

Switzerland in Motion

Integrated Activity-Based Demand Modeling and Traffic Assignment on Micro-Level for Very Large Scenarios

Outline

- *Motivation: Past and Present*
- *Introduction: Multi-Agent Transport Simulation (MATSim)*
- *Application: Switzerland in Detail*
- *Results: Switzerland in Numbers*
- *Discussion: Strength and Weakness*
- *Outlook: Into Specialization*

Motivation: Past and Present

Questions in the past

CH Motorway projects in the '70... '90:

- Daily volumes
- Peak hour volumes
- Reachability
- Travel time
- Modal-split
- ...

Questions today (1)

Time dependent road pricing in Zurich

- Who pays? How much? When?
- Who tries to avoid costs? When? Where?
- Who switches to public transport?
- Which regions benefit by that? In relation to others? Social? Economical? Ecological?
- Which shops/companies benefit by that? When?
- Socio-economic and -ecologic value? Per region?
- ...

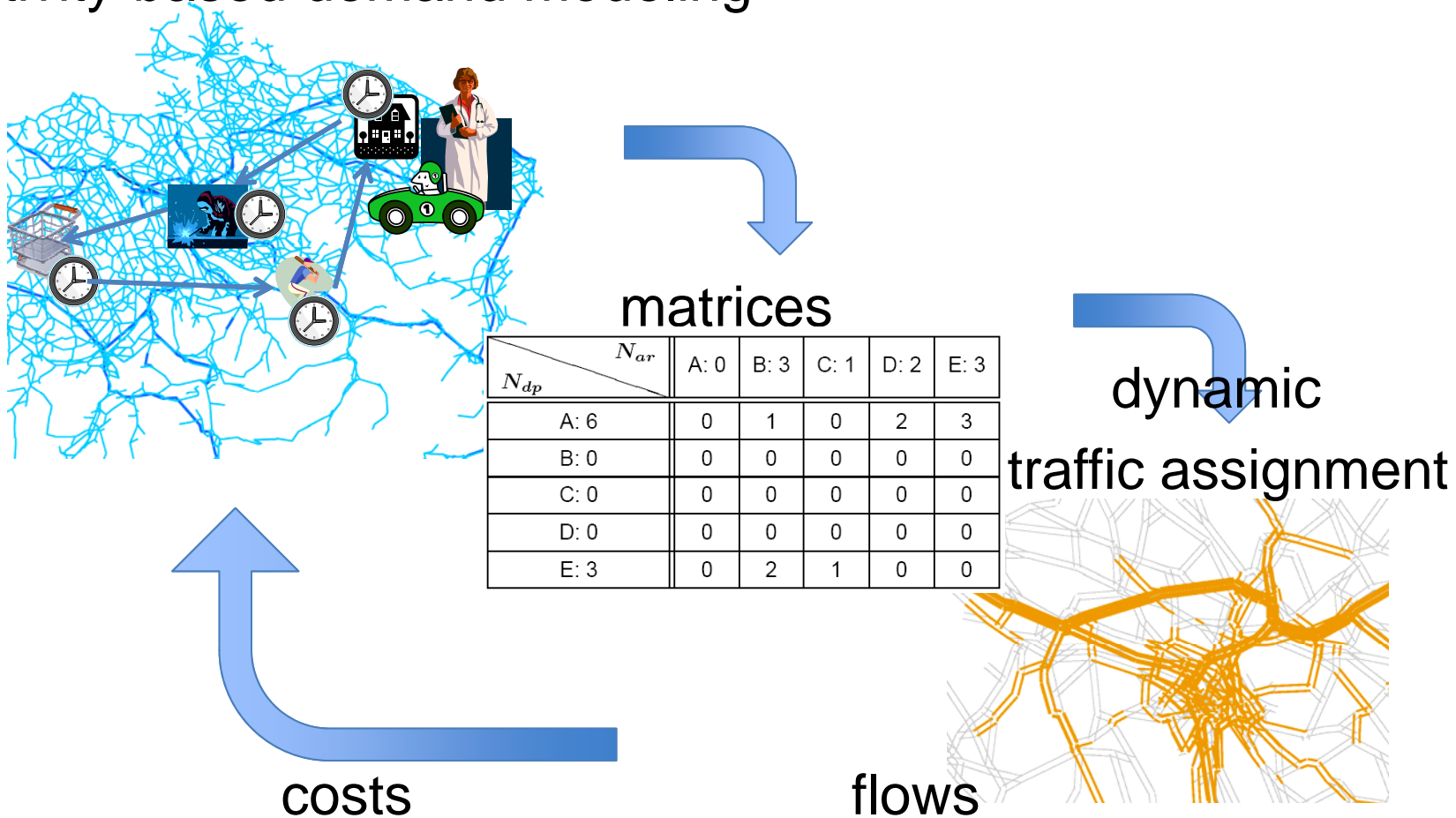
Questions today (2)

30% electric vehicles:

- What is the size of the time dependent system load of a *speed charging* fuel station?
- When do peaks of the system load occur?
- What incentives has to be given to the customers such that the demand peaks will be distributed over the day?
- To whom should the incentives be provided?
- ...

ABD & DTA

activity-based demand modeling

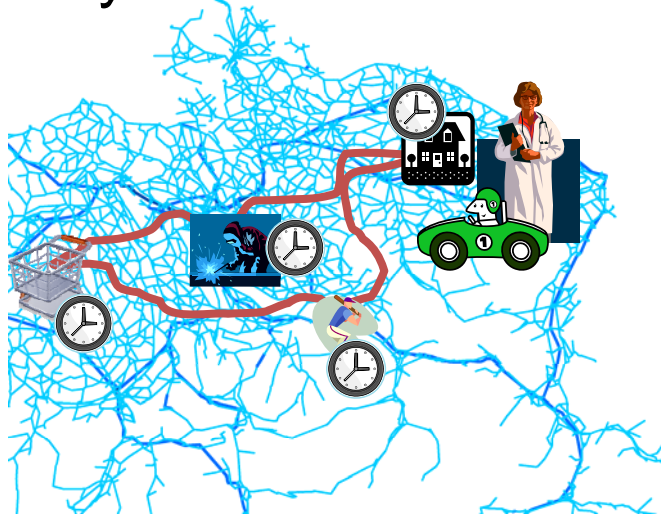


Who? When? Where? What?



ABD & DTA *integrated*

activity-based demand modeling (incl. routes)



individual, time dependent, daily
demand („schedule“, „plan“)



individual, dynamic,
microscopic shares
of costs

physical simulation

*Introduction:
Multi-Agent Transport Simulation
(MATSim)*

MATSim (1)

Dynamic, individual, microscopic demand model



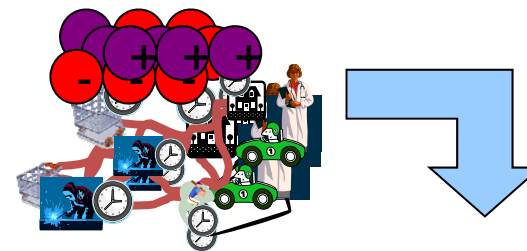
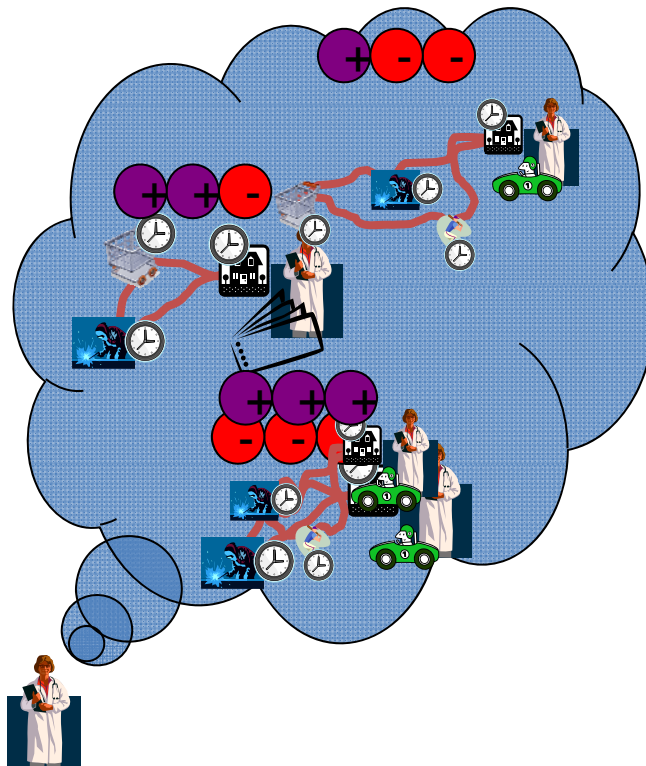
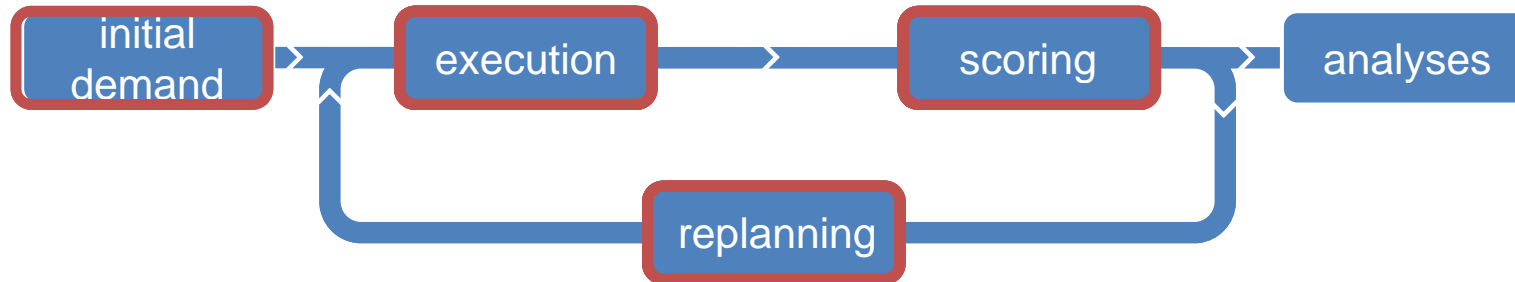
[[[OTF: pdf slide show]]]

Level of details of information per individual

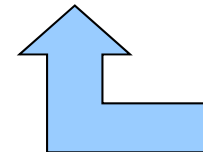


(Source: Rieser, 2008, MATSim Seminar, Castasegna)

MATSim (3)



MATSim

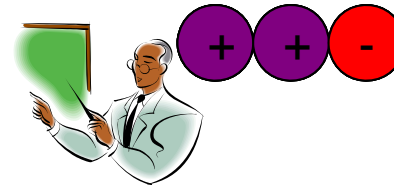
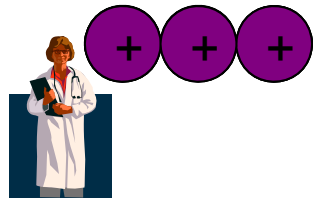


- +sports
- congestions
- closed shop

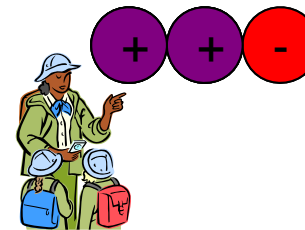
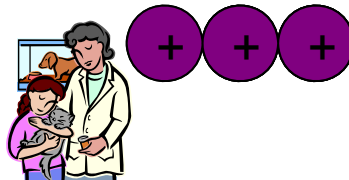
MATSim (4)

Relaxation (NE)

Iteration n



etc.

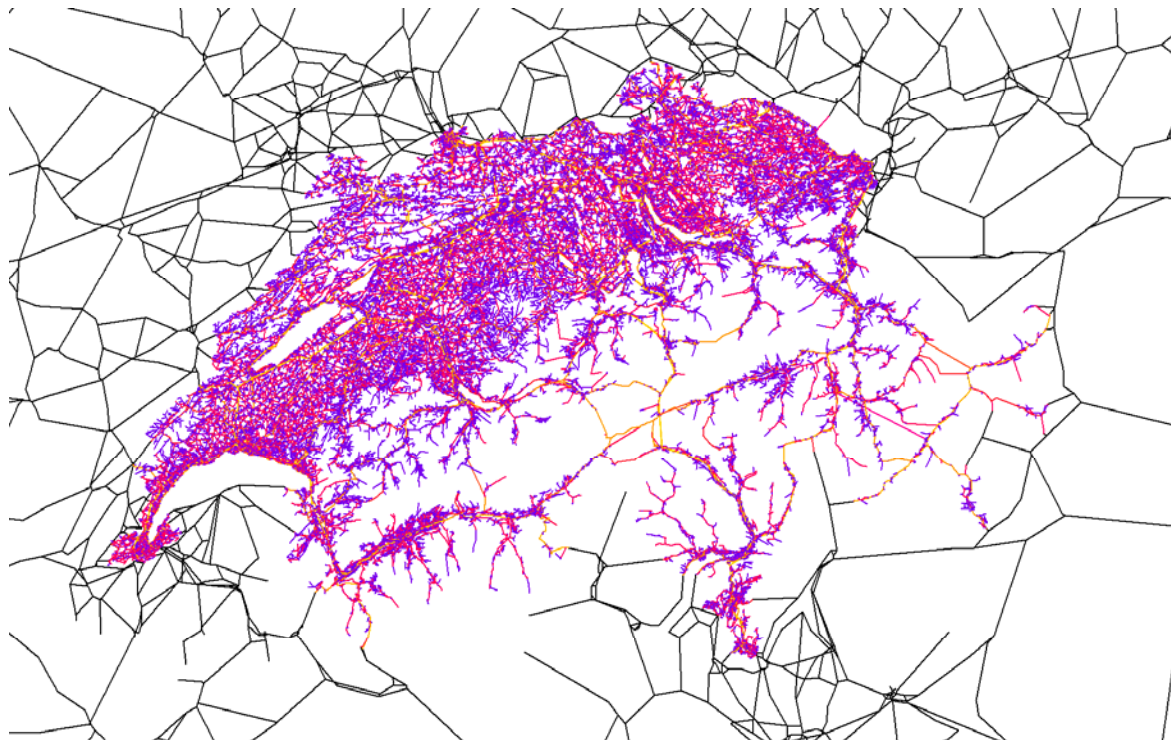


→ stable state

*Application:
Switzerland in Detail*

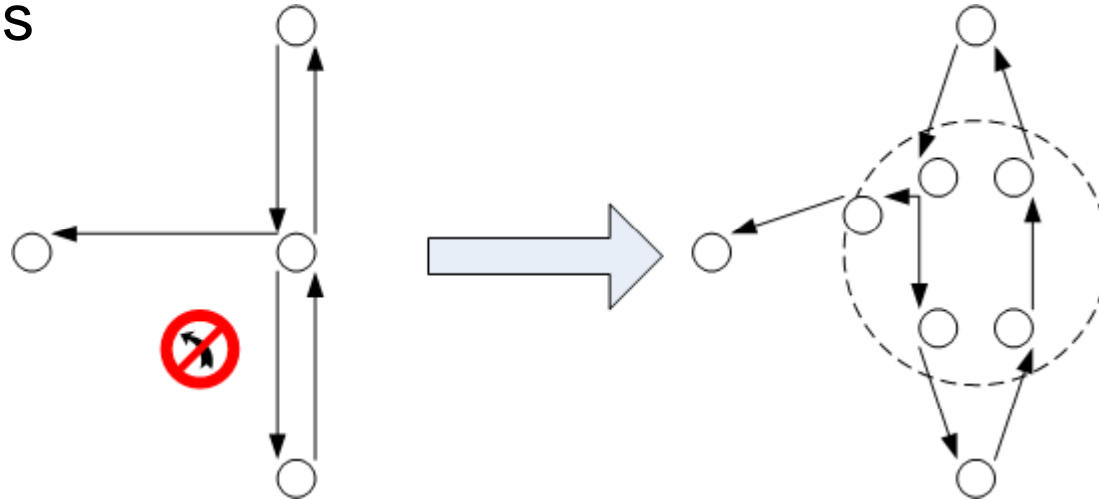
Data: Network

- High resolution navigation network (Tele Atlas) including a “turn restrictions” model



Data: Network (2)

turn restrictions



➔ network with 1.3 Mio links

network optimization

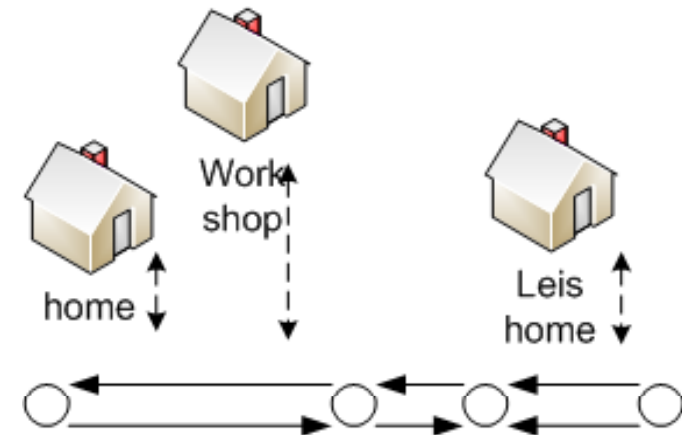


➔ network with 1 Mio links

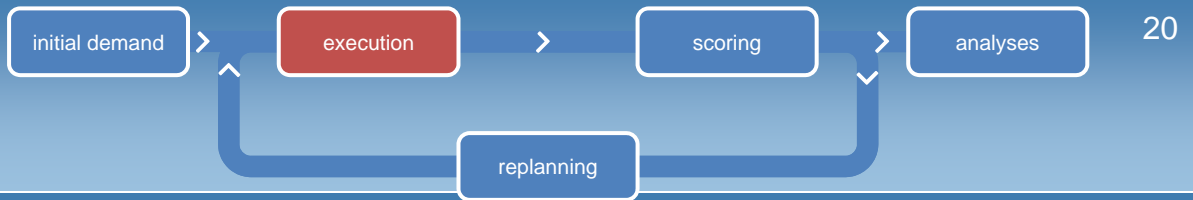
Data: Activities & Facilities

Facilities & activity opportunities:

- ~1.61 Mio facilities
 - ~1.72 Mio activity opportunities
 - 11 different activity types
 - Storage capacities, opening times
-
- ~950'000 „zones“

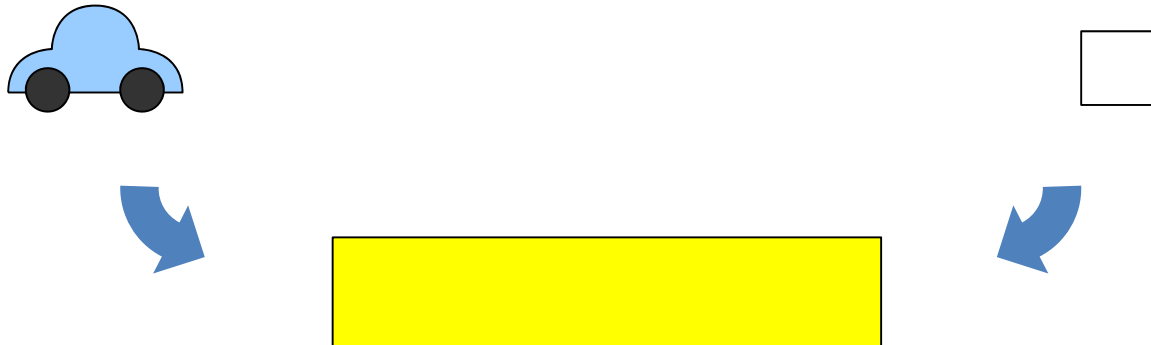


Data sources: Datapuls building data 2008 & Federal Enterprise Census 2001 (Meister, 2008)



Queueing model with more realism:

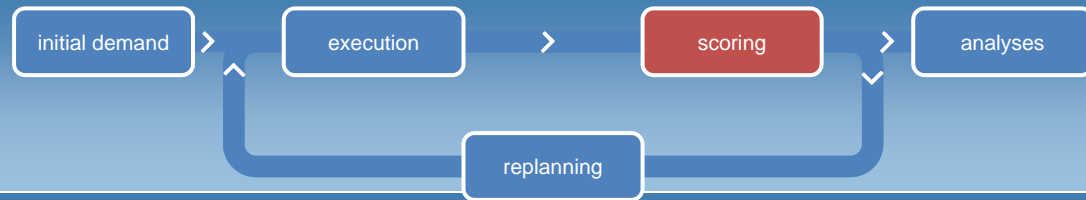
→ „returning gaps“ (Charypar, 2007)



→ Event driven instead of time steps (Charypar, 2006-2008)

→ Parallel event processing (Waraich, 2009)

Utility (1)



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Extension of the Charypar und Nagel (2006) utility function based on the Vickery model:

$$U_{plan} = \sum_{i=1}^n (U_{act,i} + U_{travel,i})$$

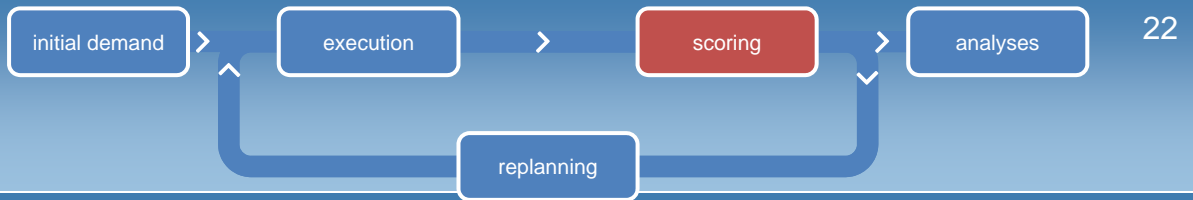
→ Activities:

$$U_{act,i} = (U_{cum,j} - U_{cum,j-1}) \cdot f_p + U_{wait,i} + U_{short,i}$$

$$U_{cum,j} = \begin{cases} \max \left(0, \beta_{perf} \cdot t^* \cdot \ln \left(\frac{\sum_{k=1}^j t_{perf,k}}{t_0} \right) \right) & j > 0 \\ 0 & j = 0 \end{cases}$$

$$f_p = \begin{cases} \min \left(\beta_{load,1} \cdot \left(\frac{load}{capacity} \right)^{\beta_{load,2}}, 0.5 \right) & , \text{ if activity type } \in \{shop, leisure\} \\ 1.0 & \text{otherwise} \end{cases}$$

Utility (2)



→ Traveling:

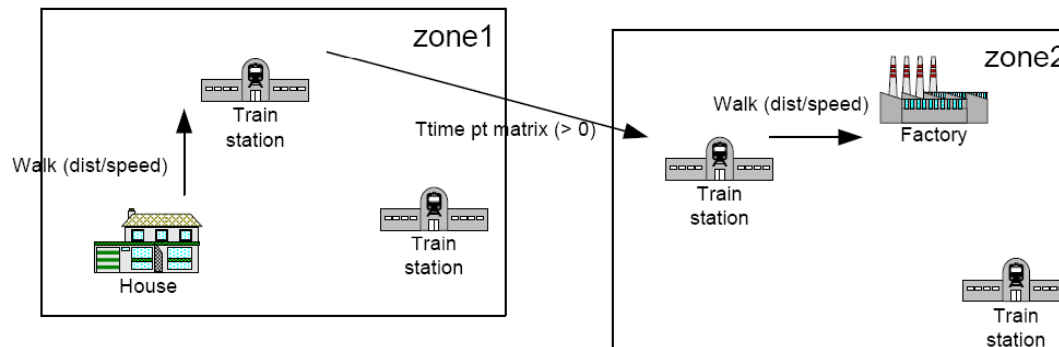
$$U_{travel,i,car} = const_{car} + \beta_{tt,car} \cdot t_{car} + \beta_{cost,car} \cdot c_{car}$$
$$U_{travel,i,pt} = \beta_{tt,walk} \cdot (t_{access} + t_{egress}) + \beta_{tt,pt} \cdot t_{pt} + \beta_{cost,pt} \cdot c_{pt}$$
$$U_{travel,i,bike} = const_{bike} + \beta_{tt,bike} \cdot t_{bike}$$
$$U_{travel,i,walk} = \beta_{tt,walk} \cdot t_{walk}$$

→ Travel times:

→ MIT: micro simulation (queue model)

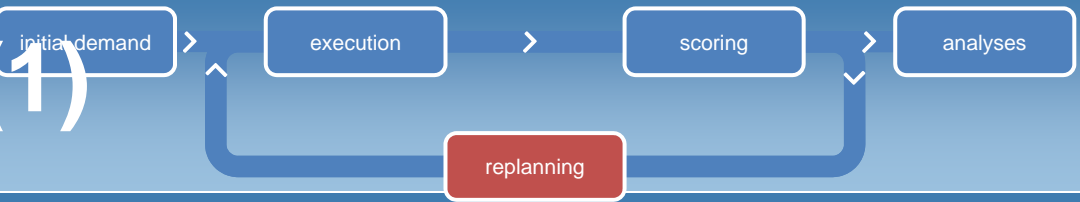
→ Walk&Bike: crow fly distance with fixed speed

→ PT:



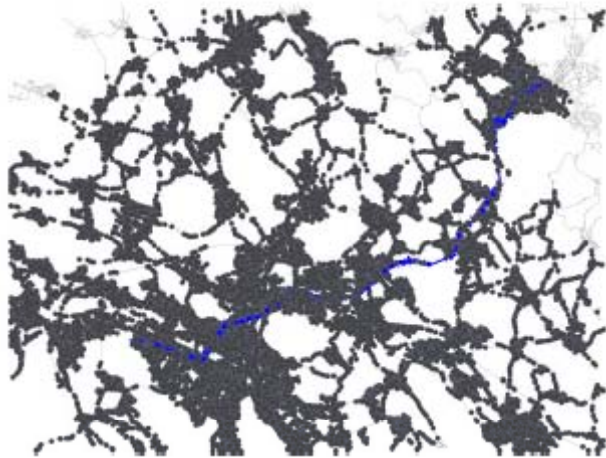
→ The MATSim micro simulation is a hybrid model at the moment!

Search space (1)

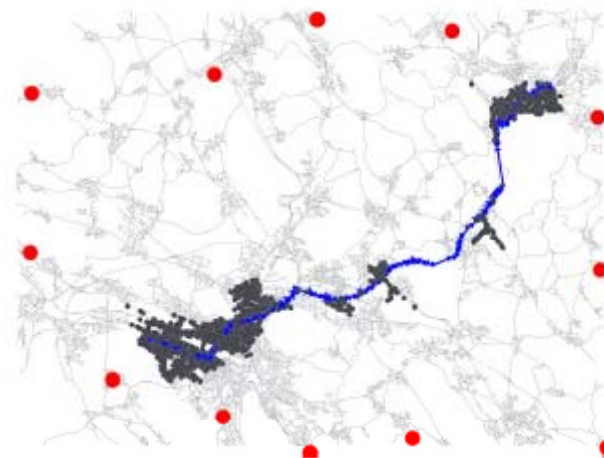


Router module:

➔ Dynamic least-cost router at geo networks (Landmarks-A* Router, Lefebvre, 2007)

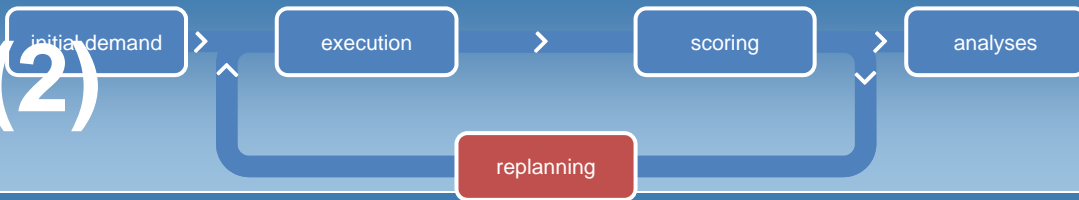


Basic/Iteration-ID Dijkstra



Landmarks A* (using 12 landmarks)

Search space (2)



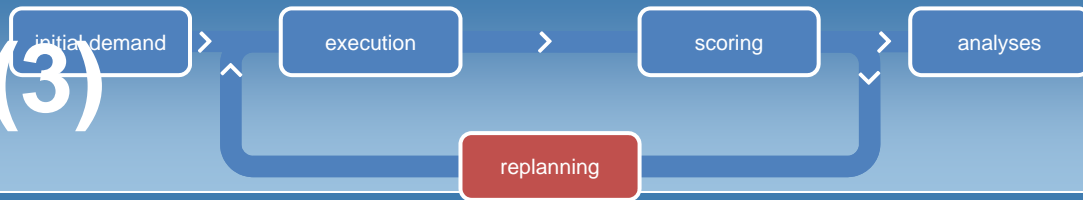
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“Planomat” module:

- ➔ Multi-space optimization of an individual’s schedule
Here: Departure time choice, activity duration choice and mode choice at sub-tour level of detail (Meister, 2010)



Search space (3)



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Secondary location choice module:

Choice set generation via:

→ Selection of secondary activity locations via space-time-prisms based on estimated time budgets (arrival, departure and activity duration), or

→ Universal choice set

Capacity restraint function

→ Attraction measures using facility load (time dynamic)

(Horni, 2009)

Results:
Switzerland in Numbers

Mode share

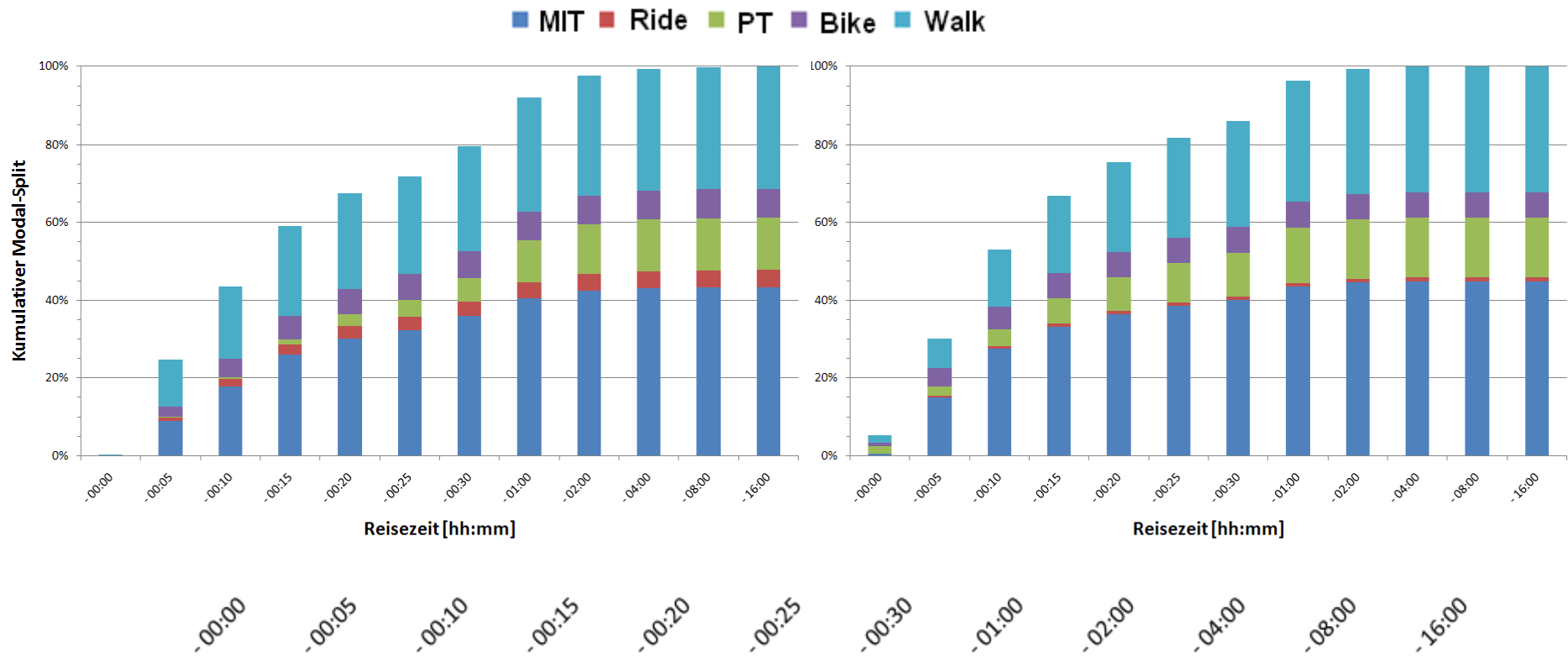
travel mode	microcensus	MATSim
car	43.3%	44.9%
share a ride	4.4%	0.9%
public transit	13.4%	15.3%
bike	7.6%	6.6%
walk	31.3%	32.2%

Travel time distribution per mode

Microcensus 2005

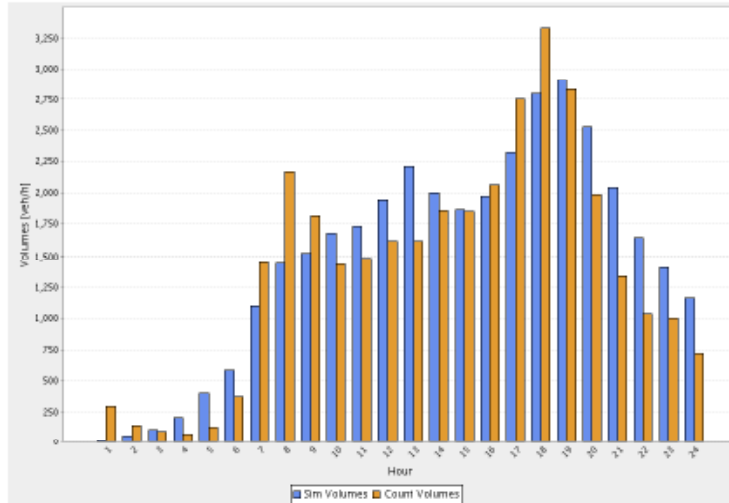
vs.

MATSim

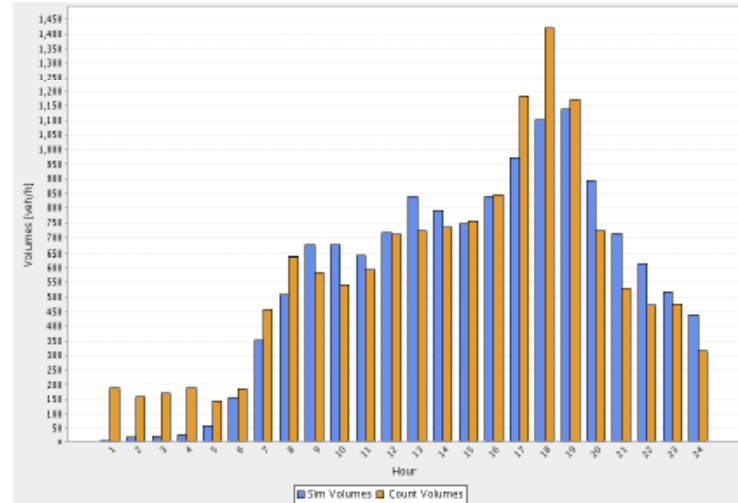


Traffic counts

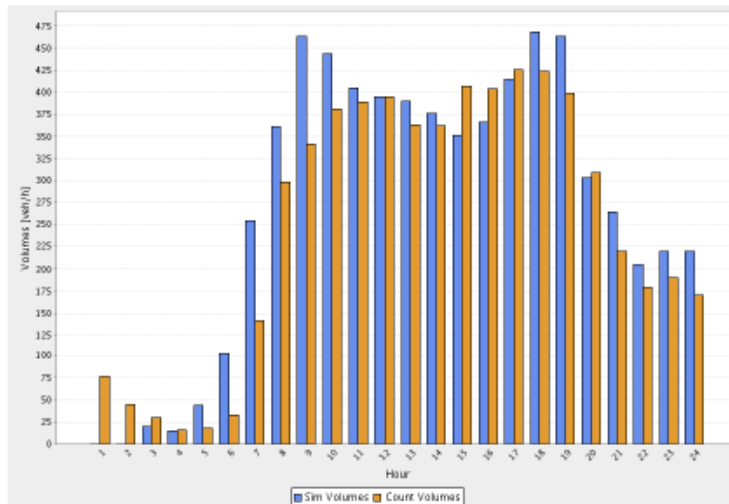
(a) Pendlerstecke: Autobahn A53 von Brüttsellen nach Uster



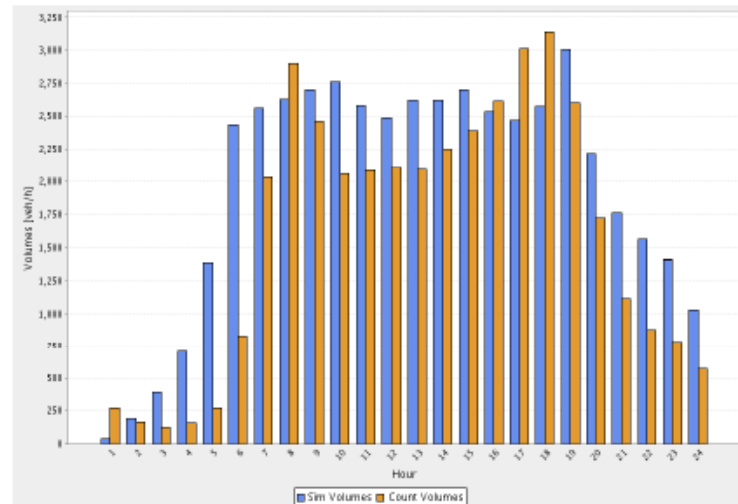
(b) Zubringerstrecke: Wehntalerstrasse von Affoltern nach Regensdorf



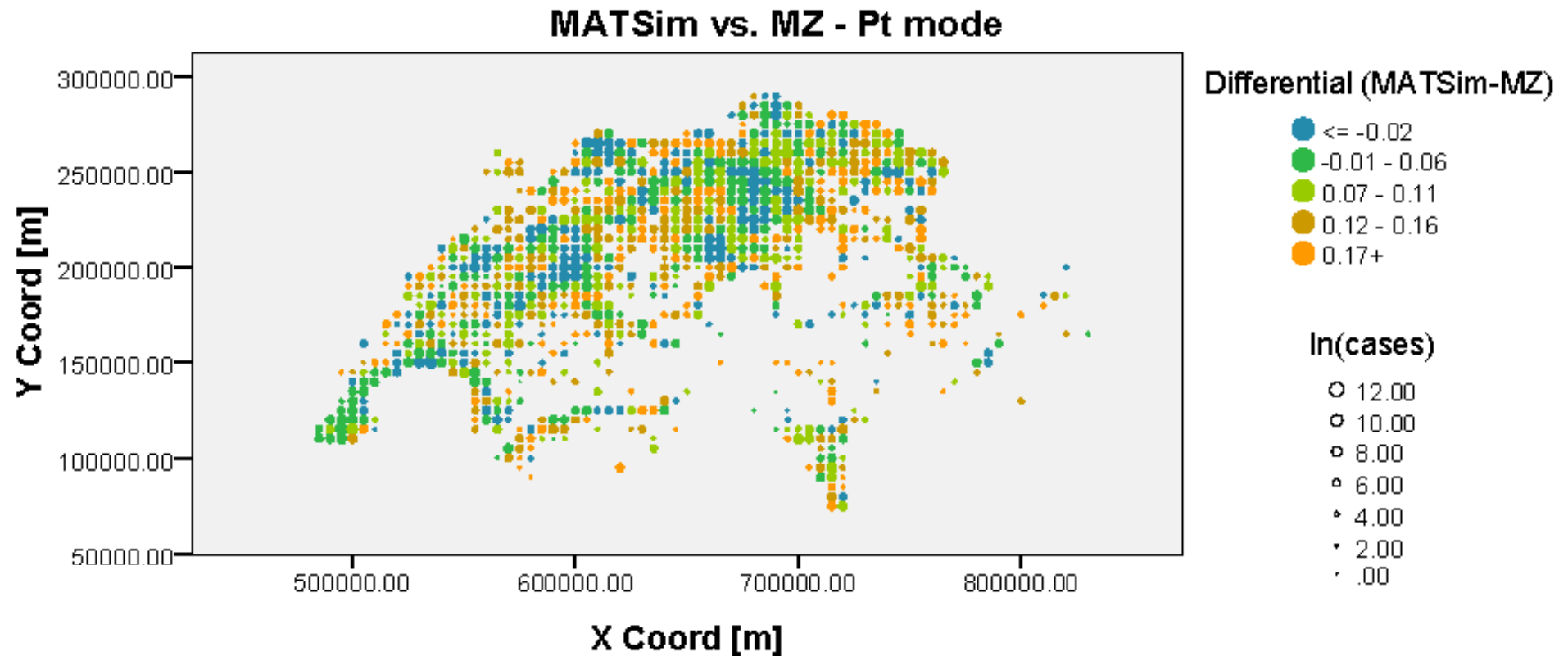
(c) Innenstadt: Talstrasse Richtung Nord-West



(d) Hauptachsen: Autobahn A1 bei Härkingen Richtung Bern



Mode share: Spatial distribution PT



Discussion:
Strength und Weakness

Discussion (1)

- + True integration of ABD & DTA
- + Quality of the outcome similar to macro models
- + Access to detailed (socio-)demography during the whole process → high resolution (links, facilities), time dynamic, individual mobility information
- + Size & speed
- + Feedback
- + Flexibility for pre- and post-process analysis
- + Modular, flexible, extensible
- + Open source

Discussion (2)

- /+ Need of more detailed input data
- /+ Calibration
- Sensitive reactions to errors in the input data
- “Out of the box” analysis
- Mathematical proof still open
- “simple” models that are “difficult” to explain

*Outlook:
Into Specialization*

Projects

- *Sustain City*: Integration (Interfacing) of MATSim and UrbanSim
- *EWZ*: Estimation of future energy need
- *Evacuation*: NE versus system optimum
- Client based modeling of future public transport need
- *Car sharing*: Location optimization
- *Network evolution*: Synthetic design vs. urban growth of transport networks
- *Replanning complete plans*: Feil (2010)
- *Multimodal micro simulation*: Rieser (2010)

(See www.ivt.ethz.ch)

Finally...

Agent-based simulation for transport planning is not (yet) *convenience food*: One has to go to the fields to sow the vegetables, but after a lot of work the harvest will be rich.

The transport planners concentrate on the choice of vegetables but the computer centers should do the gardening. At the end, we get a rich and tasty menu for the stakeholders.”

<http://matsim.org>

<http://www.ivt.ethz.ch/vpl/publications/reports/ab613.pdf>

Meister, K., M. Balmer, F. Ciari, A. Horni, M. Rieser, R. A. Waraich and K.W. Axhausen (2010) Large-scale agent-based travel demand optimization, paper presentation at the 12th World Conference on Transportation Research, Lisbon, July 2010.