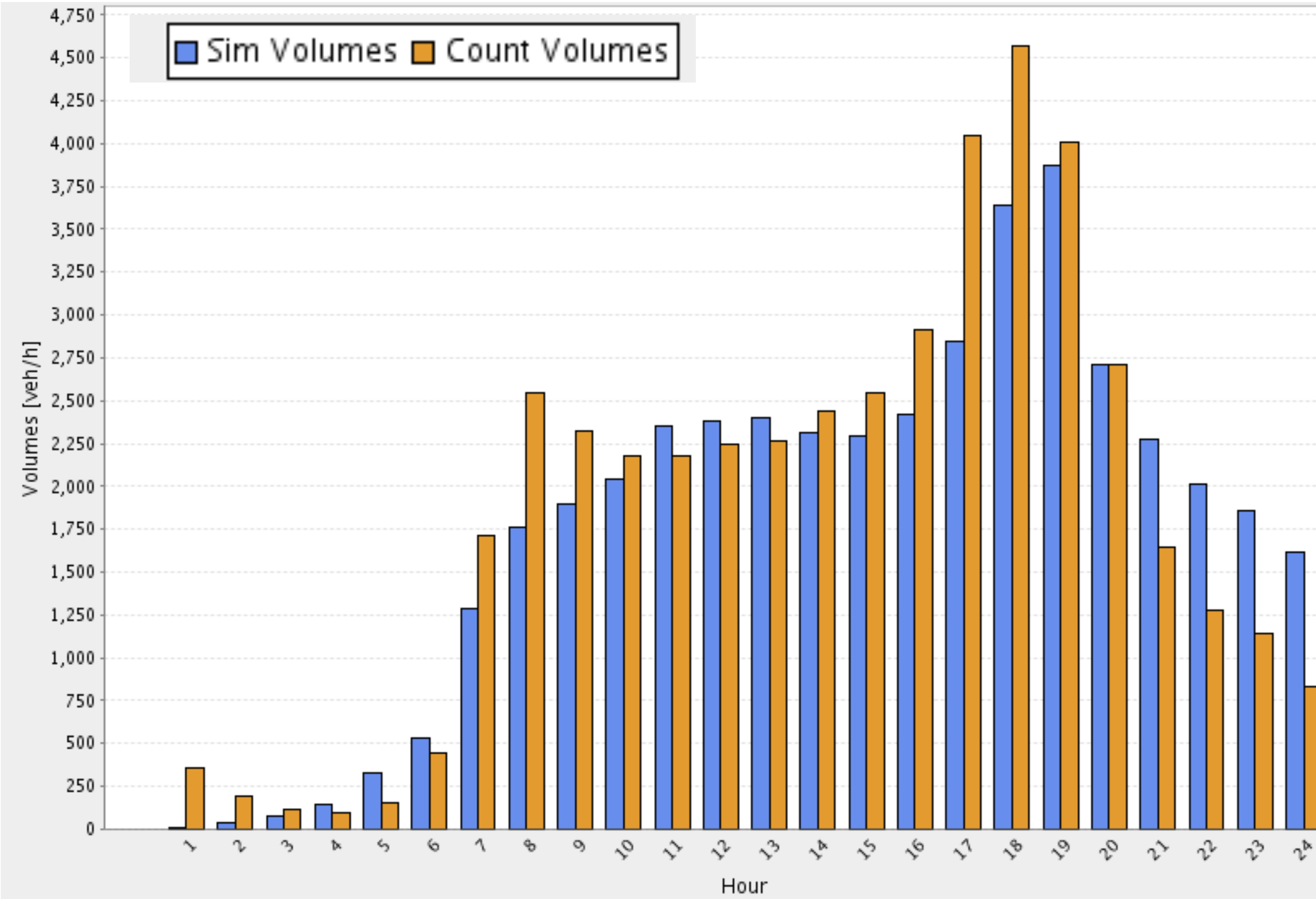


Balmer, 2009

Quality of the results: Overall counts



Quality of the results: A1 at Winterthur (no transit traffic)



Current progress: Berlin

Network: 113 000 links

Population: 4,5 million agents

Public Transport: 530 lines, 96 transit vehicle types

Mode choice, Departure time choice, Route choice (car + transit)

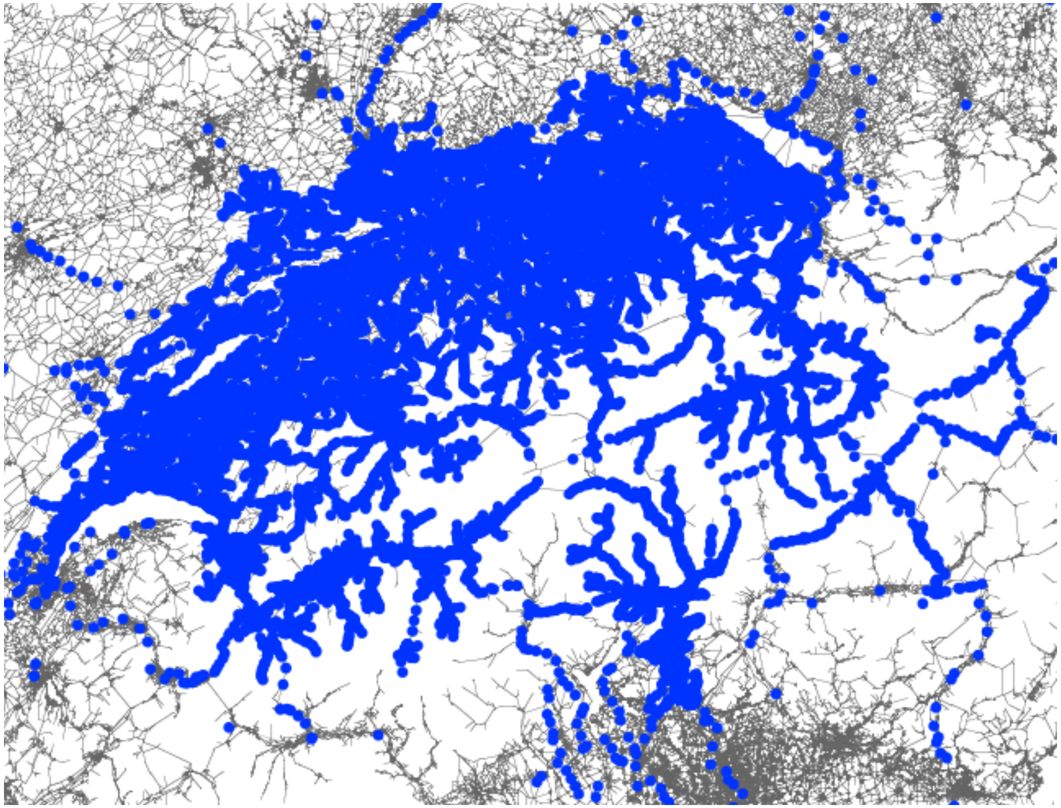
Current progress: Switzerland

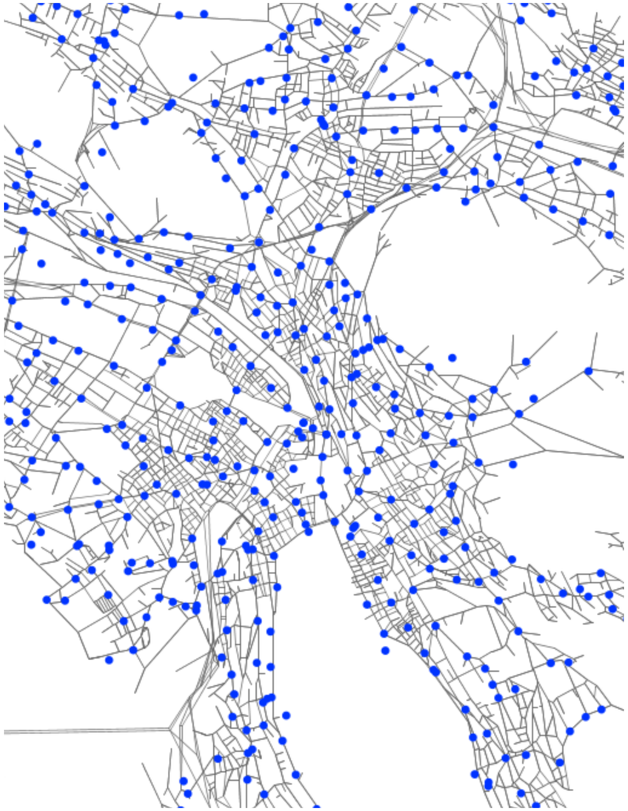
Network: ~ 1 million links (navigation network)

Population: 8 million

Complete public transport (all trains, buses, trams, cablecars, ...)

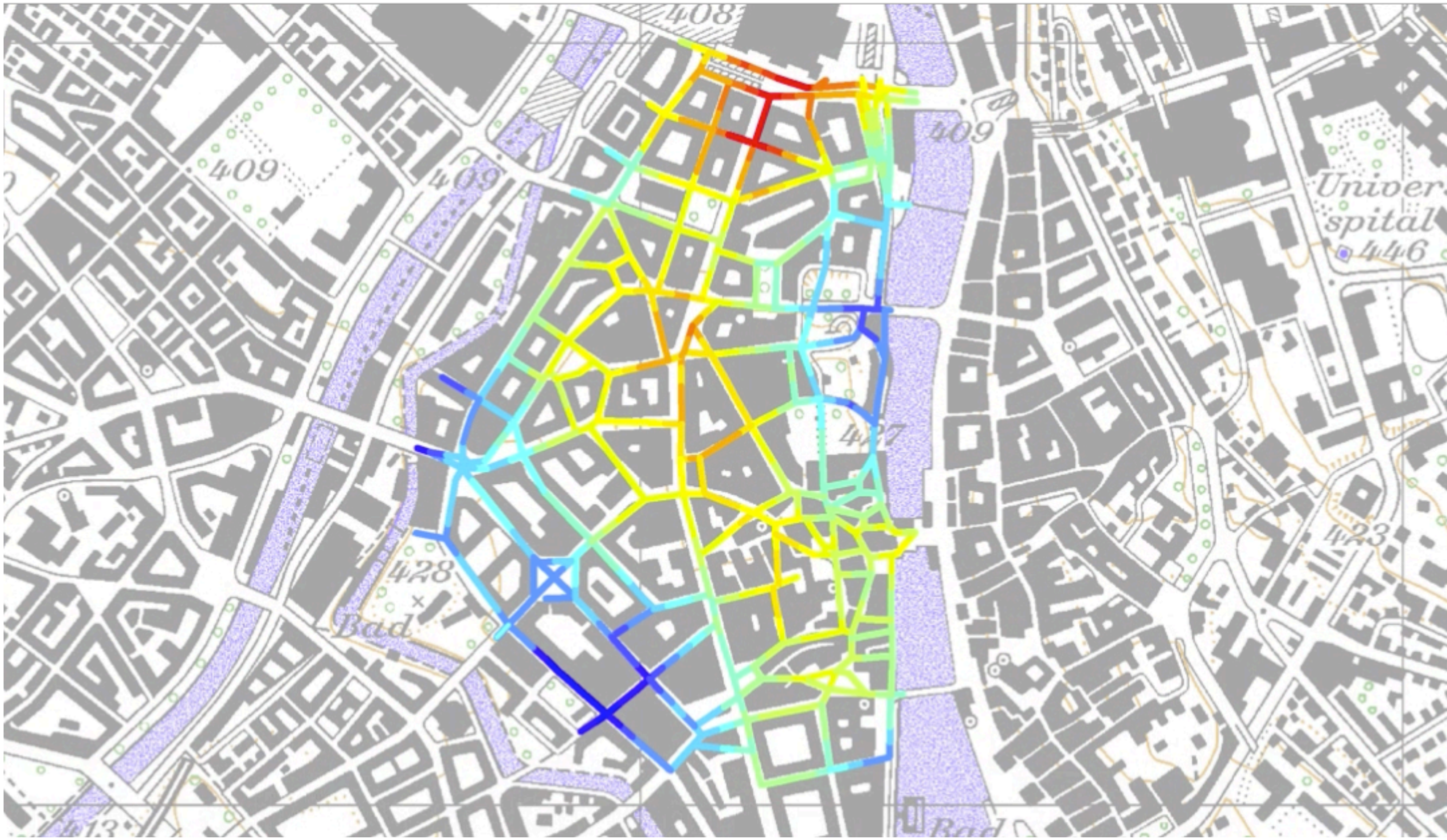
Mode choice, Departure time choice, Route choice (car + transit)





Current progress: Switzerland (cont'd)

Using the model also for site assessment and pedestrian counts



Current progress: Los Angeles

Network: 108 000 links

Population: 10+ million agents

Public transport: Estimated travel times only

Mode choice, Departure time choice, Route choice

Current progress: Singapore

Network: 80 000 links

Population: 5 million

Complete public transport (bus, MRT)

Mode choice, Departure time choice, Route choice (car + transit)

Current progress: Singapore

Schedule detail possibilities (in current stable MATSim)

Number and type of activities **(Feil, 2010)**
Sequence of activities

- **Start and duration of activity**
- Composition of the group undertaking the activity **(Kowald)**
- Expenditure division
- **Location of the activity** **(Horni)**

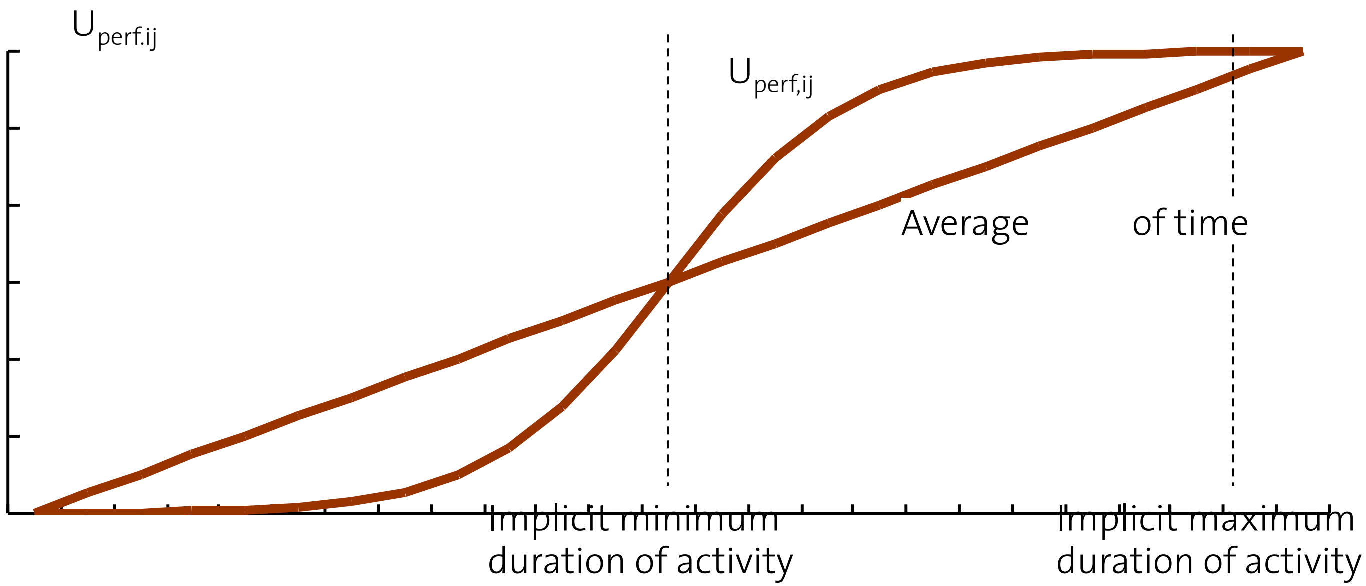
  - Movement between sequential locations

    - **Location of access and egress from the mean of transport**
      - Parking search and type **(Waraich)**
    - **Vehicle/means of transport** **(Ciari)**
    - **Route/service**
    - Group travelling together **(Dubernet)**
    - Expenditure division

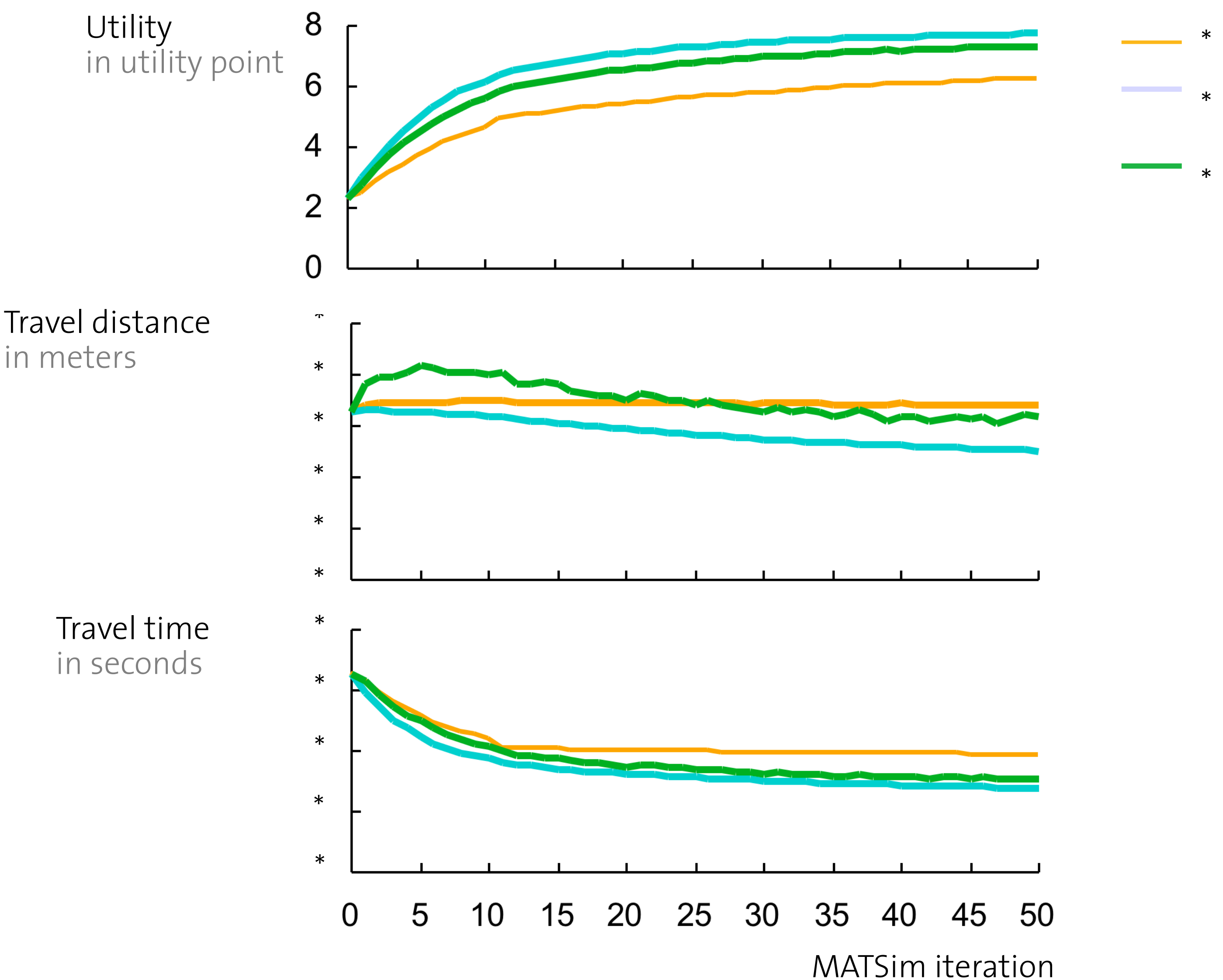
Adding induced demand

Joh's 2004 utility function for activities

$$U_{perf,ij}(t_{perf,ij}) = U_{ij}^{min} + \frac{U_{ij}^{max} - U_{ij}^{min}}{\left(1 + \gamma_{ij} \cdot exp\left[\beta_{ij}(\alpha_{ij} - t_{perf,ij})\right]\right)^{1/\gamma_{ij}}}$$

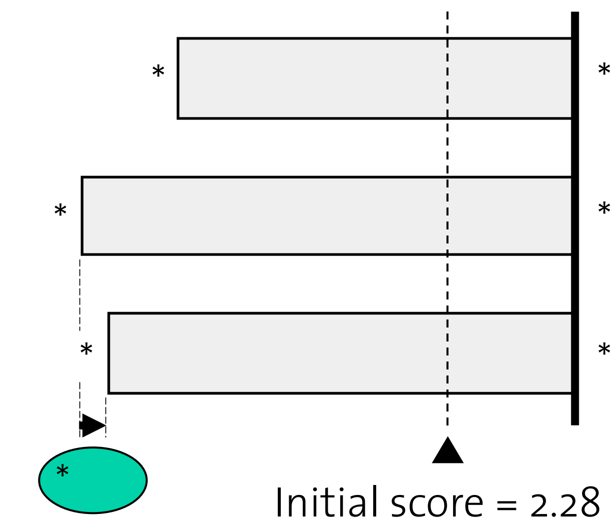


Planomat-X with schedule recycling

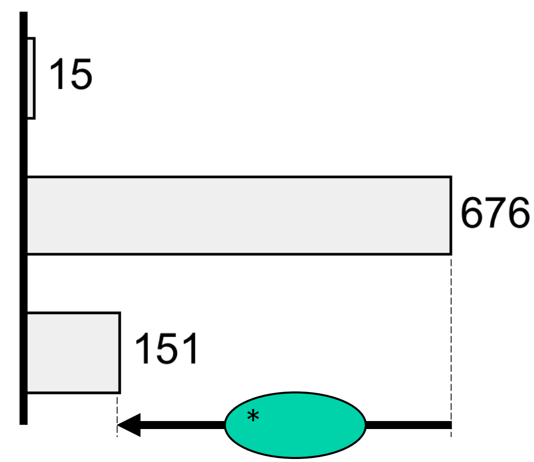


Planomat-X with schedule recycling

Final average utility score of
executed schedules
(in utility points)



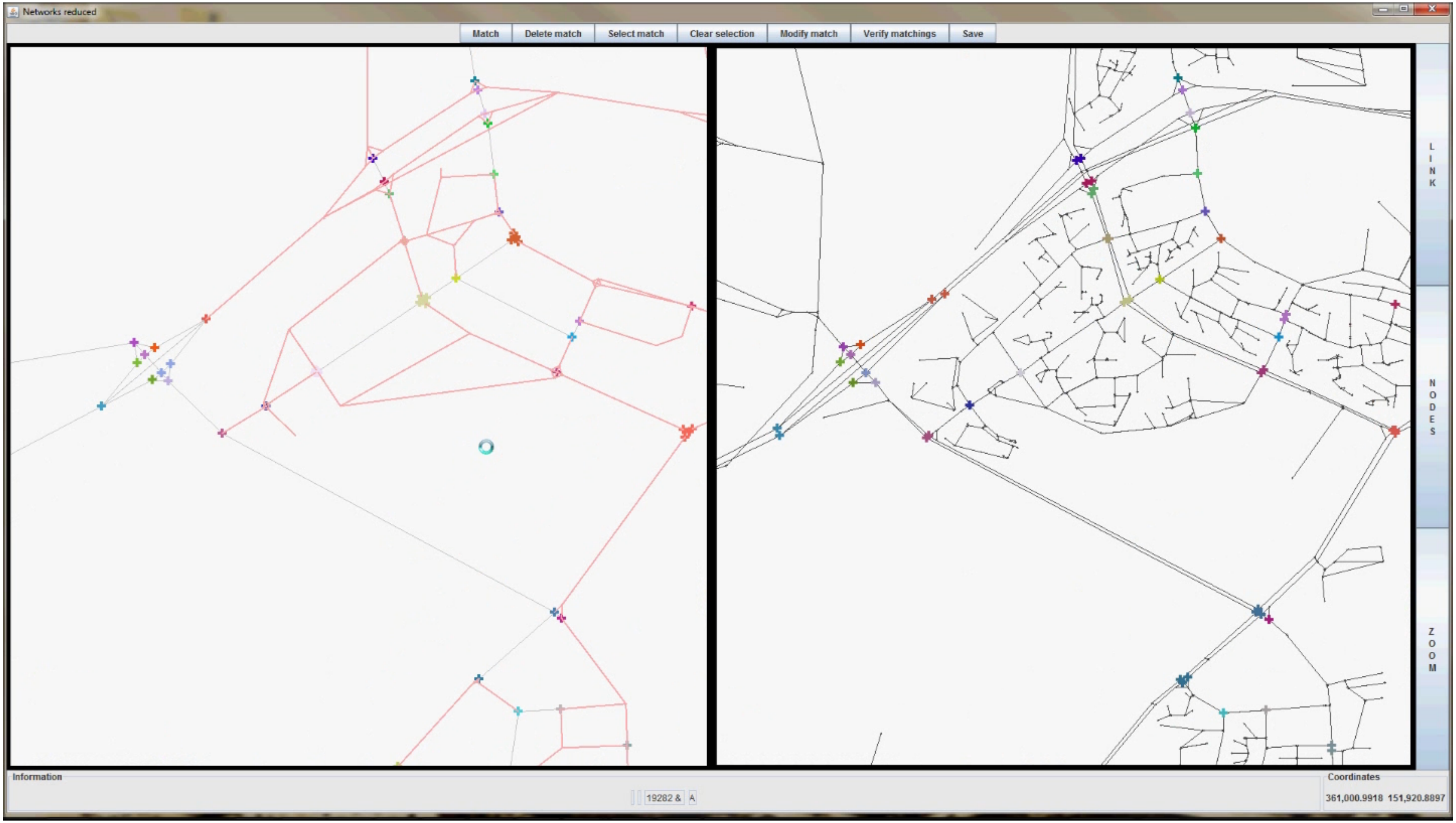
Replanning runtime* per
agent (in msec)



New tools

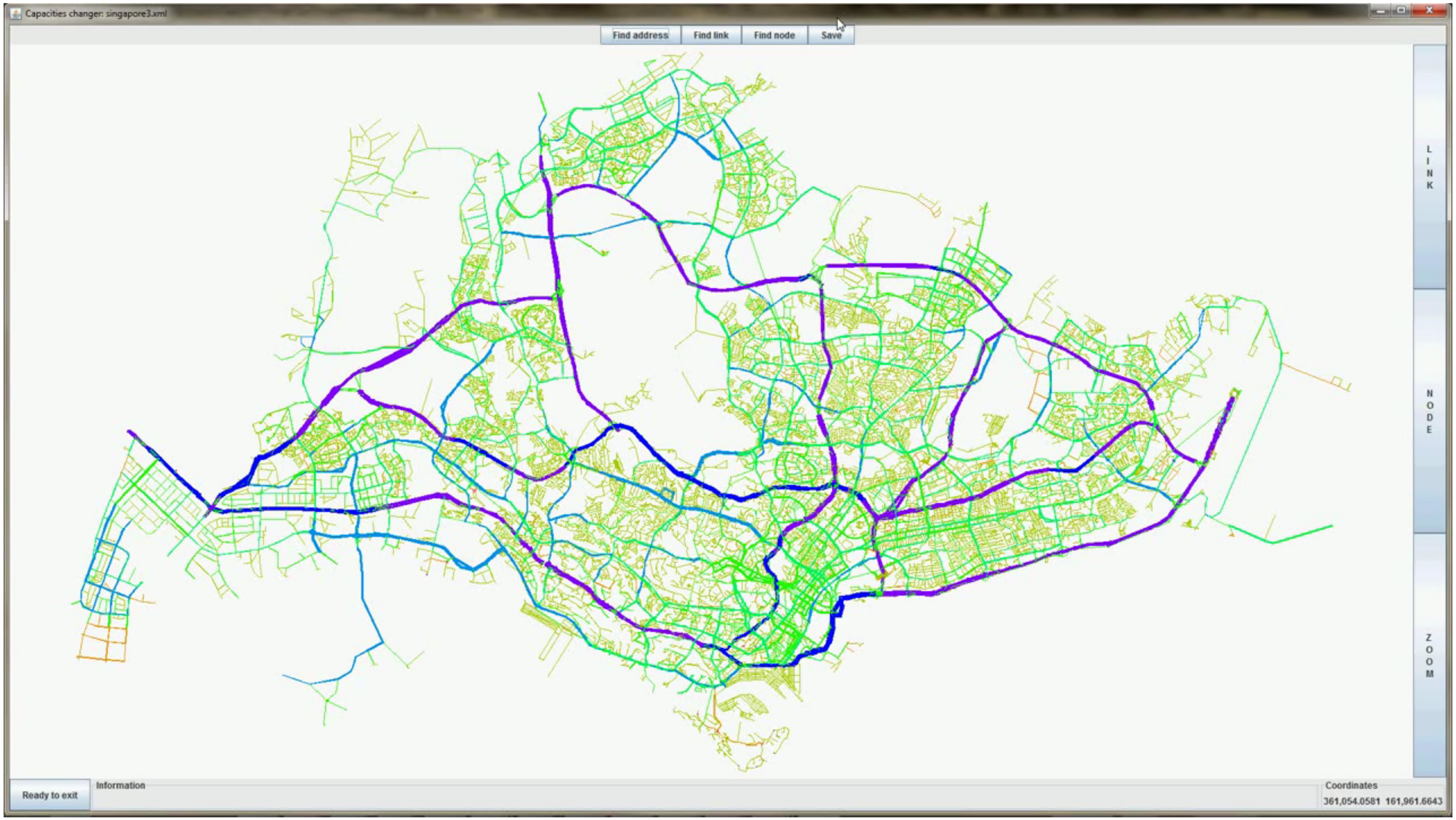
Video available at http://vimeo.com/30826962

Nodes map-to-map-matching tool



Video available at http://vimeo.com/30826962

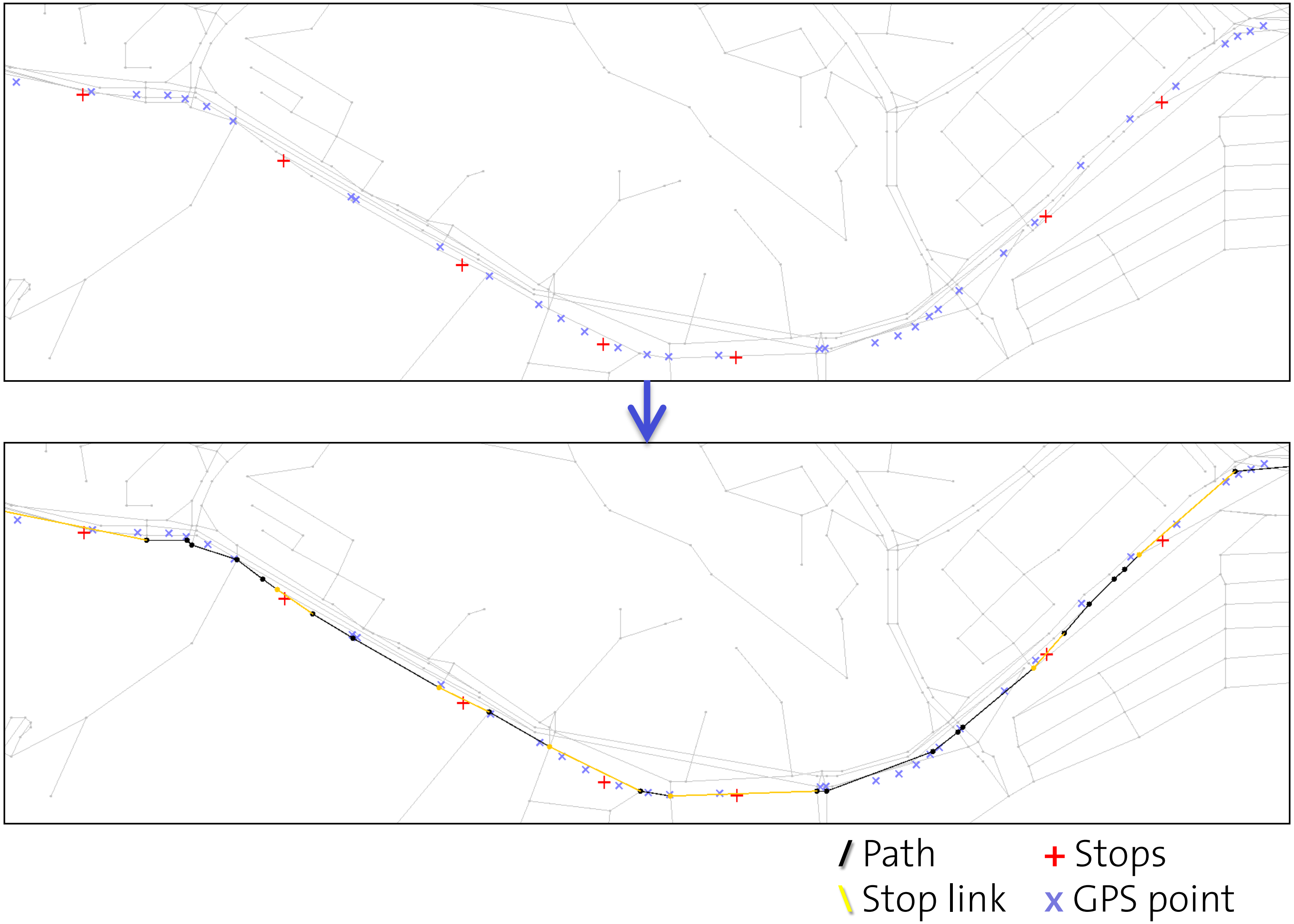
Interactive capacity and free speed fixing tool



Video available at http://vimeo.com/30826962

Results: Capacity changes

Bus routes map matching problem



Algorithm

For each pair of consecutive stops in a route:

1. Selection of candidate links related to the departure stop
2. Selection of candidate links related to the arrival stop
3. Shortest path algorithm between each pair of links
4. Selection of the best path

Save selected links and path, continue with the next pair of stops

Video available at http://vimeo.com/30826962

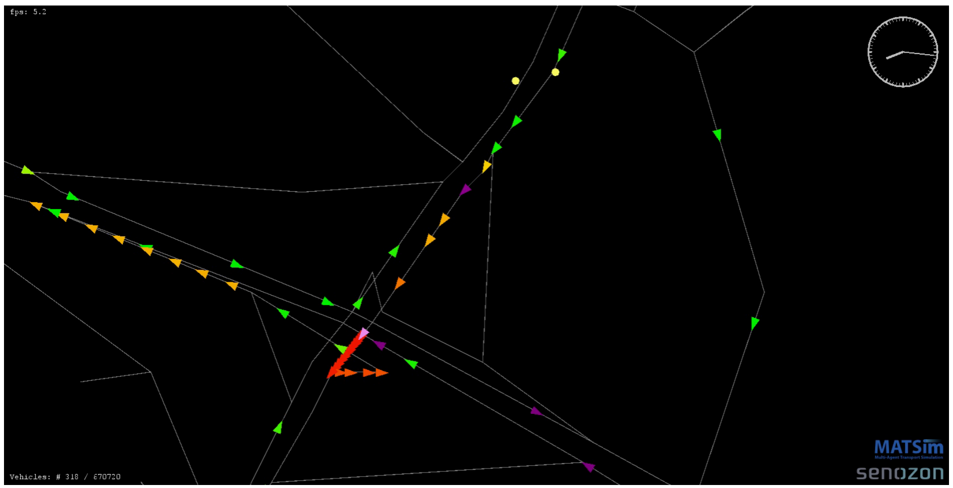
Demonstration

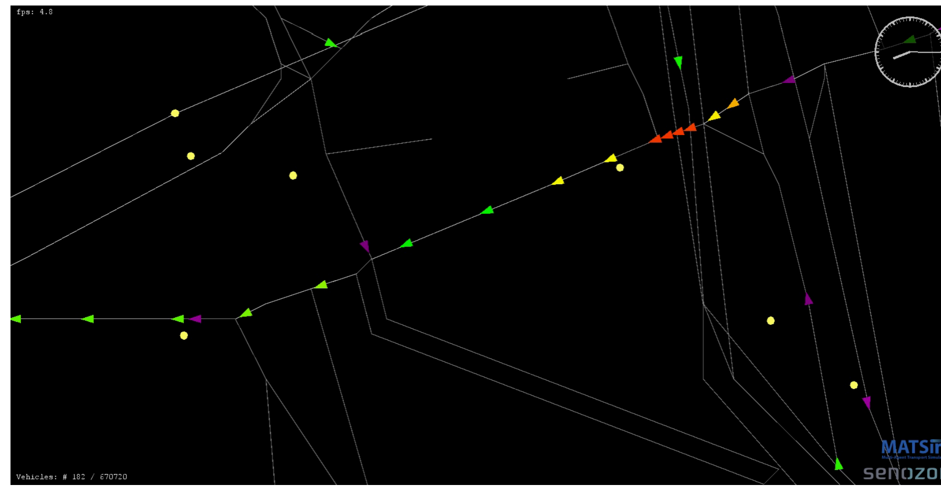
Video available at http://vimeo.com/30826962

Interaction between car and buses (purple)

Without buslane:
Adam Rd / PIE

With buslane:
Gelyang Rd, aft Sims Way





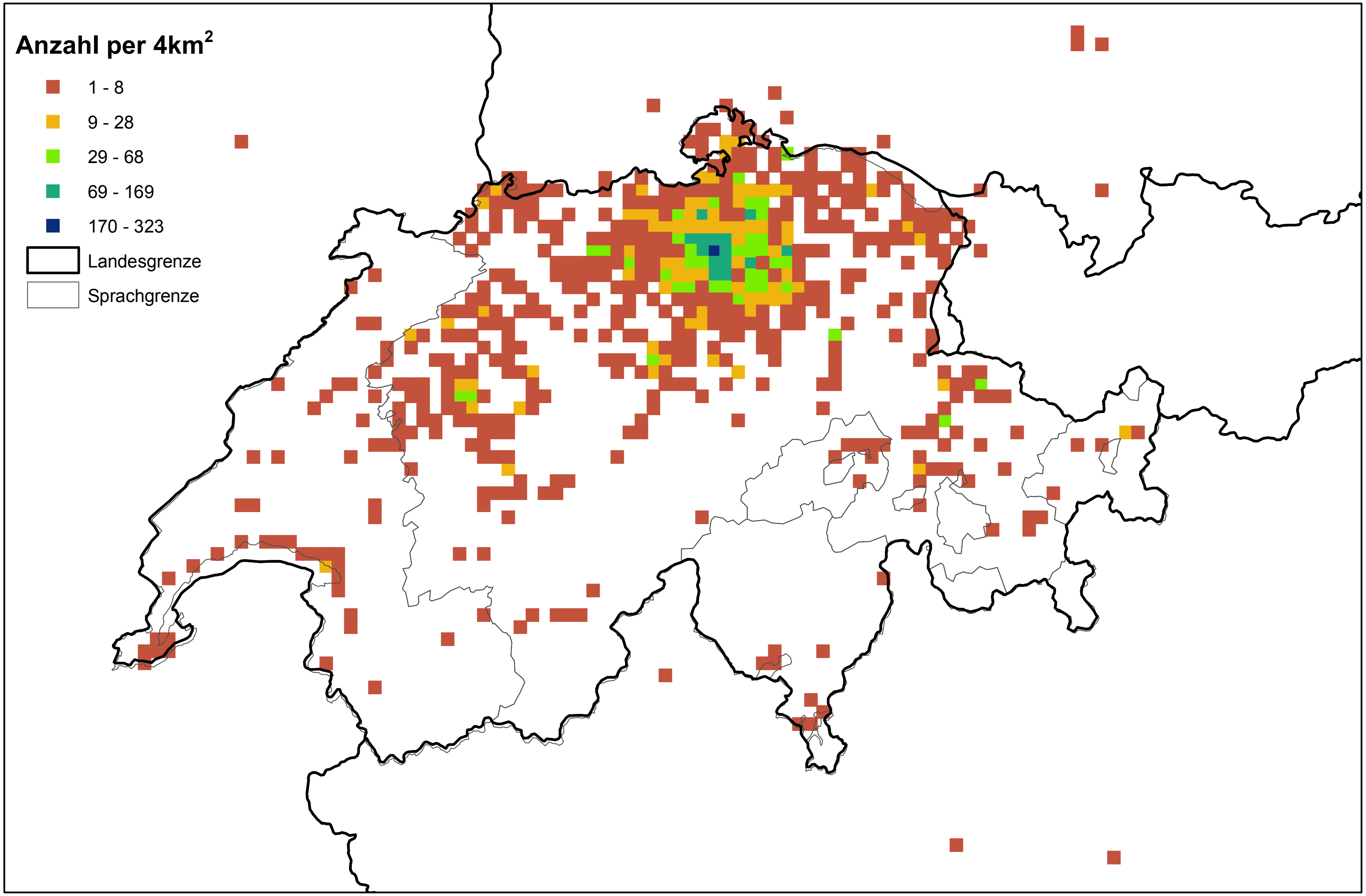
Source: maps.google.com

Simulation of public transport supply in Singapore

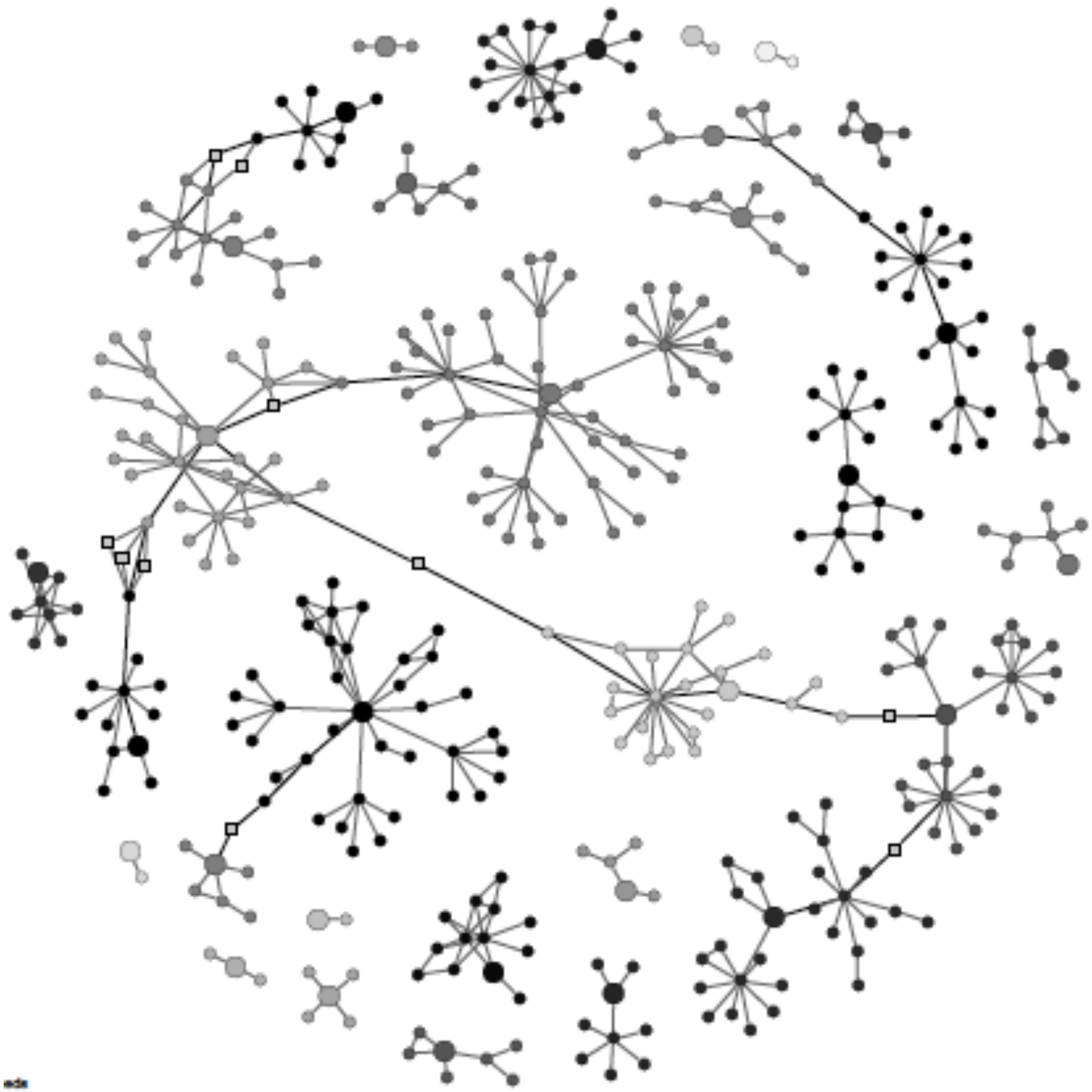
Video available at http://vimeo.com/37719740

Wider challenges for transport modelling

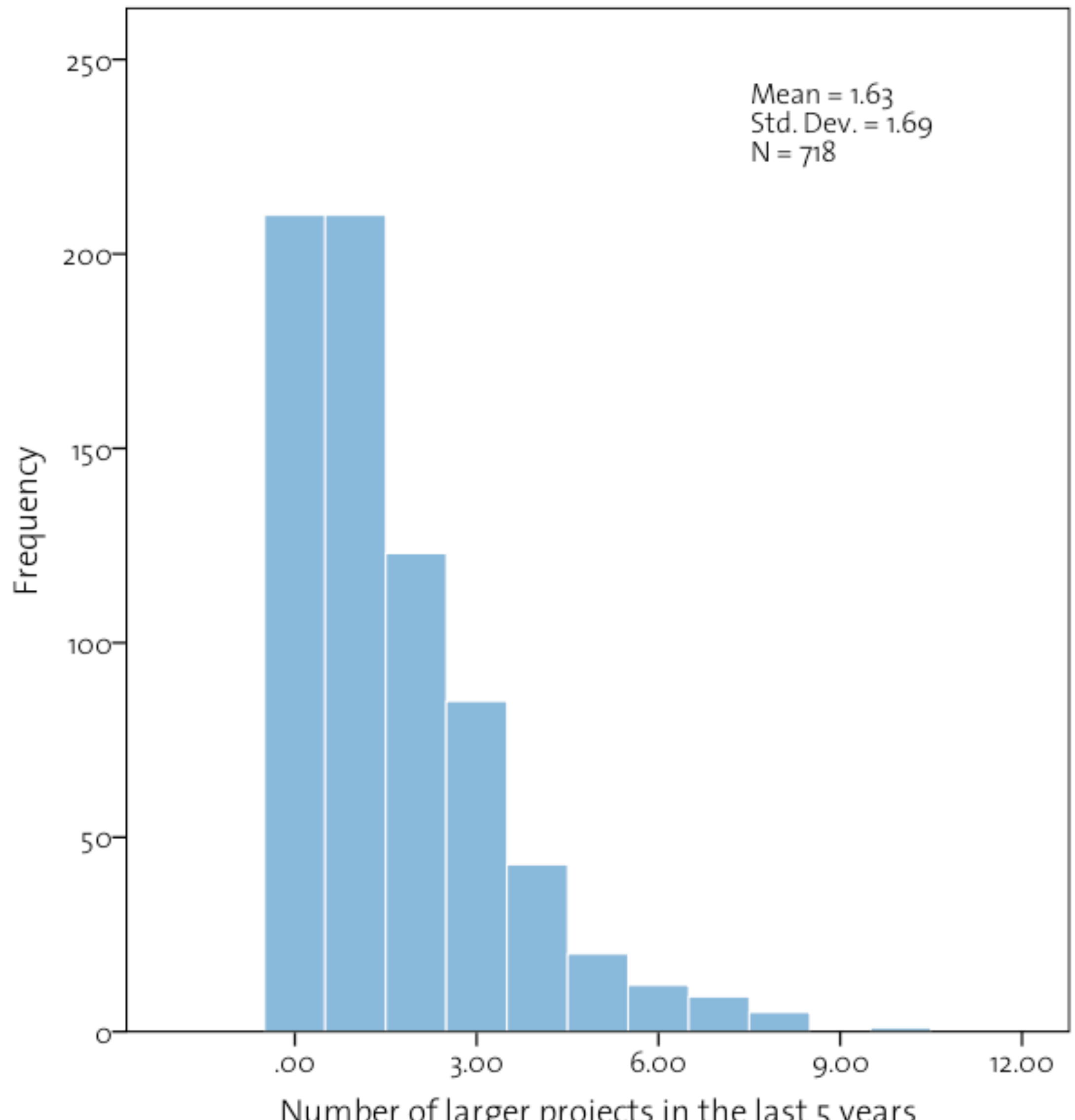
Social networks, e.g. Current snowball sample



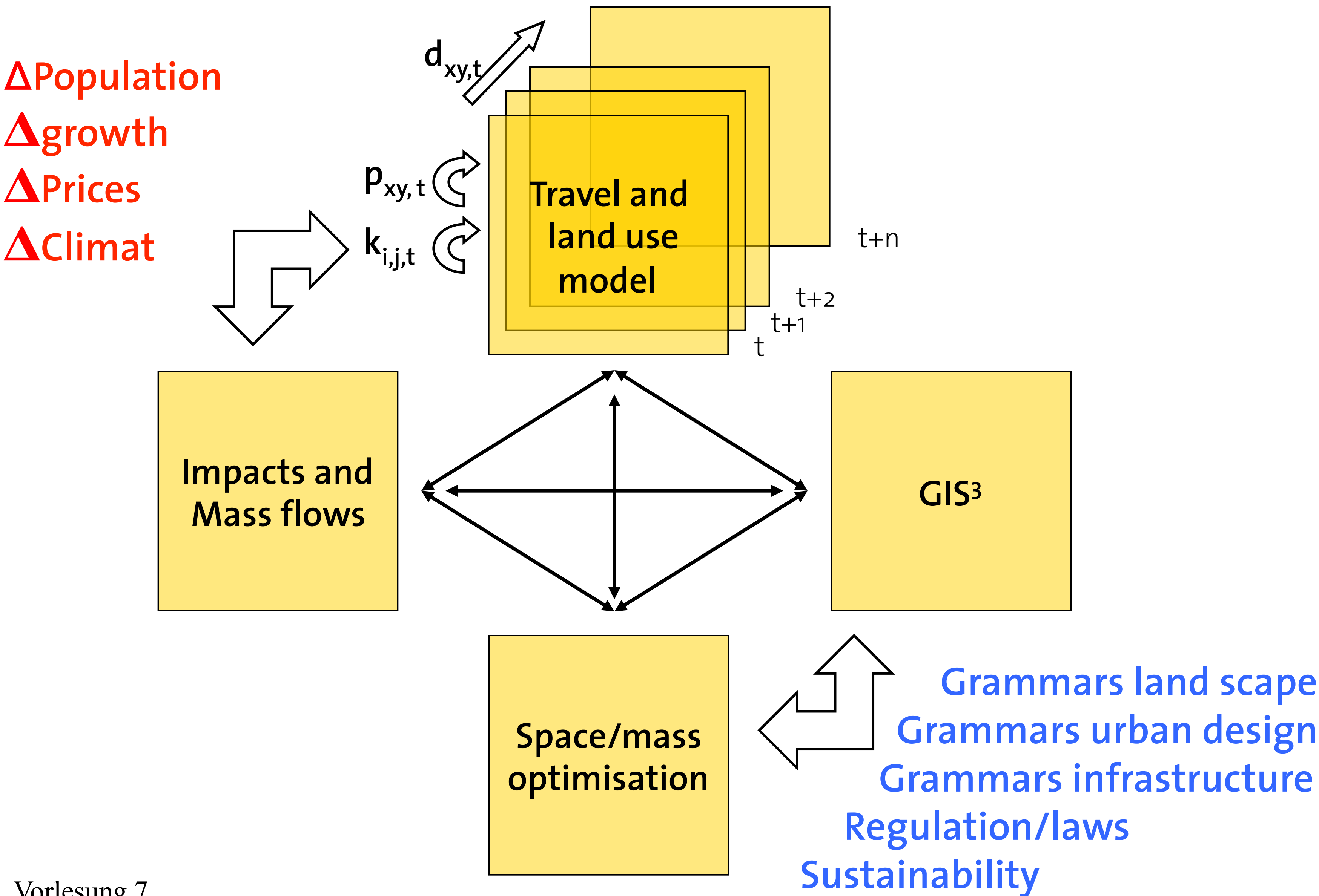
Social networks, e.g. Linked ego-centric networks



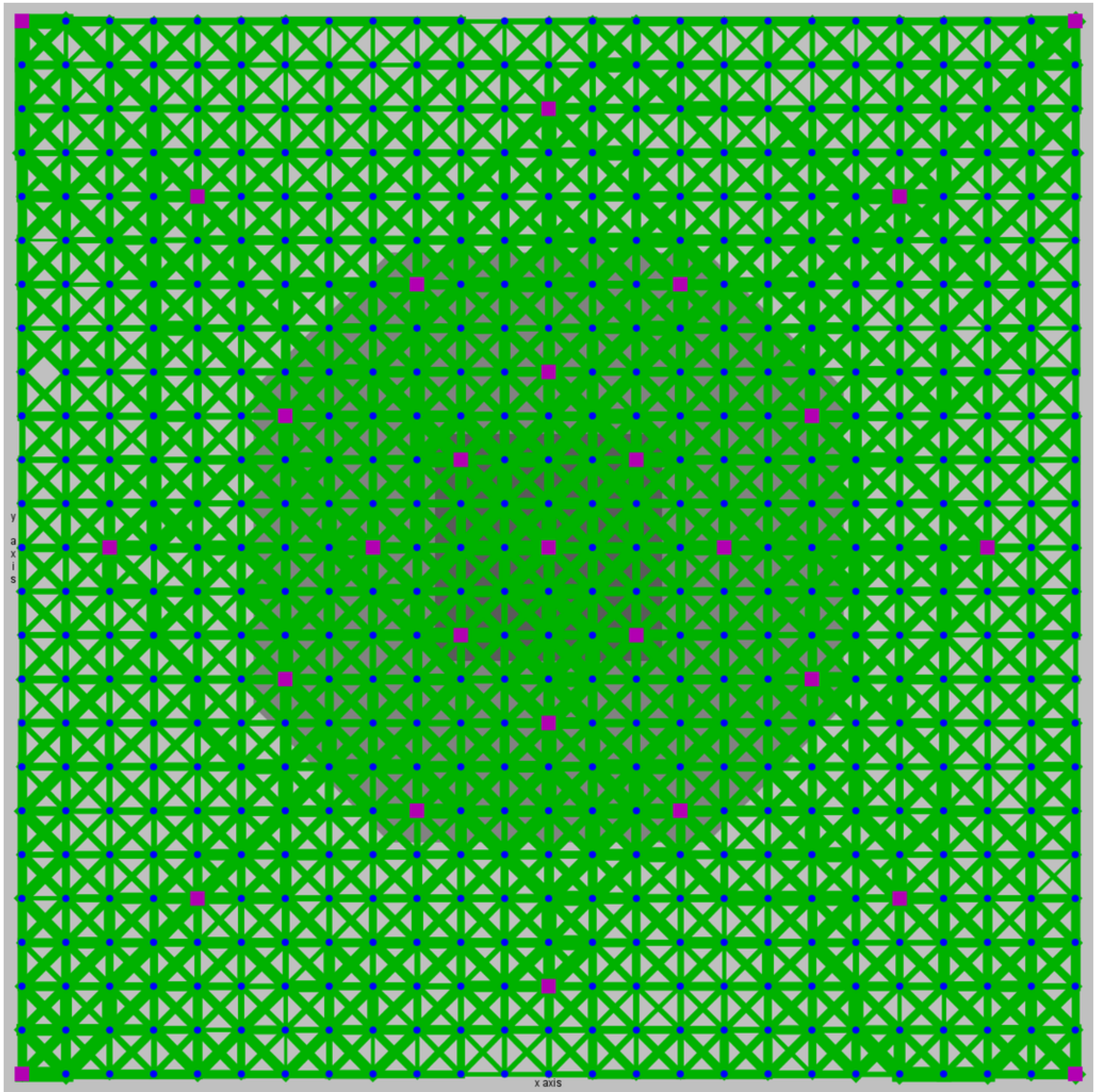
Longer term projects



Integration of land use (optimisation)



Network optimisation



Vitins, 2011

MATSim @ ETHZ, TU Berlin, FCL, Senozon (past & present)

Prof. Kay Axhausen
Dr. Michael Balmer
Dr. David Charypar
Dr. Nurhan Cetin
Artem Chakirov
Yu Chen
Francesco Ciari
Christoph Dobler
Thibaut Dubernet
Dr. Alexander Erath
Dr. Matthias Feil
Dr. Gunnar Flötteröd
Pieter Fourie

Dr. Christian Gloor
Dominik Grether
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www.matsim.org

www.ivt.ethz.ch
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