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Large choice sets in agent-based simulations: Some experiences

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- Andreas Horni

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- Matthias Feil

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 activity schedule DUE, SO & SUE

Given the

Agent's daily schedules of predetermined detail

Subject to some

Max F

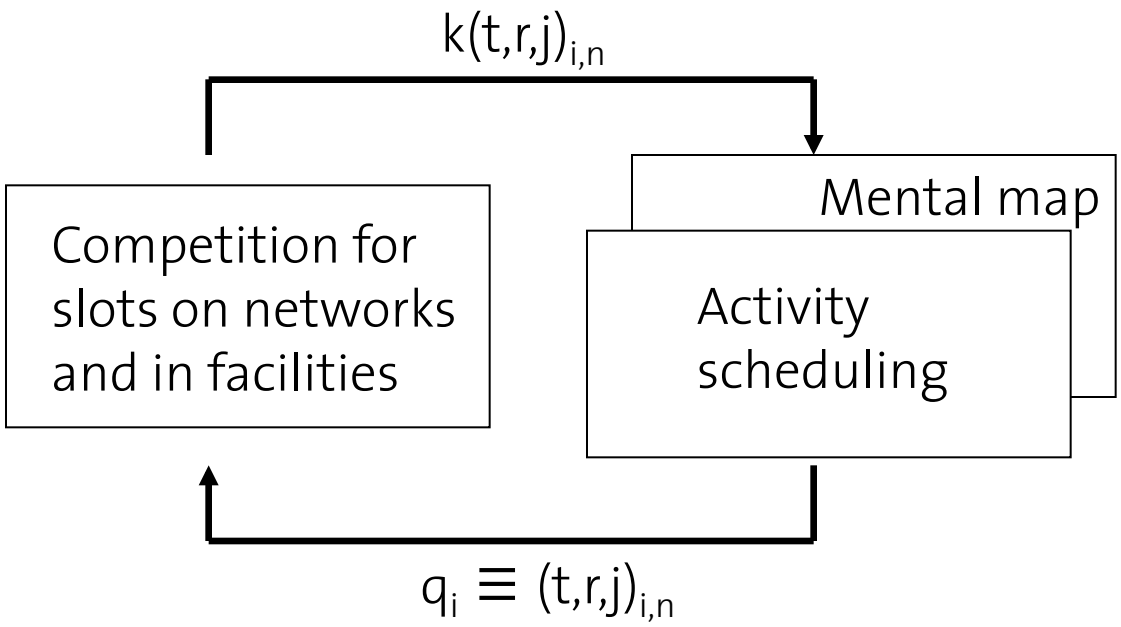
up to the resolution of the agents, links and facilities

Matching the

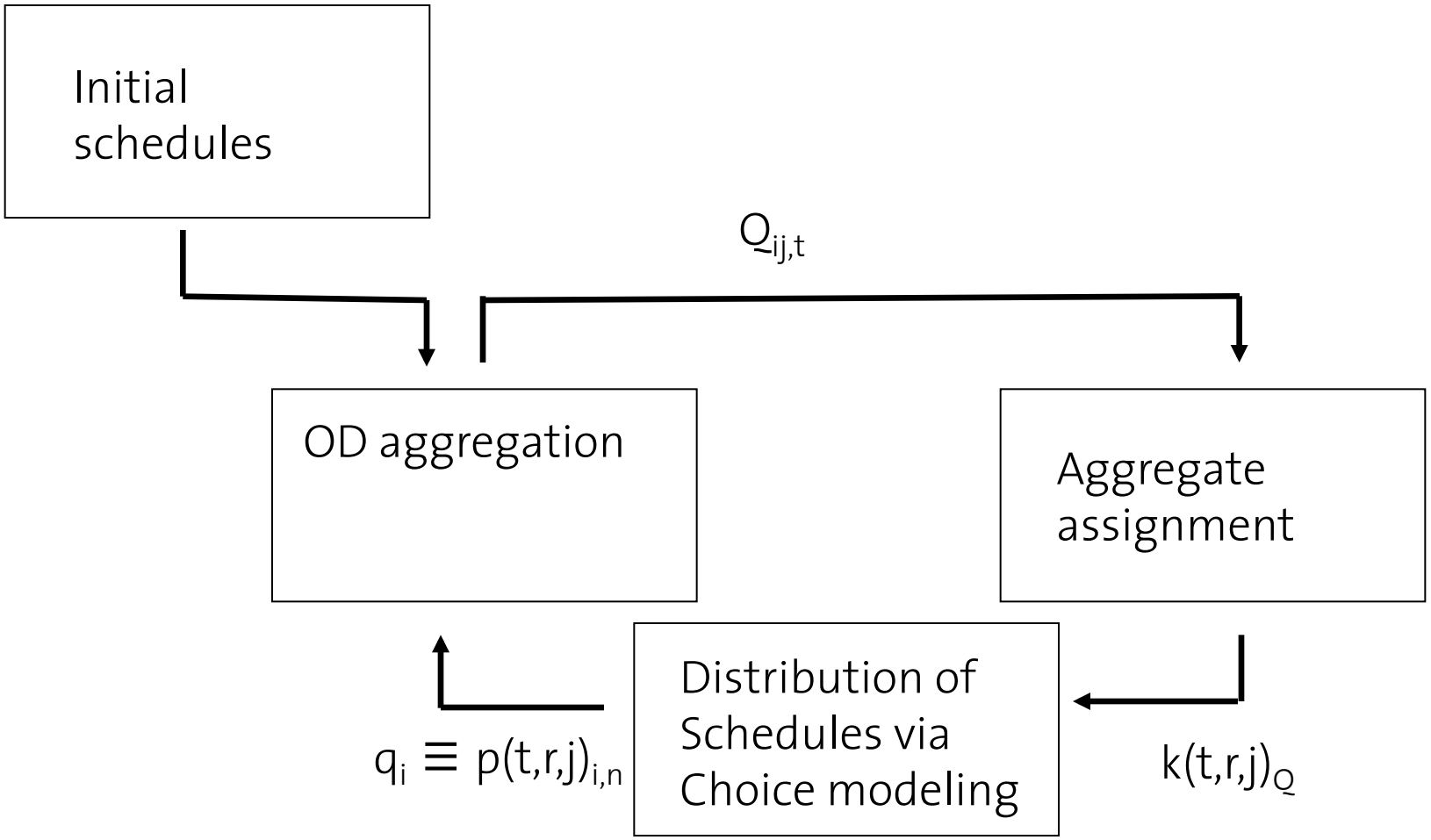
- Expected elasticities with respect to the generalized schedule costs
- Known correlations between the details of the plans
- Capacity constraints on the links, services and facilities
- Minimum loads for some of the facilities

How to find the SUE in an agent-based approach ?

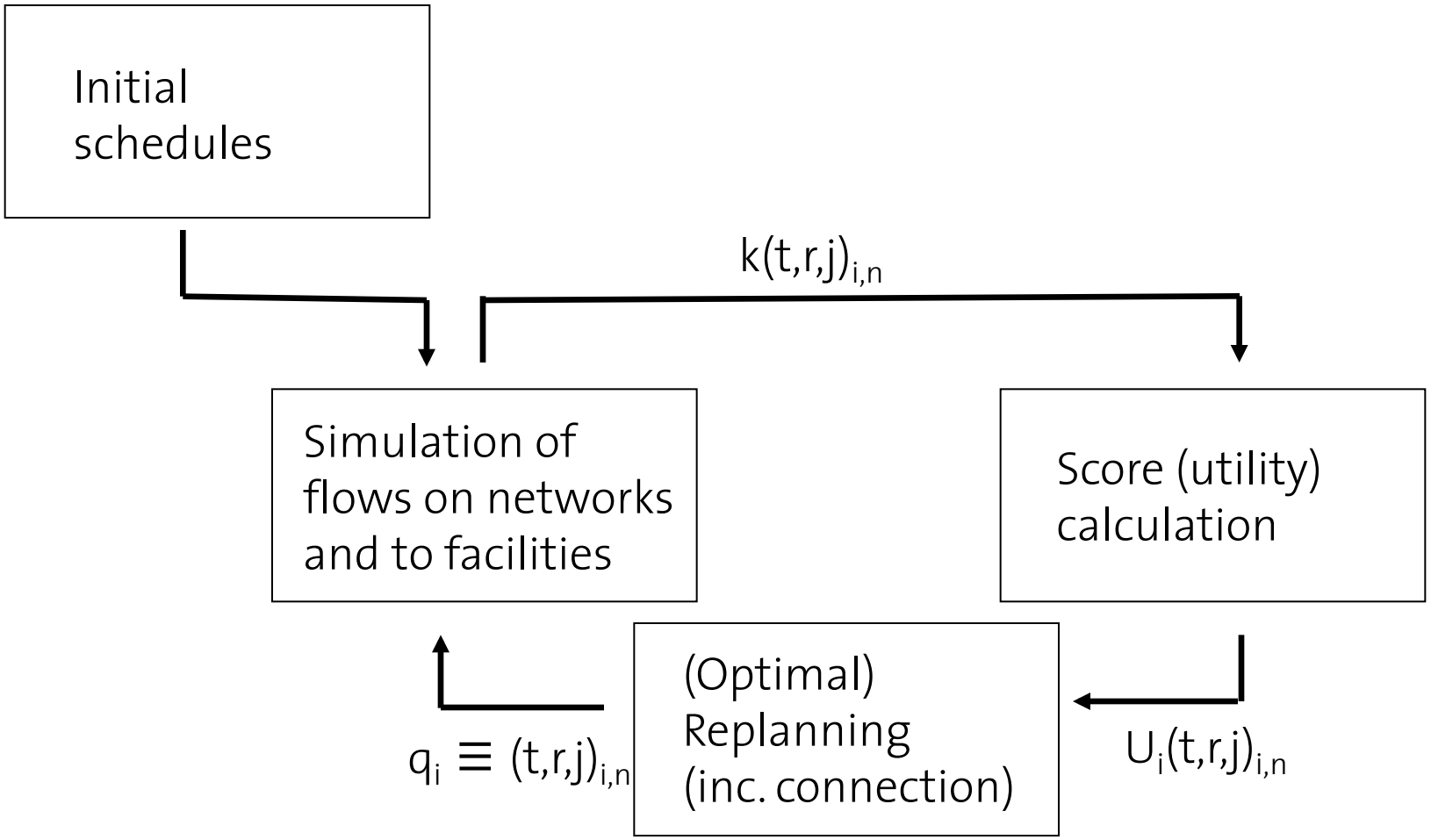
Learning approach of the generic one-day transport model



Equilibrium search in „ABM“ & assignment combinations



Equilibrium search in co-evolutionary MATSim



The challenge

Network and spatial detail: MATSim Singapore

Schedule and spatial details

Singapore 2012:

- $5.2 * 10^6$ agents with about 300 types of activity chains
- 11 activity types
- $0.16 * 10^6$ facilities
- $0.08 * 10^6$ links
- 400 bus and MRT routes with 98'500 timetabled departures
- 4'650 bus and MRT stops
- 24 * 60 * 60 seconds

Switzerland 2009:

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

Schedule and spatial details, again

Switzerland 2009:

- $6.0 * 10^6$ agents with about 500 activity chains
  - About 2.0 out of home activities
  - About 1.9 tours
  - About 5h out of home
  - 11 activity types
  - On average 12 leisure contacts and "core contacts"
- $1.6 * 10^6$ facilities
- $0.8 * 10^6$ links
- 24 * 60 * 60 seconds

The challenge, again

Packing problem of the activity schedule 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 and **structural constraints**

Matching the

Expected elasticities with respect to the generalized schedule costs

Known correlations between the details of the plans

Capacity constraints on the links, services and facilities

Minimum loads for some of the facilities

Challenge: Making the appropriate trade-offs

Between

- Resolution
- Number and form of external constraints
  - Number of endogenous dimensions
  - Size and structure of choice sets
- Accuracy of the equilibrium
- Computation time
  - Generation of the choice sets
    - Measurement of similarity
    - Structure of the choice model
  - Simulation of the competition

Typical constraints: 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

Typical constraints: Endogenous in stable MATSim

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 search and type
    - **Vehicle/means of transport**
    - **Route/service**
    - Group travelling together

    - Expenditure division

Typical constraints: Choice of activity schedule

Typical constraints: Choice of activity schedule

ABM Models:

Some GEV RUM based on imputed choice set

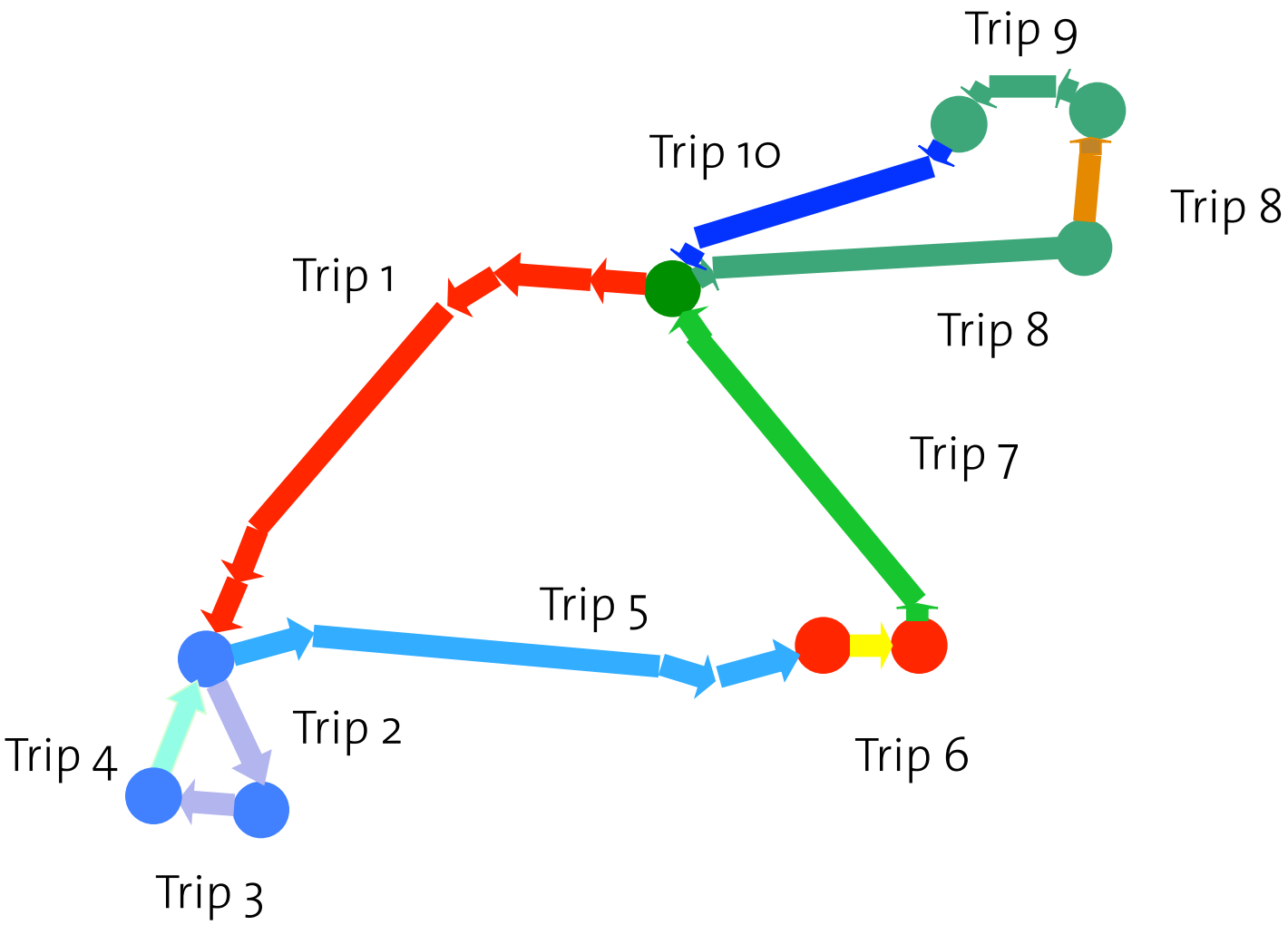
Series of GEV linked by inclusive values

Co-evaluationary iterative approach

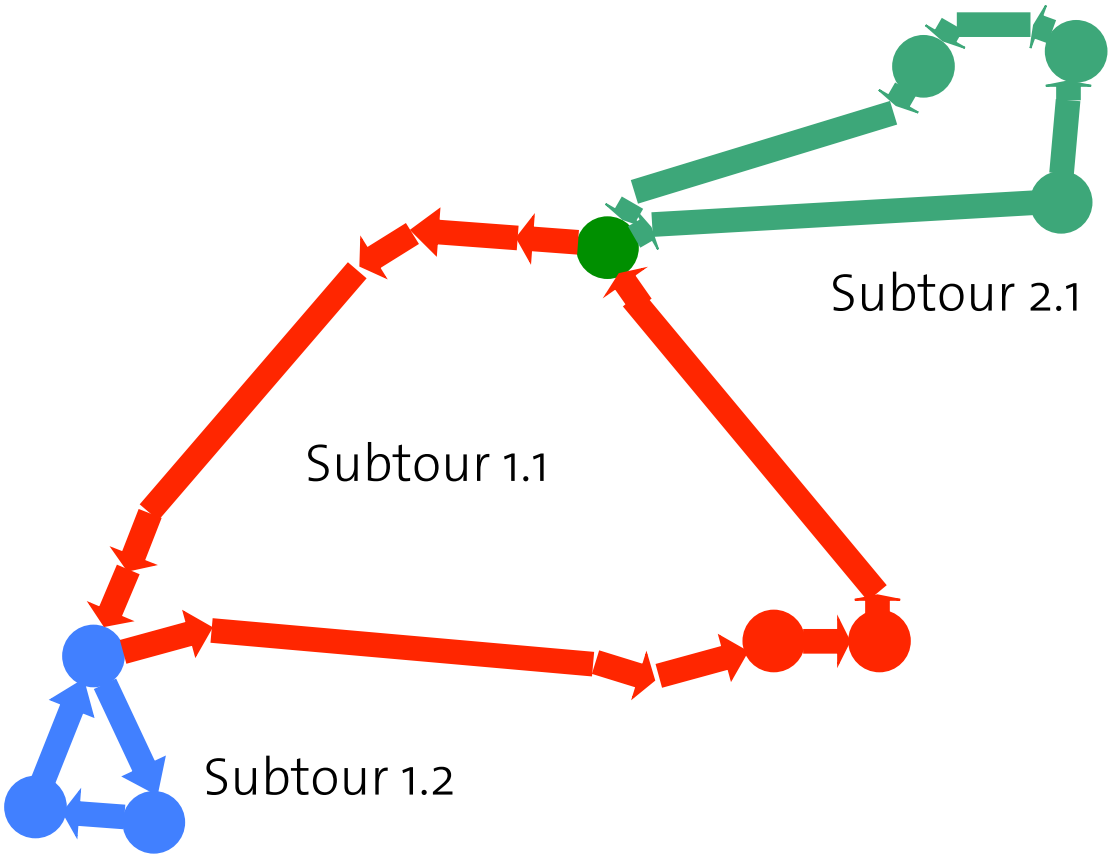
Score today's plan
Add a new plan to a random subsample
Choose among the existing plans for the non-chosen agent
Remove the worst plan, if memory runs out

Typical constraints: Mode choice

Mode choice nearly unconstrained

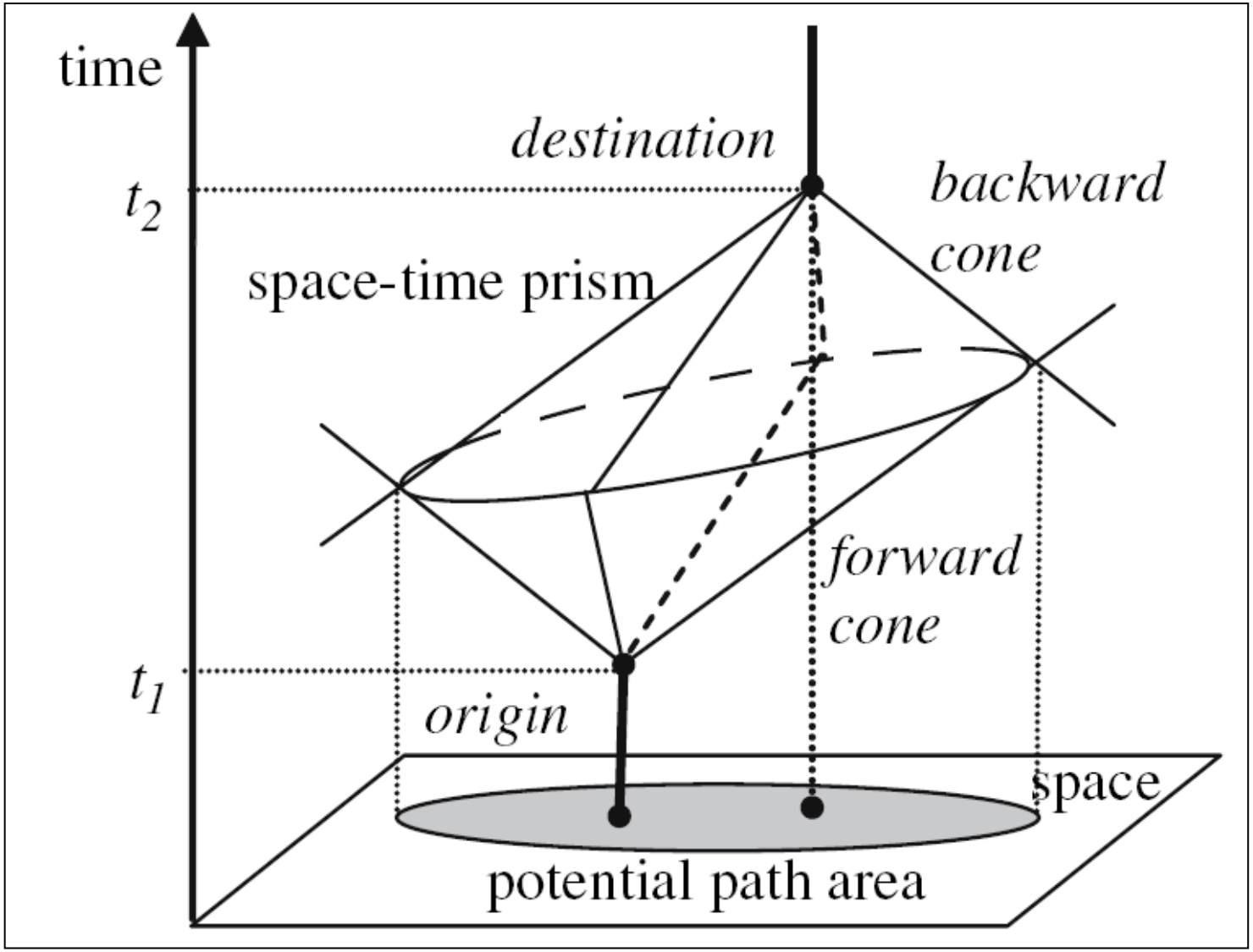


Typical constraints: Subtours in mode choice



Typical constraints: Time-space prisms for locations

Typical constraints: Time-space prisms for locations



Typical constraints: Surveying the choice set

Sie diesen Laden?
nein

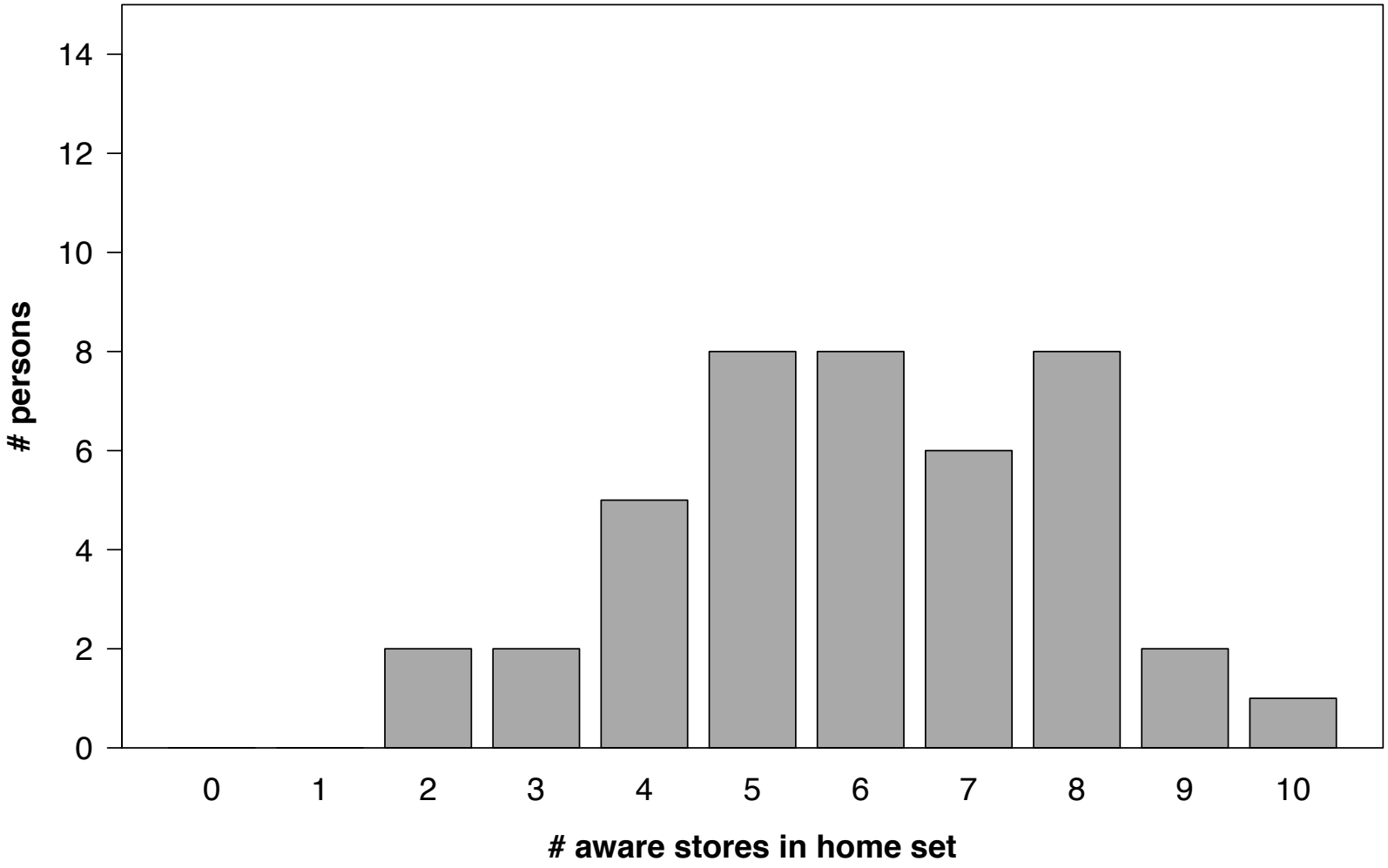
elmässig haben Sie diesen Laden in diesem Jahr besucht?

oft (mehrmals pro Woche)
a. 1 Mal pro Woche)
gentlich (wenigstens 1 Mal pro Monat)
n (wenigstens 1 Mal pro Jahr)

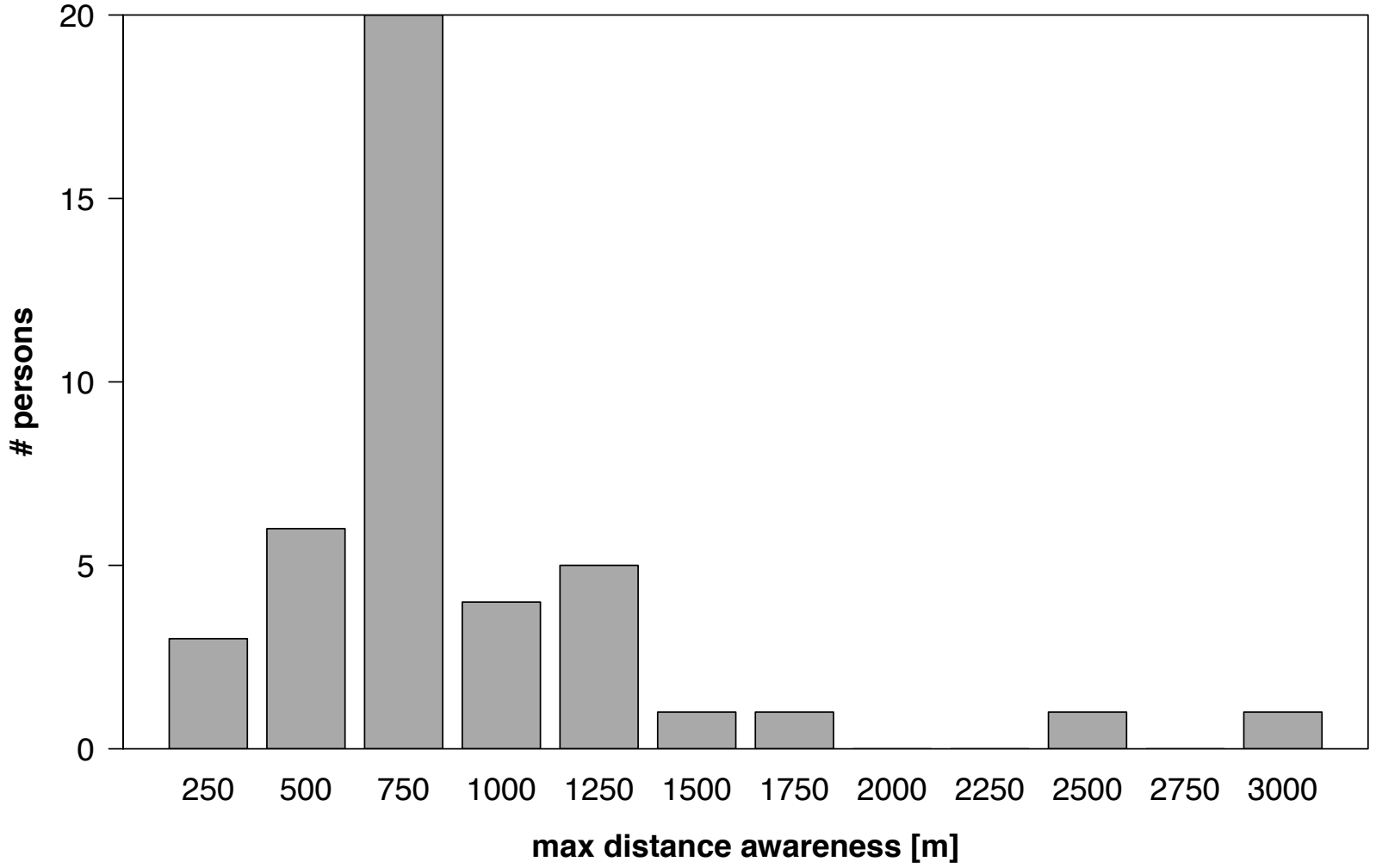
s sind die Gründe, warum Sie diesen Laden selten oder gar nie besuc
)

s nicht, habe ich mir noch nicht überlegt
ichtige Produkte fehlen
aktisch, weil für mich keine Umsteige- oder Endhaltstelle (Reise mit d
ir zu weit weg / liegt nicht an meinem Weg
echtes Preis-Leistungsverhältnis / zu teuer

Typical constraints: Grocery stores around home

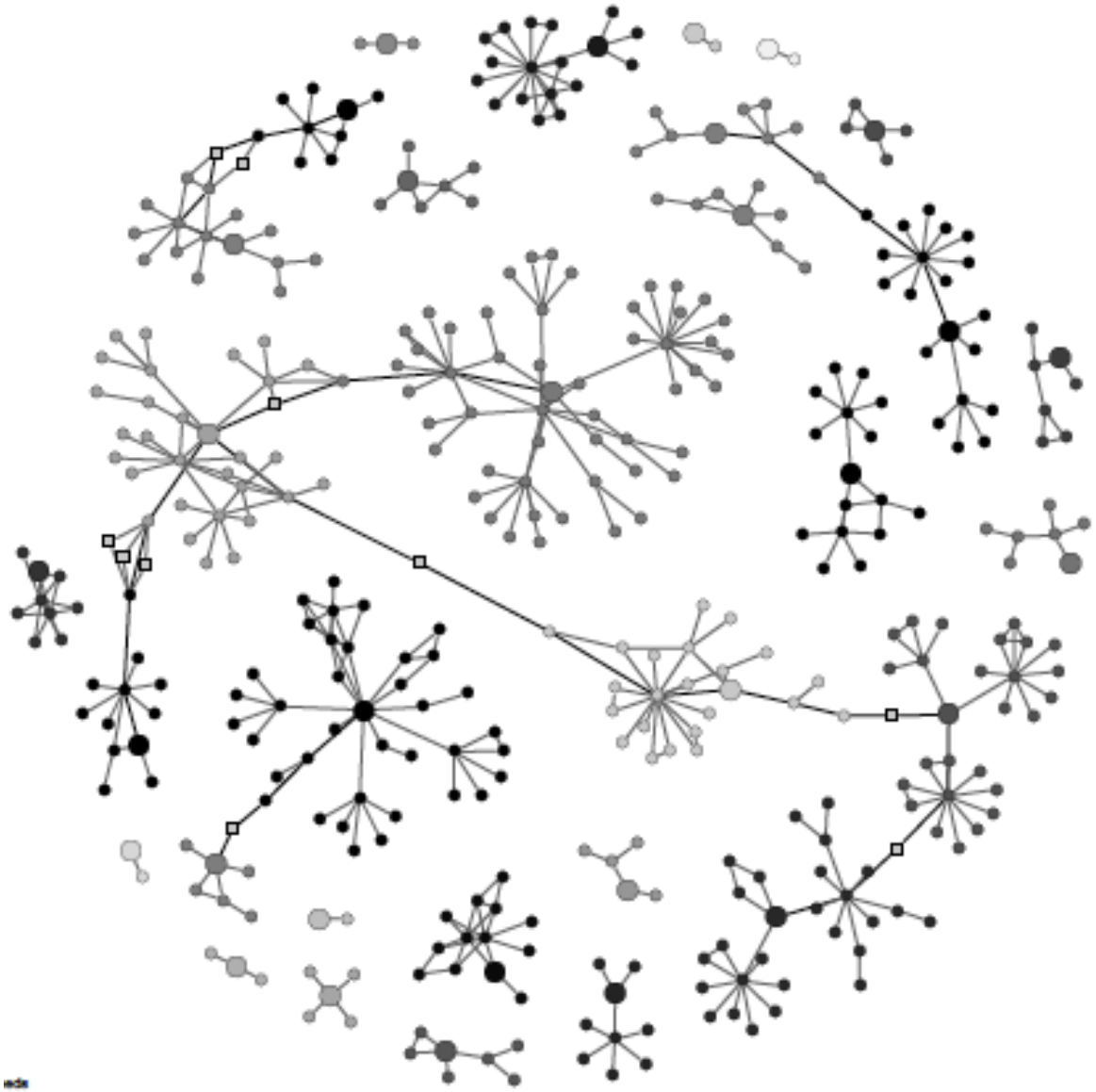


Typical constraints: Distances to store around home



Typical constraints: Social network

Social networks unconstrained

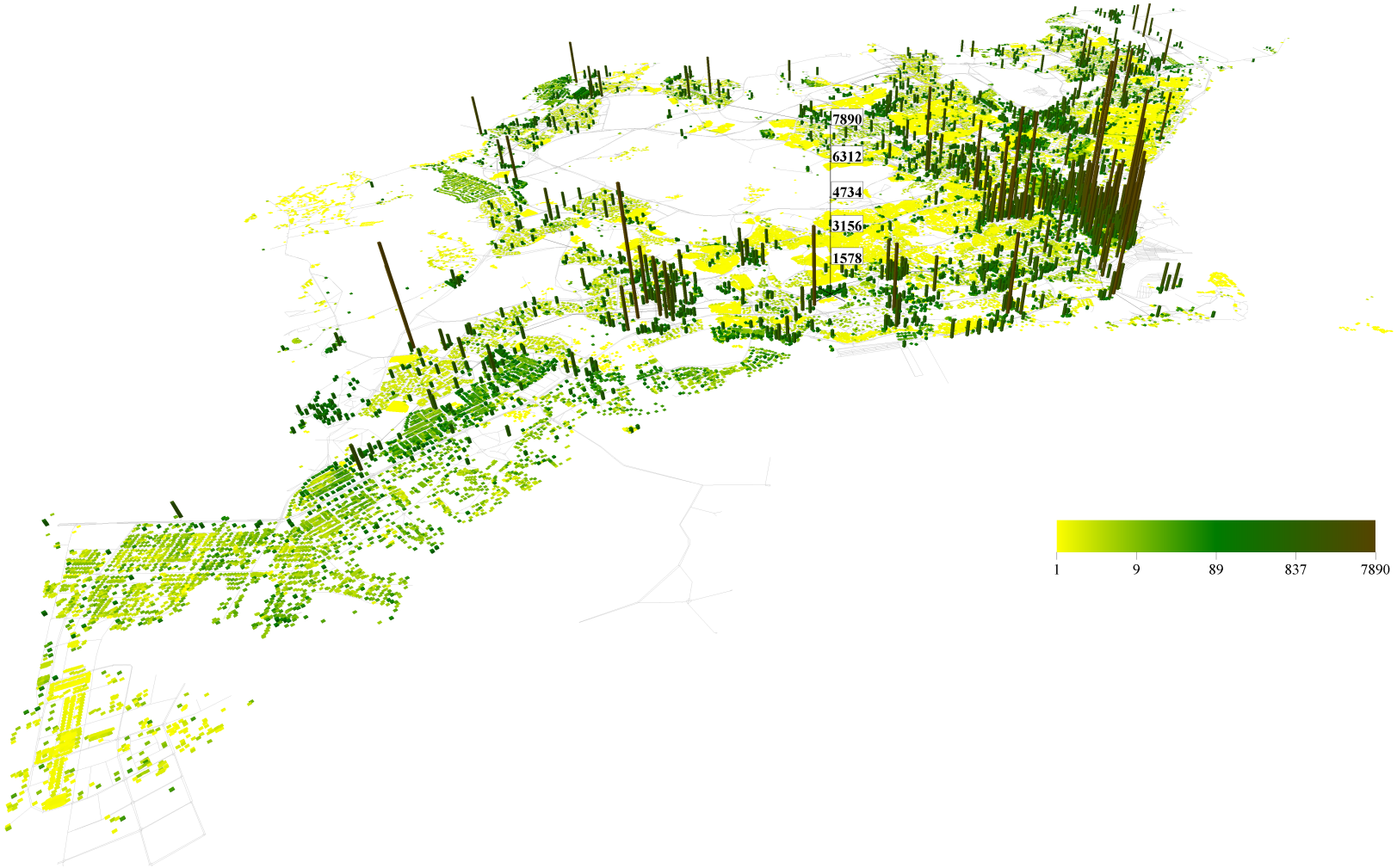


Typical constraints: Social networks

Ignore

Typical constraints: Capacities

Typical constraints: Workplaces by building



Ordonez, S and A. Erath (2012) Estimating Dynamic Workplace Capacities using Public Transport Smart Card Data and a Household Travel Survey

Sydney July 2013

Typical constraints: Capacities, be consistent

Add capacity – restraint functions to

- Roads
- Junctions
- Buses
- Trains
- Stores
- Restaurants

The ways forward

Schedule detail possibilities and fewer iterations (Fourie)

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

Questions ?

www.matsim.org

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

www.senozon.ch

Appendices

MATSim today

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**