Preferred citation style

MATSim platform and applications in Europe and beyond

KW Axhausen

IVT
ETH
Zürich

May 2014
Thinking about equilibrium
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

up to 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 links, services and facilities
   Minimum loads for some of the facilities

New York 2014
How to find the SUE in an agent-based approach?
Learning approach of the generic one-day transport model

Competition for slots on networks and in facilities

Mental map

Activity scheduling

$k(t, r, j)_{i,n}$

$q_i \equiv (t, r, j)_{i,n}$

New York 2014
Equilibrium search in „ABM“ & assignment combinations

Initial schedules

OD aggregation

Assignment

Distribution of schedules

\[ k(t,r,j)_Q \]

\[ q_i \equiv p(t,r,j)_{i,n} \]

\[ Q_{ij,t} \]
Equilibrium search in MATSim

Initial schedules

Simulation of flows on networks and to facilities

Score (utility) calculation

$\mathbf{q}_i \equiv (t,r,j)_{i,n}$

$(Optimal)$

Replanning (inc. connection)

$U_i(t,r,j)_{i,n}$
MATSim: A GNU public licence software project
MATSim: A GNU public licence software project

Main partners:
- TU Berlin (Prof. Nagel)
- ETH Zürich
- senozon (Dr. Balmer, Dr. Rieser)

Contributors, users, e.g.:
- TU Poznan
- University of Pretoria
- CASA, UCL, London
- Forschungszentrum Jülich
MATSim today
Following the agents
MATSim: Logic of the co-evolution – Step 0

Agent 1
   Plan 1.1  H-W-H; 8:00, 17:00; C,C;

Agent 2
   Plan 2.1  H-W-H; 8:00, 17:00; C,C;

Agent 3
   Plan 3.1  H-W-H; 8:00, 17:00; C,C;
Co-evolution – Step 1.1 – Simulation/scoring

<table>
<thead>
<tr>
<th>Agent 1</th>
<th>Plan 1.1</th>
<th>H-W-H; 8:00, 17:00; C,C;</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent 2</td>
<td>Plan 2.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>35</td>
</tr>
<tr>
<td>Agent 3</td>
<td>Plan 3.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>35</td>
</tr>
</tbody>
</table>
Co-evolution – Step 1.2 – After replanning (1/3)

<table>
<thead>
<tr>
<th>Agent 1</th>
<th>Plan 1.1</th>
<th>H-W-H; 8:00, 17:00; C,C;</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent 2</td>
<td>Plan 2.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>35</td>
</tr>
<tr>
<td>Agent 3</td>
<td>Plan 3.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Plan 3.2</td>
<td><strong>H-W-H; 8:15, 17:30; C,C</strong></td>
<td></td>
</tr>
</tbody>
</table>
Co-evolution – Step 1.3 – After plan selection (best/MNL)

Agent 1
  Plan 1.1  H-W-H; 8:00, 17:00; C,C;  100%

Agent 2
  Plan 2.1  H-W-H; 8:00, 17:00; C,C;  100%

Agent 3
  Plan 3.1  H-W-H; 8:00, 17:00; C,C;  35
  Plan 3.2  H-W-H; 8:15, 17:30; C,C;  New
## Co-evolution – Step 2.1 – Simulation/scoring

<table>
<thead>
<tr>
<th>Agent 1</th>
<th>Plan 1.1</th>
<th>H-W-H; 8:00, 17:00; C,C;</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent 2</td>
<td>Plan 2.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>45</td>
</tr>
<tr>
<td>Agent 3</td>
<td>Plan 3.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Plan 3.2</td>
<td>H-W-H; 8:15, 17:30; C,C;</td>
<td>60</td>
</tr>
</tbody>
</table>

New York 2014
Co-evolution – Step 2.2 – After replanning (1/3)

<table>
<thead>
<tr>
<th>Agent 1</th>
<th>Plan 1.1</th>
<th>H-W-H; 8:00, 17:00; C,C;</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan 1.2</td>
<td><strong>H-W-H; 8:00, 17:00; B,B;</strong></td>
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</tr>
<tr>
<td>Agent 2</td>
<td>Plan 2.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
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<td>35</td>
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<td></td>
<td>Plan 3.2</td>
<td>H-W-H; 8:15, 17:30; C,C;</td>
<td>60</td>
</tr>
</tbody>
</table>

New York 2014
Co-evolution – Step 2.3 – After plan selection (best/MNL)

Agent 1
  Plan 1.1  H-W-H; 8:00, 17:00; C,C;  45
  Plan 1.2  H-W-H; 8:00, 17:00; B,B;  New

Agent 2
  Plan 2.1  H-W-H; 8:00, 17:00; C,C;  100%

Agent 3
  Plan 3.1  H-W-H; 8:00, 17:00; C,C;  38%
  Plan 3.2  H-W-H; 8:15, 17:30; C,C;  62%

New York 2014
## Co-evolution – Step 3.1 – Simulation/scoring

<table>
<thead>
<tr>
<th>Agent 1</th>
<th>Plan 1.1</th>
<th>H-W-H; 8:00, 17:00; C,C;</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan 1.2</td>
<td>H-W-H; 8:00, 17:00; B,B;</td>
<td>70</td>
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<tr>
<td>Agent 2</td>
<td>Plan 2.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>45</td>
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<tr>
<td>Agent 3</td>
<td>Plan 3.1</td>
<td>H-W-H; 8:00, 17:00; C,C;</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Plan 3.2</td>
<td>H-W-H; 8:15, 17:30; C,C;</td>
<td>60</td>
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</tbody>
</table>
### Co-evolution – Step 3.2 – After replanning (1/3)

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<th>Agent 1</th>
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<tbody>
<tr>
<td></td>
<td>Plan 1.2</td>
<td>H-W-H; 8:00, 17:00; B,B;</td>
<td>70</td>
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<td>Agent 2</td>
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</tr>
<tr>
<td></td>
<td>Plan 3.2</td>
<td>H-W-H; 8:15, 17:30; C,C;</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Plan 3.3</td>
<td><strong>H-W-H; 7:30, 17:15; B,B</strong></td>
<td></td>
</tr>
</tbody>
</table>
Co-evolution – Step 3.3 – After plan selection (best/MNL)

<table>
<thead>
<tr>
<th>Agent 1</th>
<th>Plan</th>
<th>Time</th>
<th>Location</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan 1.1</td>
<td>8:00, 17:00; C,C;</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan 1.2</td>
<td>8:00, 17:00; B,B;</td>
<td>64%</td>
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</table>

<table>
<thead>
<tr>
<th>Agent 2</th>
<th>Plan</th>
<th>Time</th>
<th>Location</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan 2.1</td>
<td>8:00, 17:00; C,C;</td>
<td>100%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Agent 3</th>
<th>Plan</th>
<th>Time</th>
<th>Location</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plan 3.1</td>
<td>8:00, 17:00; C,C;</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan 3.2</td>
<td>8:15, 17:30; C,C;</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan 3.3</td>
<td>7:30, 17:15; B,B</td>
<td>New</td>
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</table>

(The (worst) plan more then memory allows is deleted)
## Co-evolution – Summary of best scores

<table>
<thead>
<tr>
<th></th>
<th>Iteration 1</th>
<th>Iteration 2</th>
<th>Iteration 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent 1</td>
<td>35</td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>Agent 2</td>
<td>35</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Agent 3</td>
<td>35</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>35</strong></td>
<td><strong>50</strong></td>
<td><strong>62</strong></td>
</tr>
</tbody>
</table>
Activity schedule dimensions
Activity scheduling dimensions

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

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

\[ U_{\text{act},i} = U_{\text{dur},i} + U_{\text{late.ar},i} \]
Current progress: Berlin
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

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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)
Sequence of activities (Ordonez)

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

- Movement between sequential locations
  - Location of access and egress from the mean of transport (Waraich)
    - Parking search and type (Ciari)
  - Vehicle/means of transport (Chakirov)
  - Route/service (Dubernet, Fourie)
- Expenditure division
MATSim @ ETHZ, TU Berlin, FCL, Senozon (past & present)

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

Dr. Dominik Grether
Dr. Jeremy K. Hackney
Dr. Andreas Horni
Dr. Johannes Illenberger
Dr. Gregor Lämmel
Nicolas Lefebvre
Prof. Kai Nagel
Dr. Konrad Meister
Manuel Moyo
Kirill Müller
Dr. Andreas Neumann
Dr. Thomas Nicolai
Benjamin Kickhöfer

Sergio Ordonez
Dr. Bryan Raney
Dr. Marcel Rieser
Dr. Nadine Rieser
Lijun Sun
Alexander Stahel
Dr. David Strippgen
Michael Van Eggermond
Dr. Rashid Waraich
Michael Zilske

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Questions?

www.matsim.org

www.ivt.ethz.ch

www.futurecities.ethz.ch

www.senozon.com