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
- ...
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 an -ecologic value? Per region?
- ...

Questions today (1)
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?
• …
activity-based demand modeling
Who? When? Where?
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)
Dynamic, individual, microscopic demand model

[[[OTF: pdf slide show]]]
Level of details of information per individual

ActEnd
AgentDeparture
Wait2Link
LeaveLink
EnterLink
AgentArrival
ActStart

(Source: Rieser, 2008, MATSim Seminar, Castasegna)
MATSim (3)

- Initial demand
- Execution
- Scoring
- Analyses

Replanning

+ Sports
- Congestions
- Closed shop

MATSim

Multi-Agent Transport Simulation
Relaxation (NE)

Iteration $n$

$\Rightarrow$ stable state
Application:
Switzerland in Detail
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
Facilities & activity opportunities:

- ~1.61 Mio facilities
- ~1.72 Mio activity opportunities
- 11 different activity types
- Storage capacities, opening times

- ~950‘000 „zones“

Data: IIDM

Individuals:

- Id, attributes (e.g. age, driving license, pt time tickets, etc.)
- Primary activity location ("home", "work", "education")
- Personal preferences (desired activity duration)

Demand:

- Dynamic, individual, activity based, micro-demand for all inhabitants of Switzerland

Data sources: Micro census 2005, census 2000, Datapuls person dataset
(Balmer et al, 2008, 2009; Ciari et al, 2008)
Queueing model with more realism:

- „returning gaps“ (Charypar, 2007)

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

- Parallel event processing (Waraich, 2009)
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:**

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

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

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

**Traveling:**

\[ U_{\text{travel}, i, \text{car}} = const_{\text{car}} \]

\[ U_{\text{travel}, i, \text{pt}} = \beta_{tt, \text{walk}} \cdot (t_{\text{access}} + t_{\text{egress}}) \]

\[ U_{\text{travel}, i, \text{bike}} = const_{\text{bike}} \]

\[ U_{\text{travel}, i, \text{walk}} = \]

**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!**
Router module:

- Dynamic least-cost router at geo networks (Landmarks-A* Router, Lefebvre, 2007)
“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)
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 via facility load (time dynamic)

(Horni, 2009)
Performance

initial demand → execution → scoring → analyses → replanning

![Graph showing performance metrics and iterations]
Results: Switzerland in Numbers
## Mode share

<table>
<thead>
<tr>
<th>travel mode</th>
<th>microcensus</th>
<th>MATSim</th>
</tr>
</thead>
<tbody>
<tr>
<td>car</td>
<td>43.3%</td>
<td>44.9%</td>
</tr>
<tr>
<td>share a ride</td>
<td>4.4%</td>
<td>0.9%</td>
</tr>
<tr>
<td>public transit</td>
<td>13.4%</td>
<td>15.3%</td>
</tr>
<tr>
<td>bike</td>
<td>7.6%</td>
<td>6.6%</td>
</tr>
<tr>
<td>walk</td>
<td>31.3%</td>
<td>32.2%</td>
</tr>
</tbody>
</table>
Travel time distribution per mode

Microcensus 2005 vs. MATSim
Traffic counts

(a) Pendlerstrecke: Autobahn A53 von Brüttisellen 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
+ 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 prove still open
- “simple” models that are “difficult” to explain
Outlook: Into Specialization
Projects

- **Sustain City**: Integration of MATSim and UrbanSim
- **EWZ**: Estimation of future energy need
- **Evacuation**: NE versus system optimum
- **BVG**: 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](http://www.ivt.ethz.ch))
Agent-based simulation for transport planning is not yet *convenience food*: One has to go to the fields to seed 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