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MATSim: An agent-based framework of travel demand and traffic flow

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July 2015

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Activity-based versus agent-based approaches

A terminological problem ?

Resolution	Agents, flows
Scheduling model	Trip, tour, daily chain (with breaks)
Choice model	DCM, rules&heuristics
Route choice	Integrated, external (with consistent valuations?)
Choice set construction	Explicit, implicit
Solution method	Whole population (& MSA or similar) Sample enumeration (& MSA or similar), co-evolutionary search
Schedule equilibrium	Yes, no

The typical four-stage model

Resolution	Agents**, flows**
Scheduling model	**Trip, tour**, daily chain (with breaks)
Choice model	**DCM,** rules&heuristics
Route choice	Integrated, **external without consistent valuations**
Choice set construction	**Explicit**, implicit
Solution method	**Whole population** (& MSA or similar) Sample enumeration (& MSA or similar), co-evolutionary search
Schedule equilibrium	**(Yes)**, no

The typical activity-based model (ABM)

Resolution	**Agents**, flows
Scheduling model	Trip, tour, **daily chain** (with breaks)
Choice model	**DCM** , rules&heuristics
Route choice	Integrated, **external without consistent valuations**
Choice set construction	**Explicit**, implicit
Solution method	Whole population (& MSA or similar) **Sample enumeration** (& MSA or similar), co-evolutionary search
Schedule equilibrium	Yes, **none reported it yet**

MATSim

Resolution	**Agents**, flows
Scheduling model	Trip, tour, **daily chain** without breaks
Choice model	DCM, **rules**&heuristics
Route choice	**Integrated with consistent valuations**, external
Choice set construction	Explicit, **implicit**
Solution method	Whole population (& MSA or similar) Sample enumeration (& MSA or similar), **co-evolutionary search**
Schedule equilibrium	**Yes**, no

MATSim

MATSim: A GNU public licence software project

MATSim: A GNU public licence software project

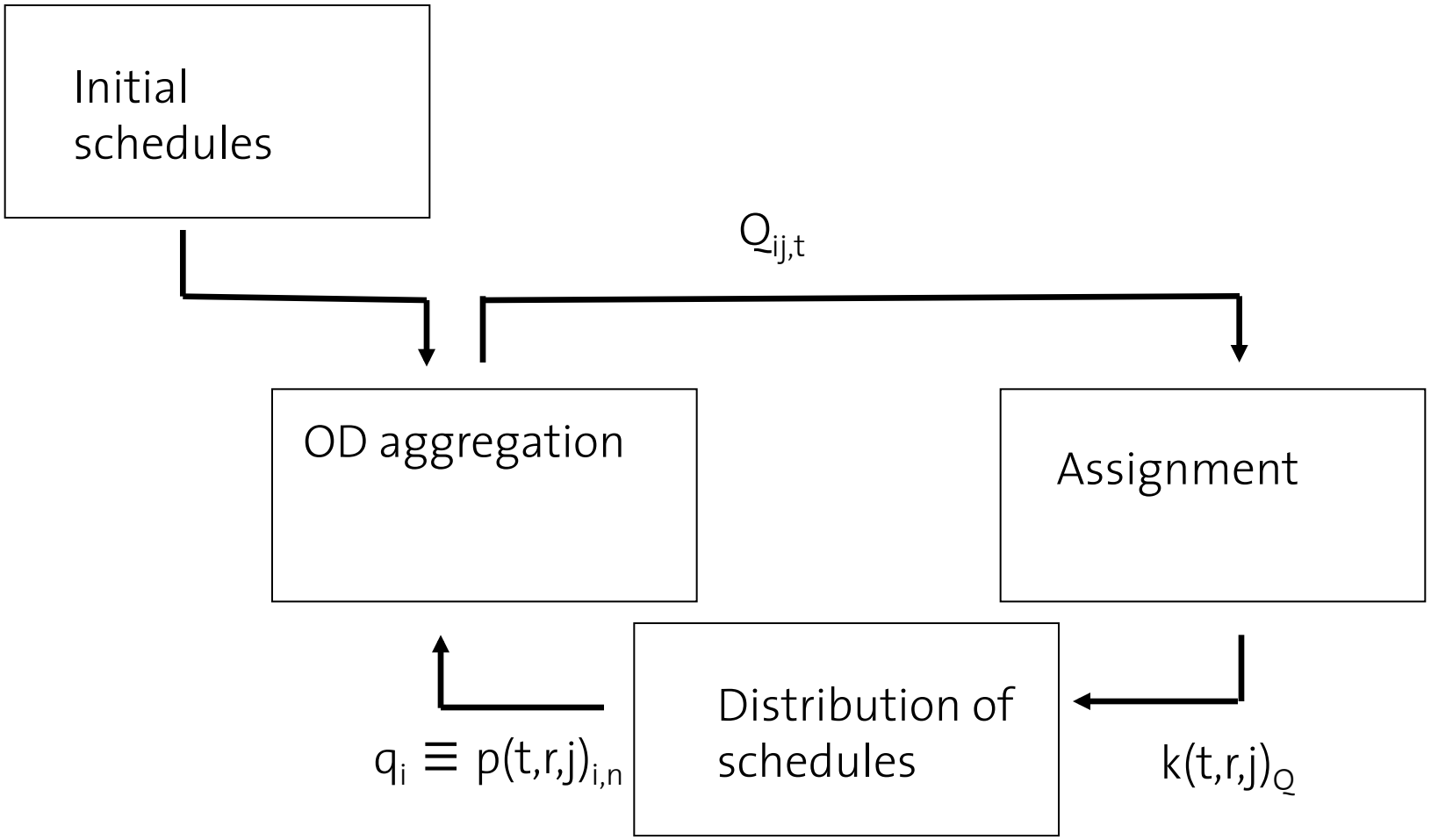
Main partners:

- TU Berlin (Prof. Nagel)
- ETH Zürich & FCL SIngapore
- senozon (Dr. Balmer, Dr. Rieser)

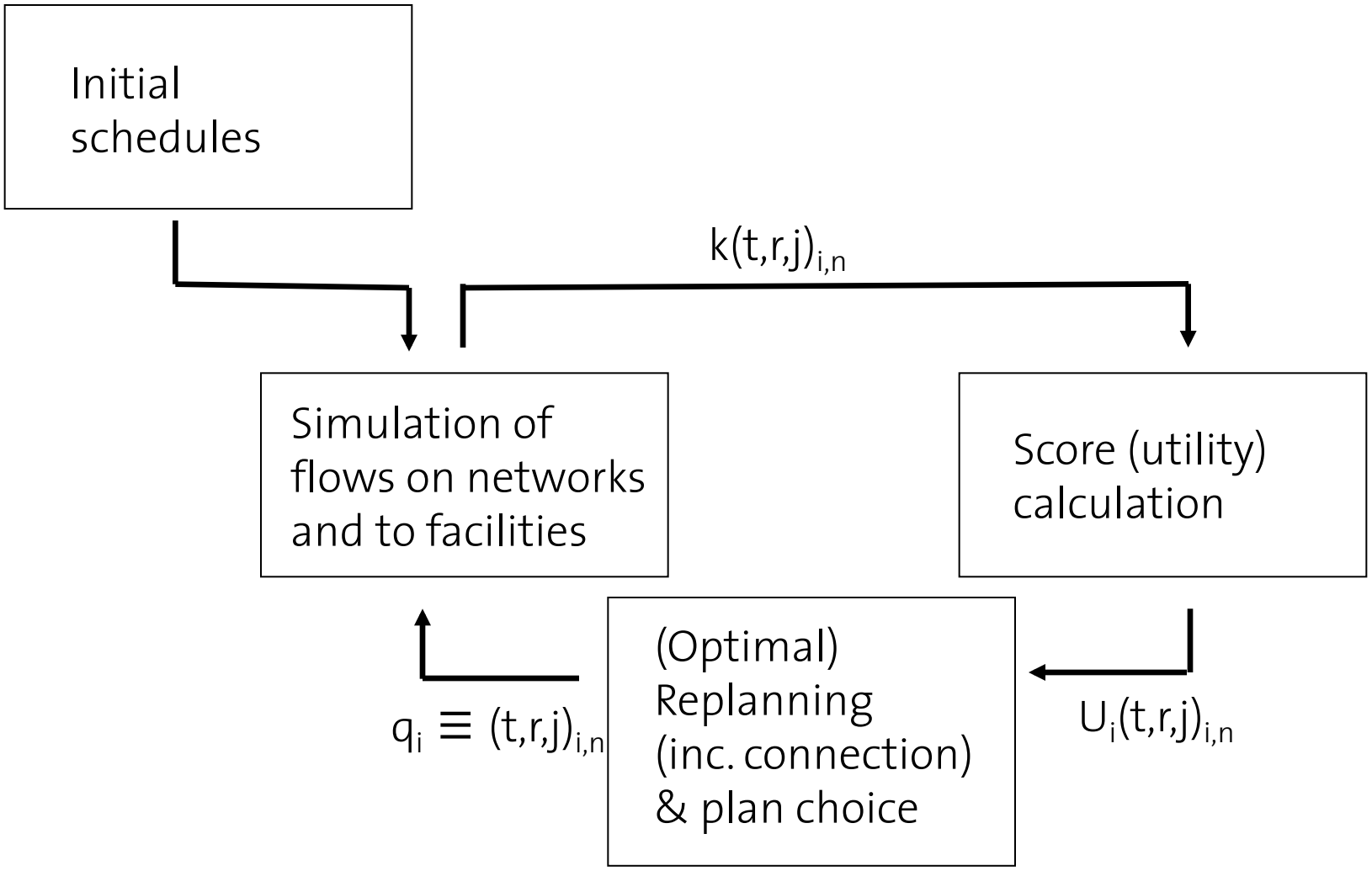
Contributors, users, e.g.:

- TU Poznan
- University of Pretoria
- CASA, UCL, London
- Forschungszentrum Jülich

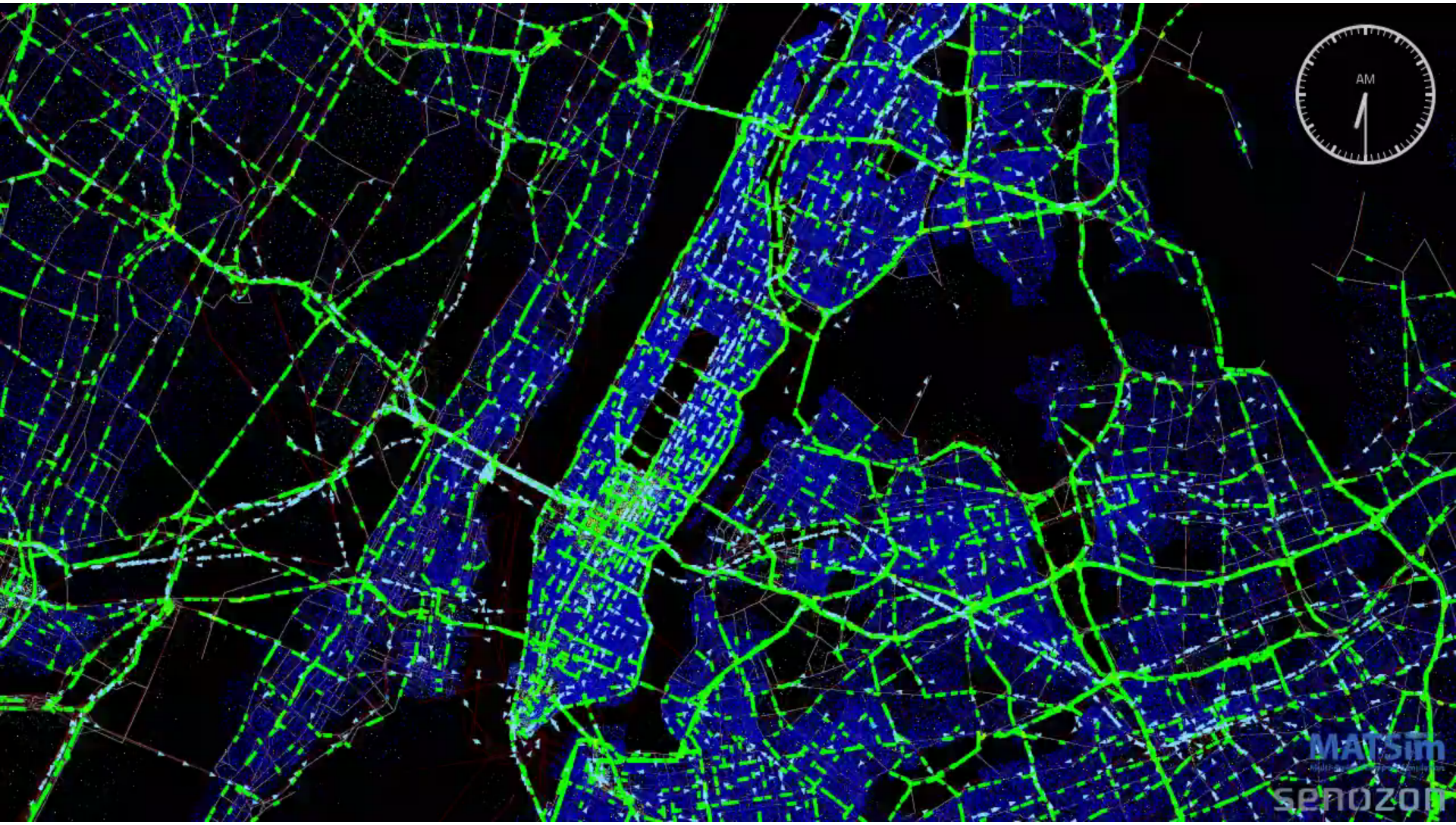
Equilibrium search in „ABM“ & assignment combinations



Equilibrium search in MATSim



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

Agent 1

Plan 1.1	H-W-H; 8:00, 17:00; C,C;	35

Agent 2

Plan 2.1	H-W-H; 8:00, 17:00; C,C;	35

Agent 3

Plan 3.1	H-W-H; 8:00, 17:00; C,C;	35

Co-evolution – Step 1.2 – After replanning (1/3)

Agent 1		
Plan 1.1	H-W-H; 8:00, 17:00; C,C;	35
Agent 2		
Plan 2.1	H-W-H; 8:00, 17:00; C,C;	35
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**	

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

Agent 1		
Plan 1.1	H-W-H; 8:00, 17:00; C,C;	**45**
Agent 2		
Plan 2.1	H-W-H; 8:00, 17:00; C,C;	**45**
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;	**60**

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

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;**	
Agent 2		
Plan 2.1	H-W-H; 8:00, 17:00; C,C;	45
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;	60

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%

Co-evolution – Step 3.1 – Simulation/scoring

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;	**70**
Agent 2		
Plan 2.1	H-W-H; 8:00, 17:00; C,C;	**45**
Agent 3		
Plan 3.1	H-W-H; 8:00, 17:00; C,C;	**45**
Plan 3.2	H-W-H; 8:15, 17:30; C,C;	60

Co-evolution – Step 3.2 – After replanning (1/3)

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;	70
Agent 2		
Plan 2.1	H-W-H; 8:00, 17:00; C,C;	45
Agent 3		
Plan 3.1	H-W-H; 8:00, 17:00; C,C;	45
Plan 3.2	H-W-H; 8:15, 17:30; C,C;	60
Plan 3.3	**H-W-H; 7:30, 17:15; B,B**	

Co-evolution – Step 3.3 – After plan selection (best/MNL)

Agent 1		
Plan 1.1	H-W-H; 8:00, 17:00; C,C;	36%
Plan 1.2	H-W-H; 8:00, 17:00; B,B;	**64%**
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;~~	~~45~~
Plan 3.2	H-W-H; 8:15, 17:30; C,C;	60
Plan 3.3	H-W-H; 7:30, 17:15; B,B	**New**

(The (worst) plan, more then memory allows, is deleted)

Co-evolution – Summary of best scores

	Iteration 1	Iteration 2	Iteration 3
Agent 1	35	45	80
Agent 2	35	45	45
Agent 3	35	60	60
Mean	**35**	**50**	**62**

Co-evolution – Issues

- Size of search space ~ Behavioural alternatives
- Rate of replanning (~ MSA)
- Size of the choice set ~ RAM
- Similarity of the daily schedules
- Integration into a log-sum term

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

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

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

Future whole day utility function?

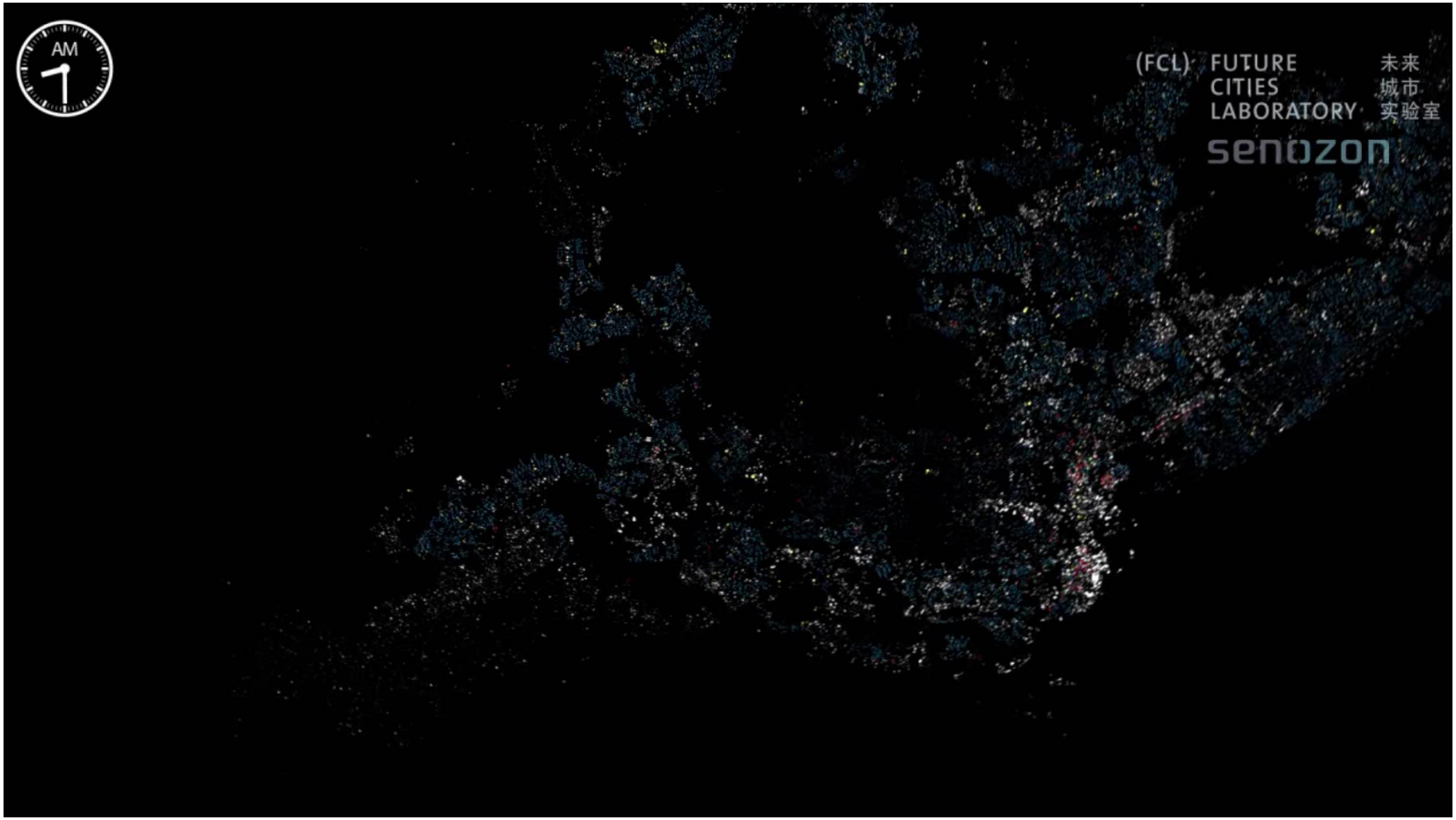
Time elements	linear
• Travel time	By mode and type of service; by crowding level by comfort level (parking search, stop&go)
• Transfer penalty	
• Late penalty	by activity type
Activity time	log (Vickrey) or S-shape (Joh) (all, individual)
• Minimum duration	by activity type
• Preferred duration	by activity type
• Duration	by time of day (might go away if participation is included)
Destination	Attractiveness, Value for money
Expenditure	by activity
	by mode/type of service

Current status

Current status

Known implementations:	About 35 (Europe, Asia, US)
Research groups:	About 25 (including some beyond transport)
Uses:	Research Some initial commercial uses Some policy consulting
Software:	Last reimplementation in 2012/13 Stable API Daily tests JAVA

Current progress: Singapore



Schedule detail possibilities (in current stable MATSim)

Number and type of activities (Feil, Balac)
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**
      - Parking search and type (Waraich)
    - **Vehicle/means of transport** (Ciari, Bösch)
    - **Route/service** (Chakirov)
    - Group travelling together (Dubernet, Fourie)
    - Expenditure division

Recent and current developments and applications at ETH

Integration of walking	Multi-level network resolution
New modes	Escalators and ‘walkways’
Autonomous vehicles	Include a ‘gopher mode’
Car sharing:	Station-based car-sharing Free-float car sharing
Parking search	Specialised within day replanning In conjunction with recent SC experiments
Evacuation	Specialised within-day replanning

Challenges

Challenges for MATSim

- Econometric estimation of the whole day scoring function
- Increase the size and variance of the implicit choice set
- Link to a log-sum formulation
- Accelerating the iterative equilibrium search
- Gridlock modeling (& stability of equilibrium)
- Generation of artificial social networks in the agent-population

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

Prof. Kay Axhausen
Milos Balac
Dr. Michael Balmer
Henrik Becker
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
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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

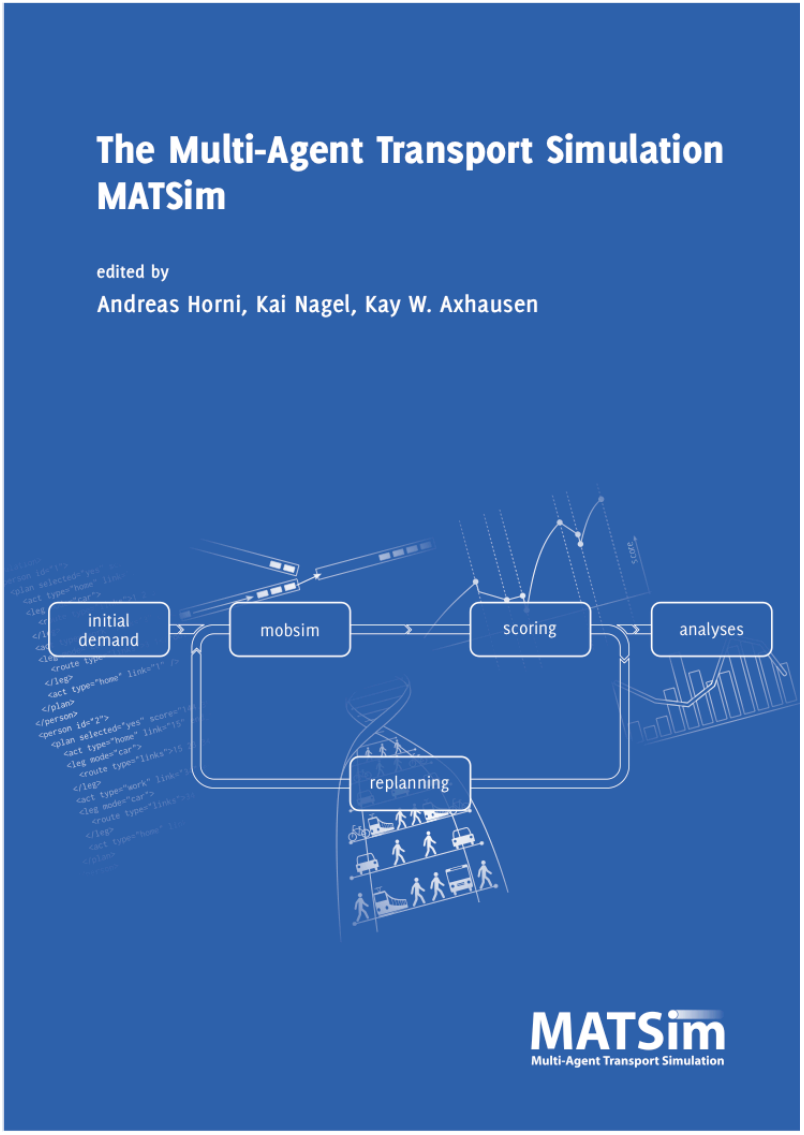
Questions ?

www.matsim.org

www.ivt.ethz.ch
www.futurecities.ethz.ch

www.senozon.com

Questions ?


The Multi-Agent Transport Simulation
MATSim
edited by
Andreas Horni, Kai Nagel, Kay W. Axhausen
initial demand
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analyses
replanning
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