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The Parking Game

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Motivation

- Parking search traffic can be substantial (average 30%, 16 cities, D. Shoup, 2007)
- Parking supply and price can have impact on e.g. mode and destination choice
- Parking can be used for modelling policy: Models should help to design parking policies
- Requirement: Model should be compatible with agent-based user equilibrium models like MATSim

How is agent-based parking search modelled till now?

- In Benenson *et al.* (2008) PARKAGENT is presented:
- residential parking
- agent’s enter simulation close to destination
- decision in each time step (park or not)
- take any parking, after destination link
- max. search time 10min: drive to closest off-street parking

What are the challenges? What is missing?

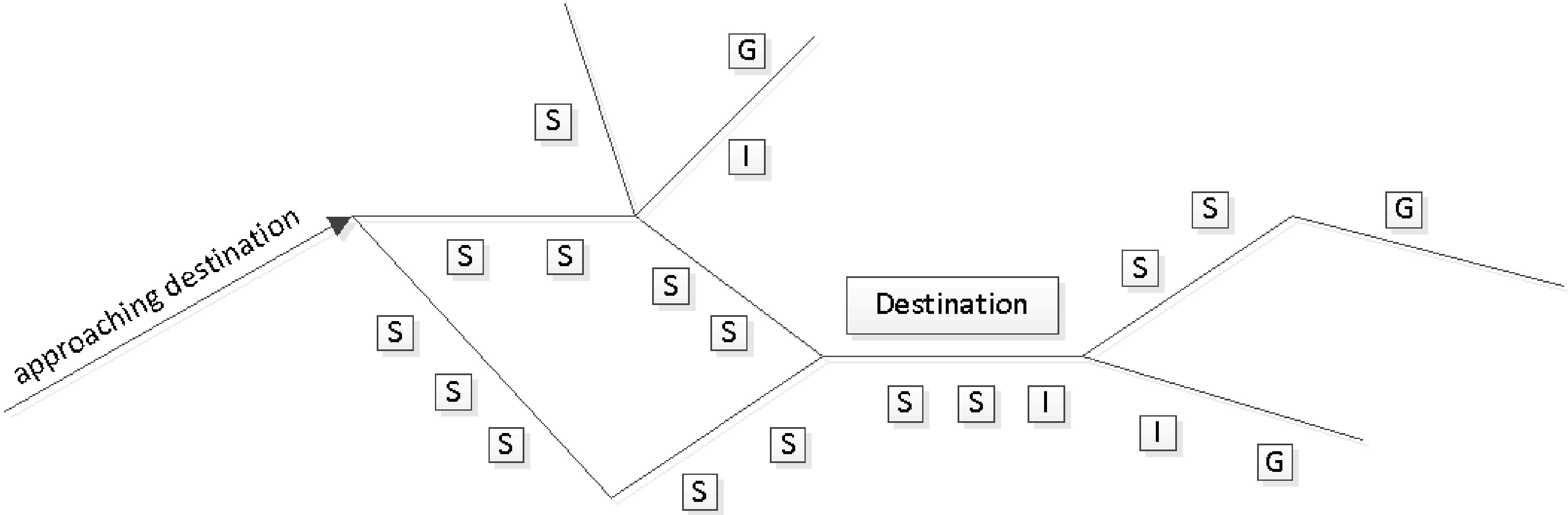
- Just one single strategy for all people => realistic?
- Treating off-street parking ALWAYS as a last option
    - systematic over-estimation of parking search time
- What is strategy based on?

Multiple Parking Strategies

Axhausen and Polak (1989):

- -> First comes parking strategy choice
- -> group discussions/ surveys: 7 search strategies
  - -> e.g. high probability parking set
  - -> anchor: off-street parking and use on-street parking, if opportunity arises
  - -> circle around destination
  - -> illegal parking
  - -> combinations
- -> Survey to find out which strategies used in Karlsruhe/Birmingham?

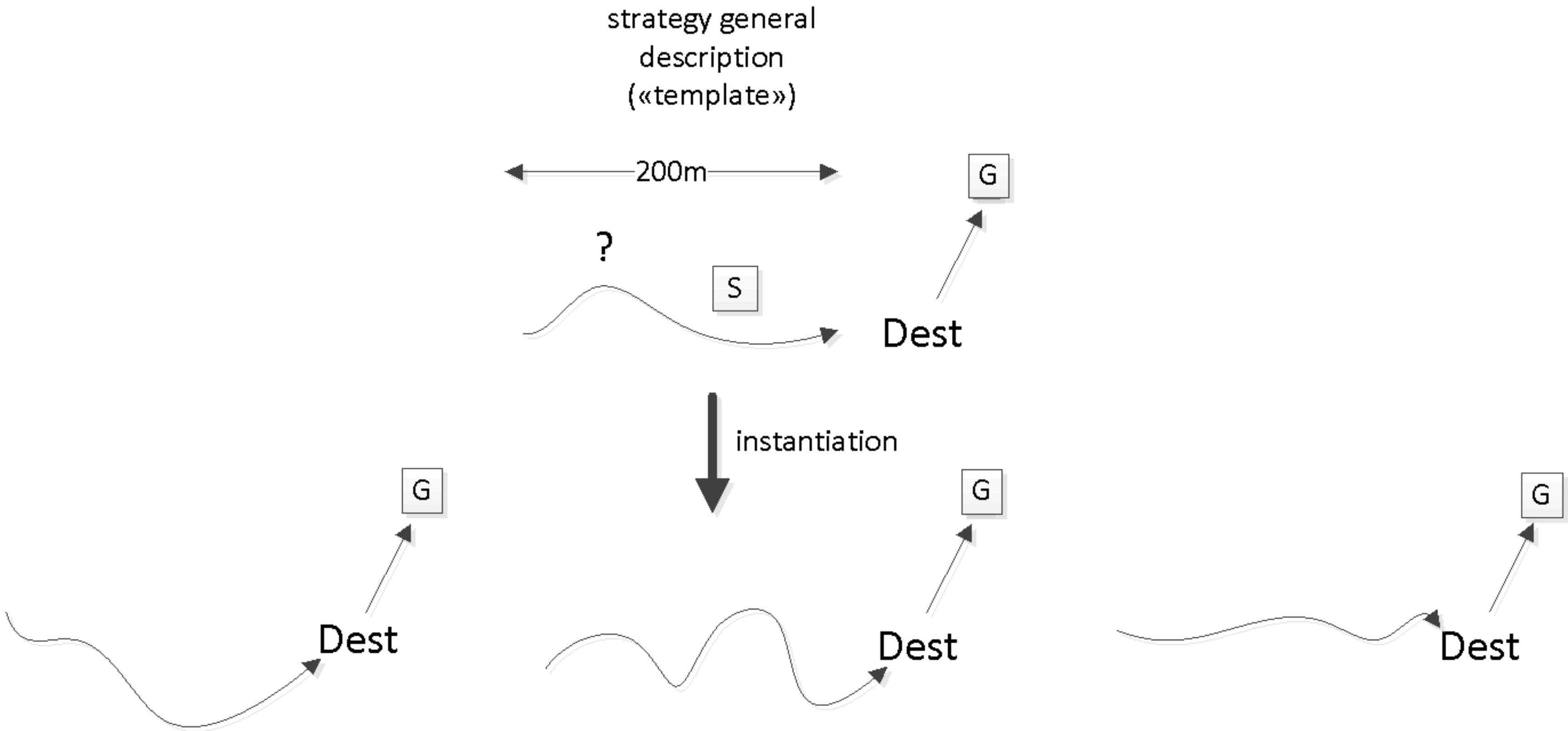
General Structure of Parking Search Strategies



proactive strategies start operation already before reaching destination

Backup strategy starts operation (mostly random or garage)

Instantiation of Parking Strategy



Utility Function

$$U_{parking,i} = U_{P_{cost},i} + U_{P_{searchTime},i} + U_{P_{walk},i} + \epsilon_i \quad (1)$$

$$U_{plan,i} = \sum U_{travelTime,i} + U_{travelCost,i} + U_{performActivity,i} \cdots + \sum \boldsymbol{U_{parking,i}} \qquad (2)$$

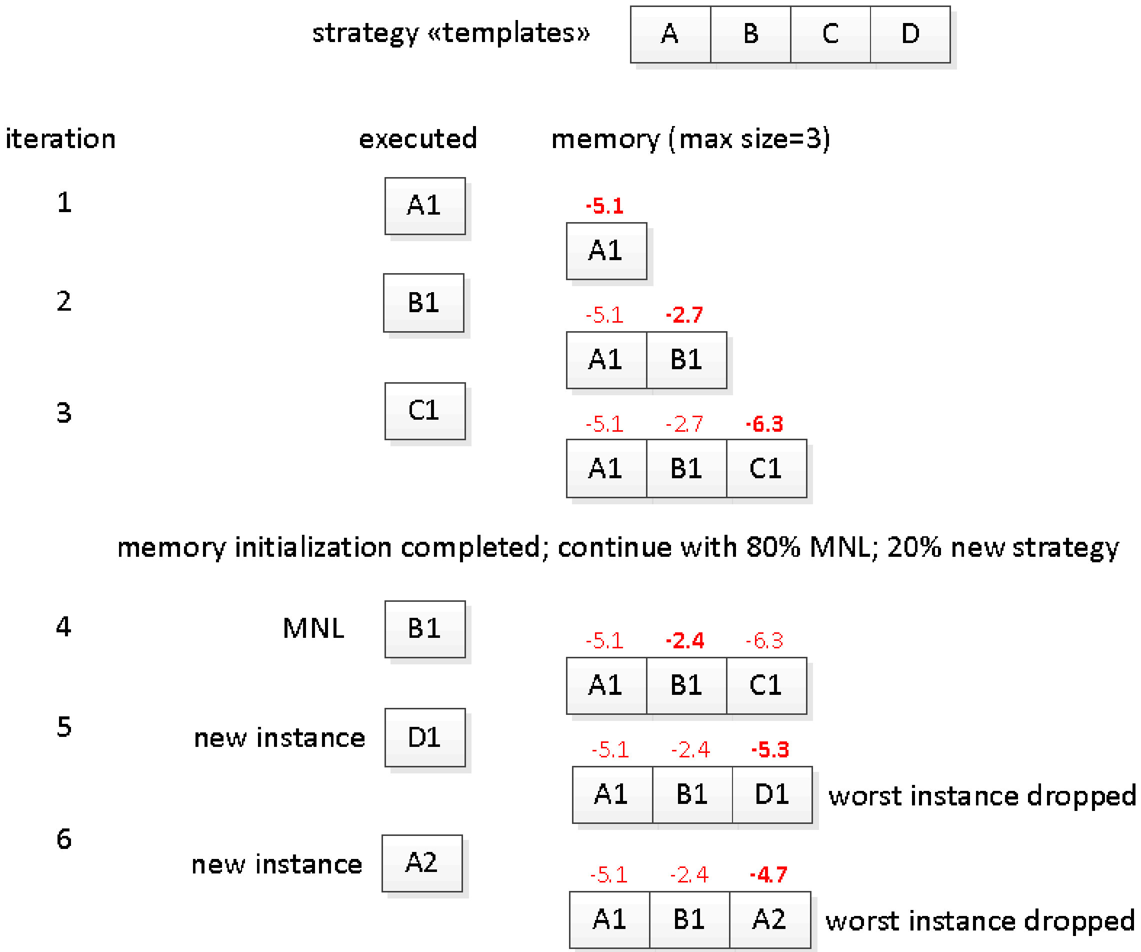
Utility function used: Weis et al. (2013) => age, gender, income

- Sensitive to policy changes
  - Price change
  - Supply/capacity change
  - Restricting allowed parking time (e.g. max. parking)
  - Increased law enforcement

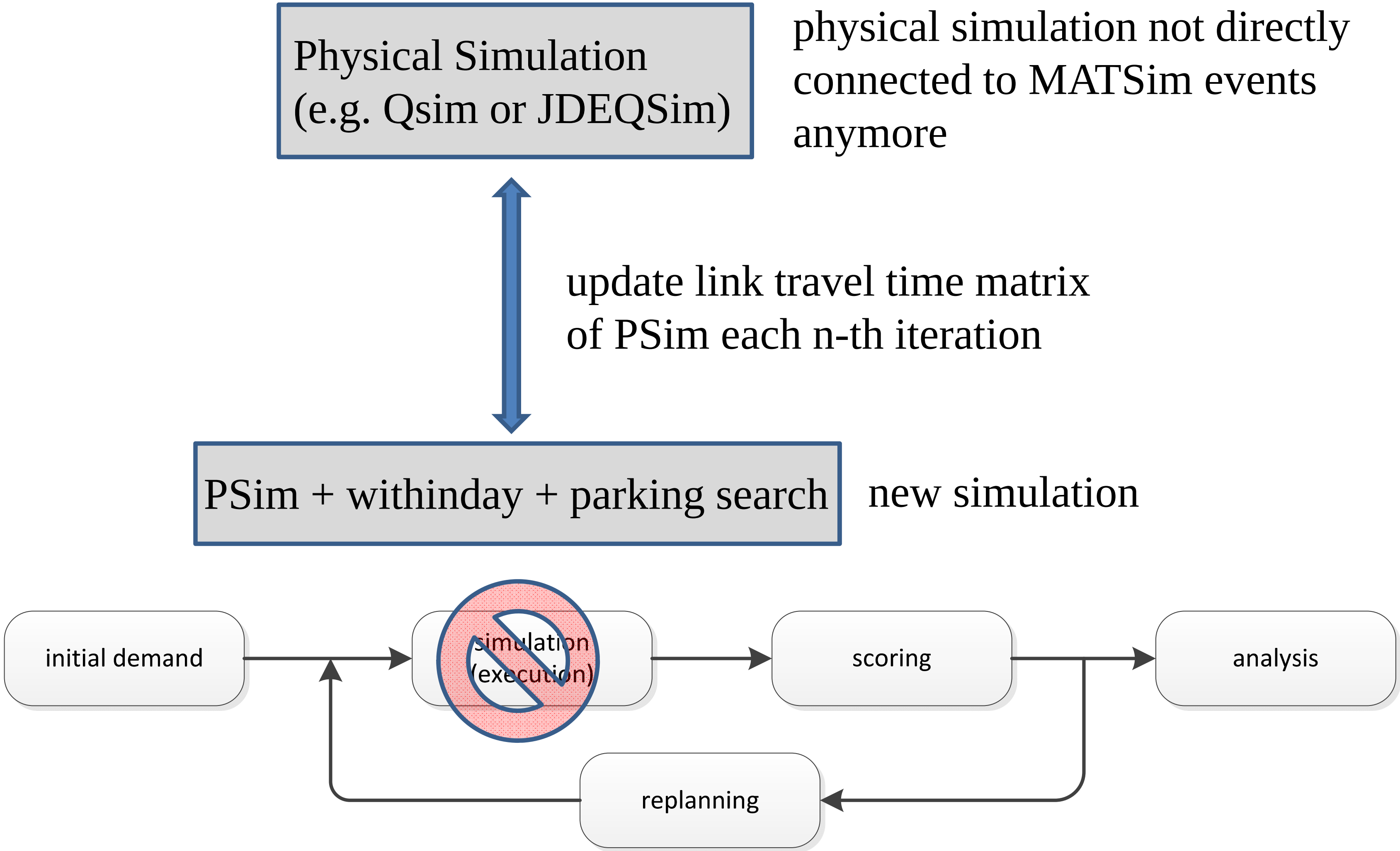
The Parking Game

- Parking game played by people/agents as part of a bigger game against each other (in the context of activity/travel demand). Goal of the game is to chose/find a parking strategy, which maximizes the parking utility of the agent
- Utility score used to provide feedback to the higher level game

Optimization (similar to MATSim)



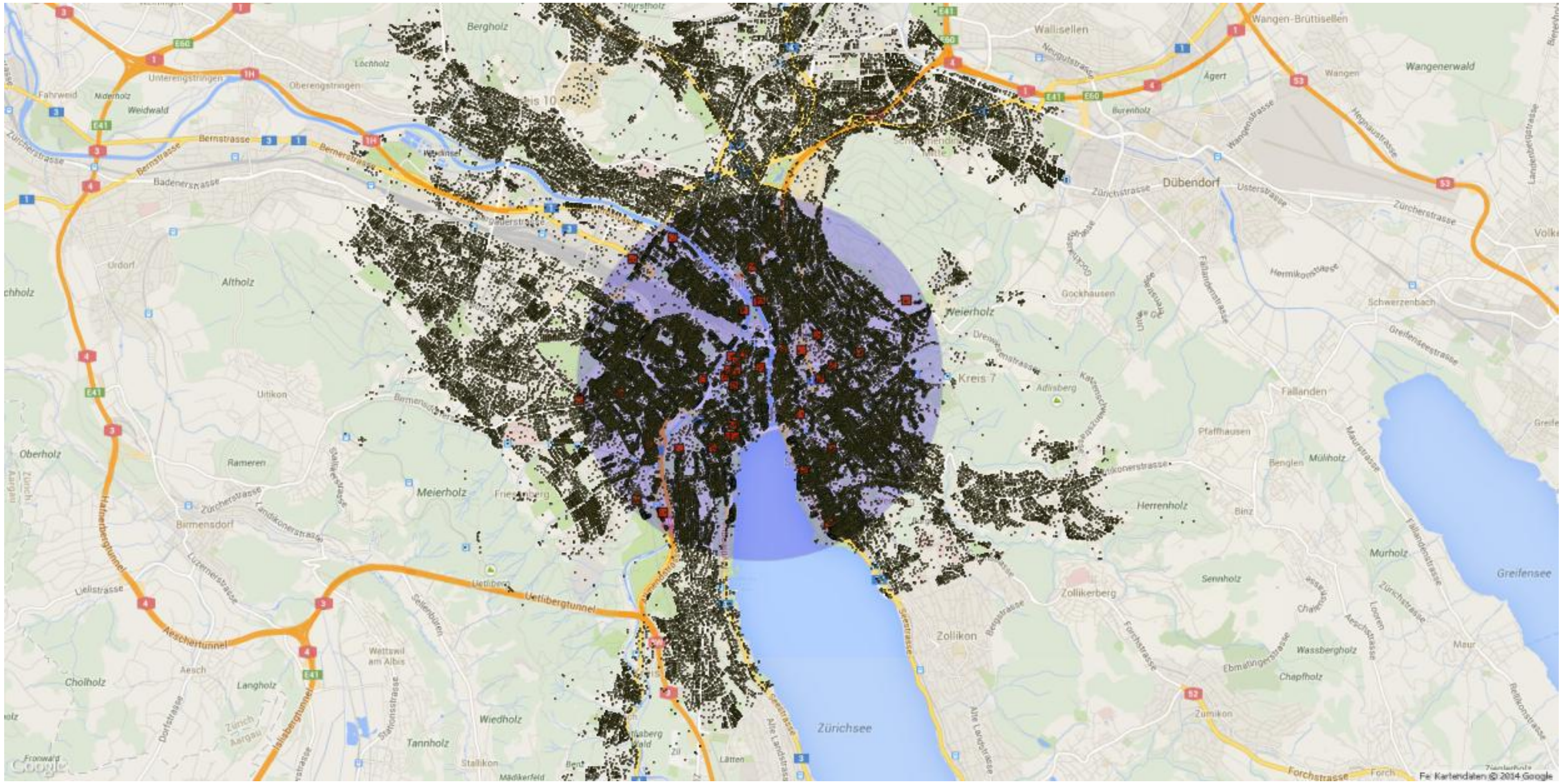
MATSim Simulation with Parking Search



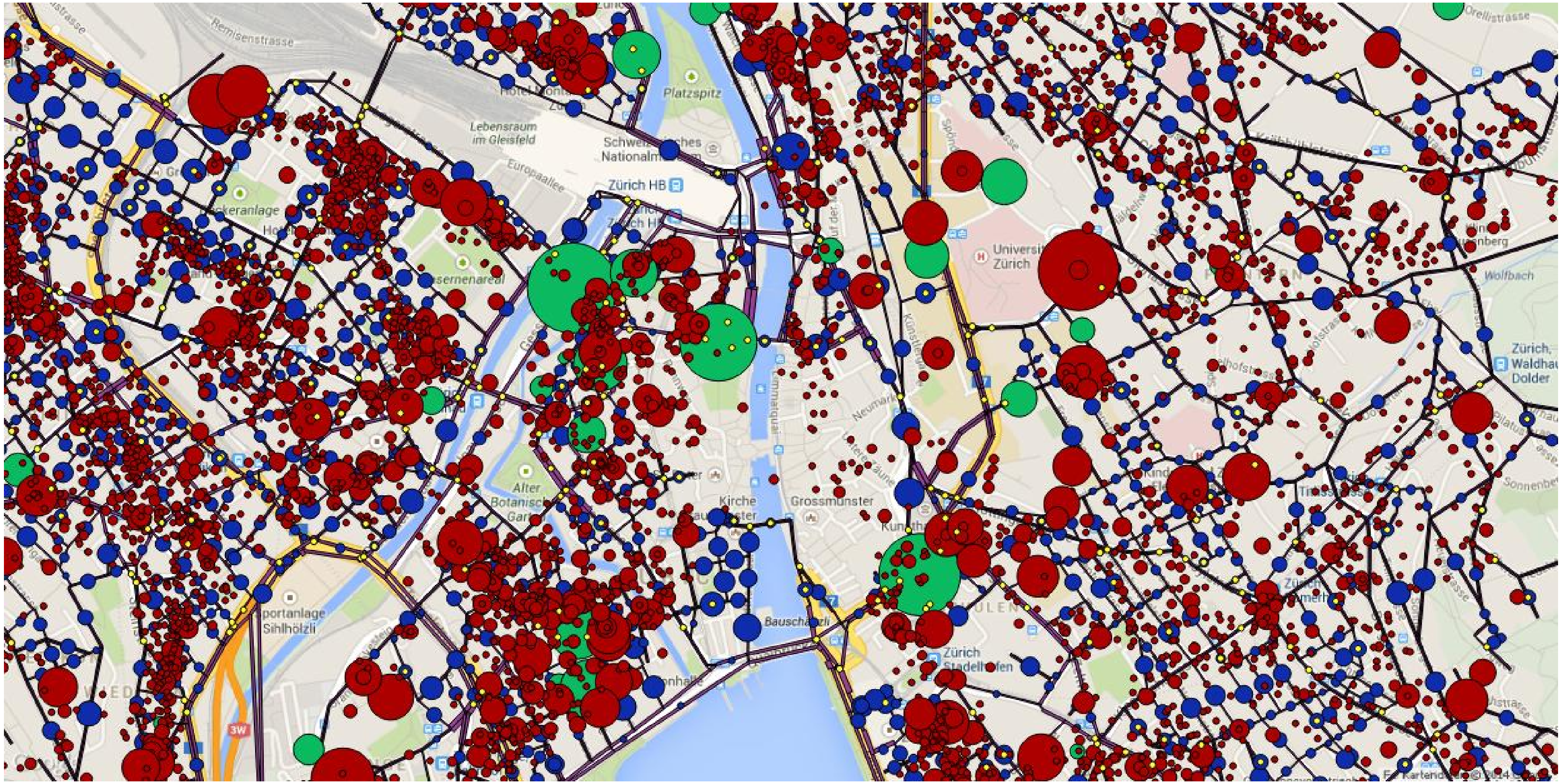
Experiments

- We have implemented around 15 strategies – mostly based on ideas from Axhausen and Polak (1989) + Park Agent + other Heuristics
- Scenario: Zürich – replanning only for parking search strategies – other replanning fixed

Study Area (2.5km radius)



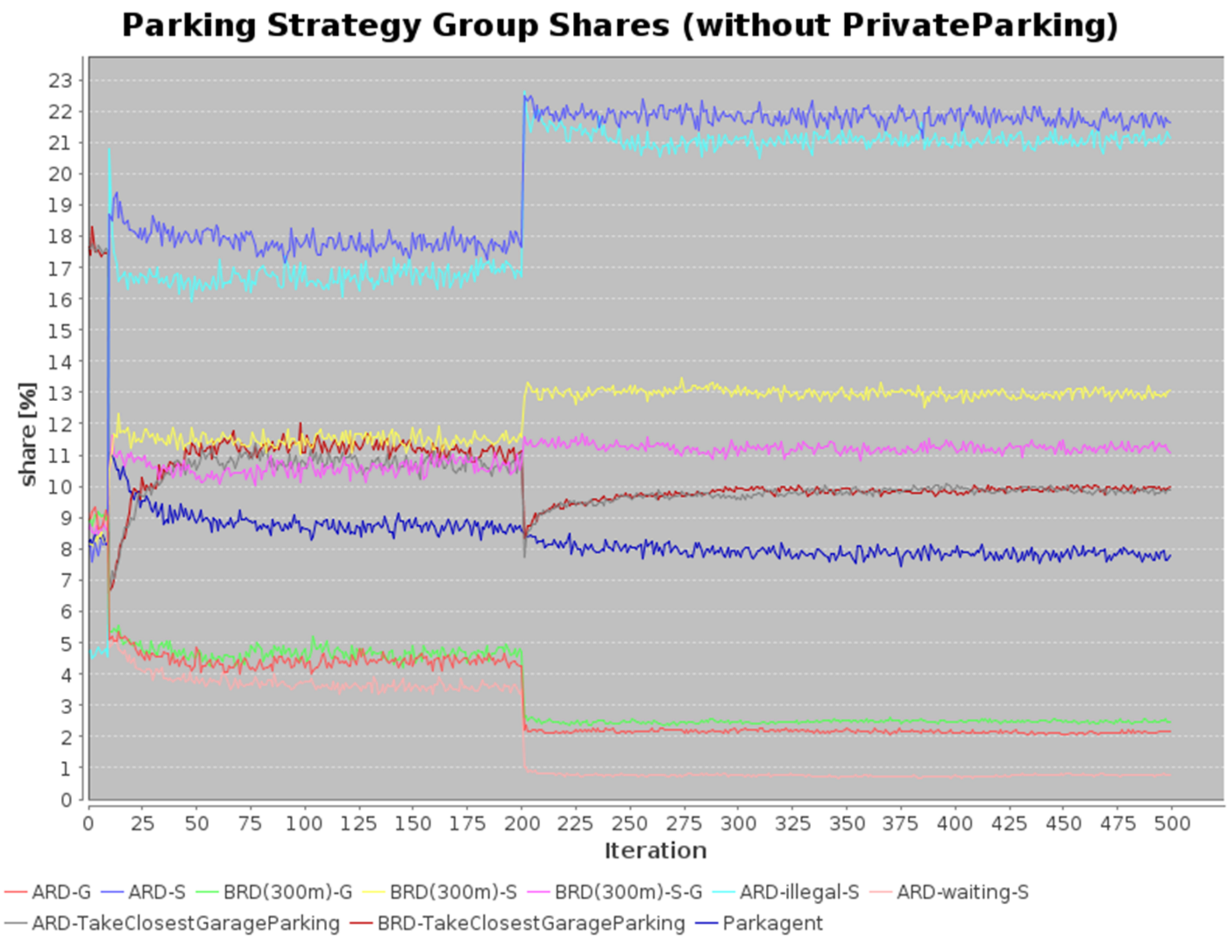
Parking Capacities



Strategies

Strategies	(primary) focus
ARD-G	garage
BRD(300m)-G	garage
ARD-TakeClosestGarageParking	garage
BRD-TakeClosestGarageParking	garage
BRD(300m)-S-G	street -> garage
Parkagent	street -> garage
ARD-S	street
BRD(300m)-S	street
ARD-waiting-S	street
ARD-illegal-S	street -> illegal

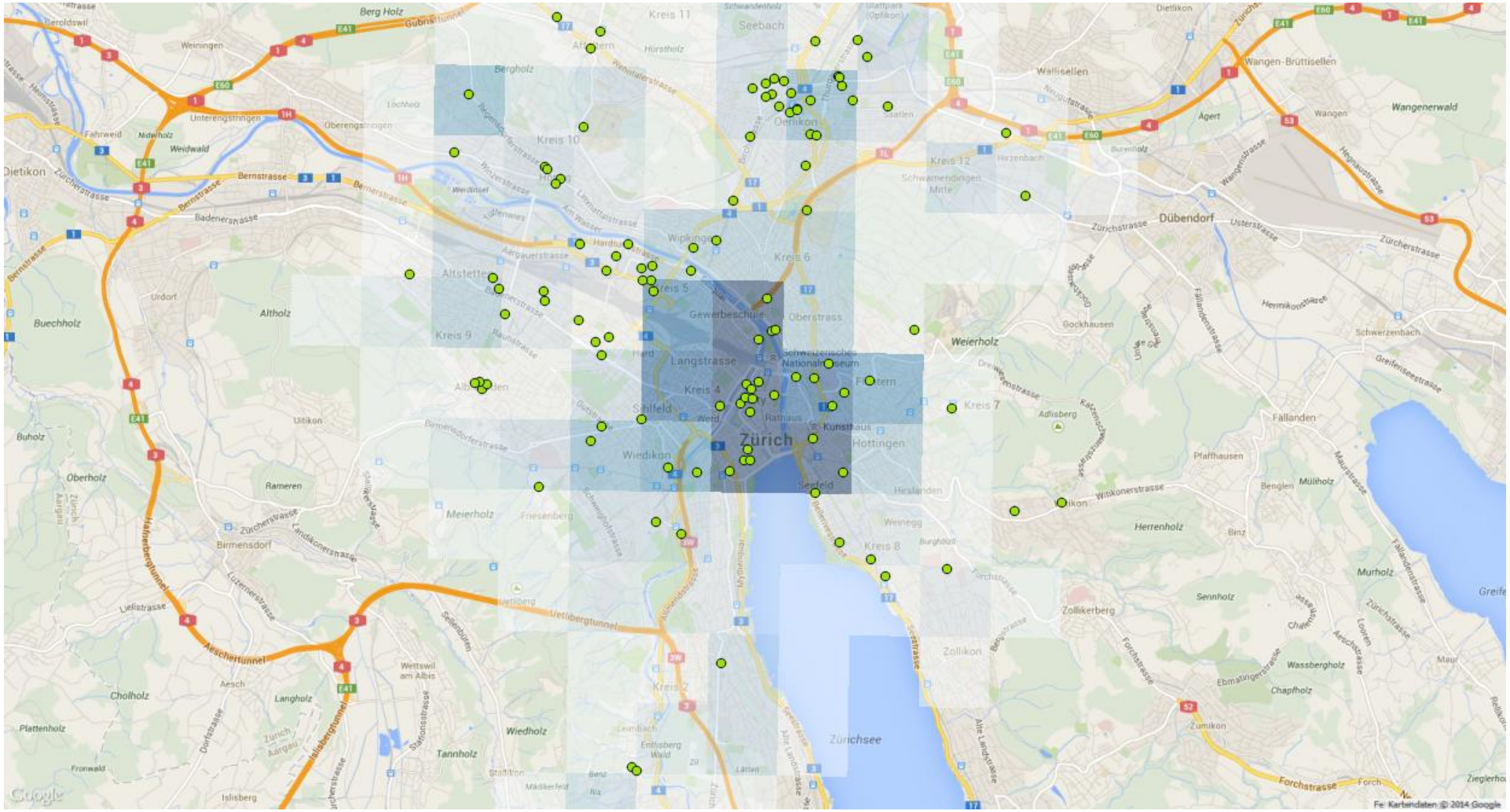
Parking Strategy Shares



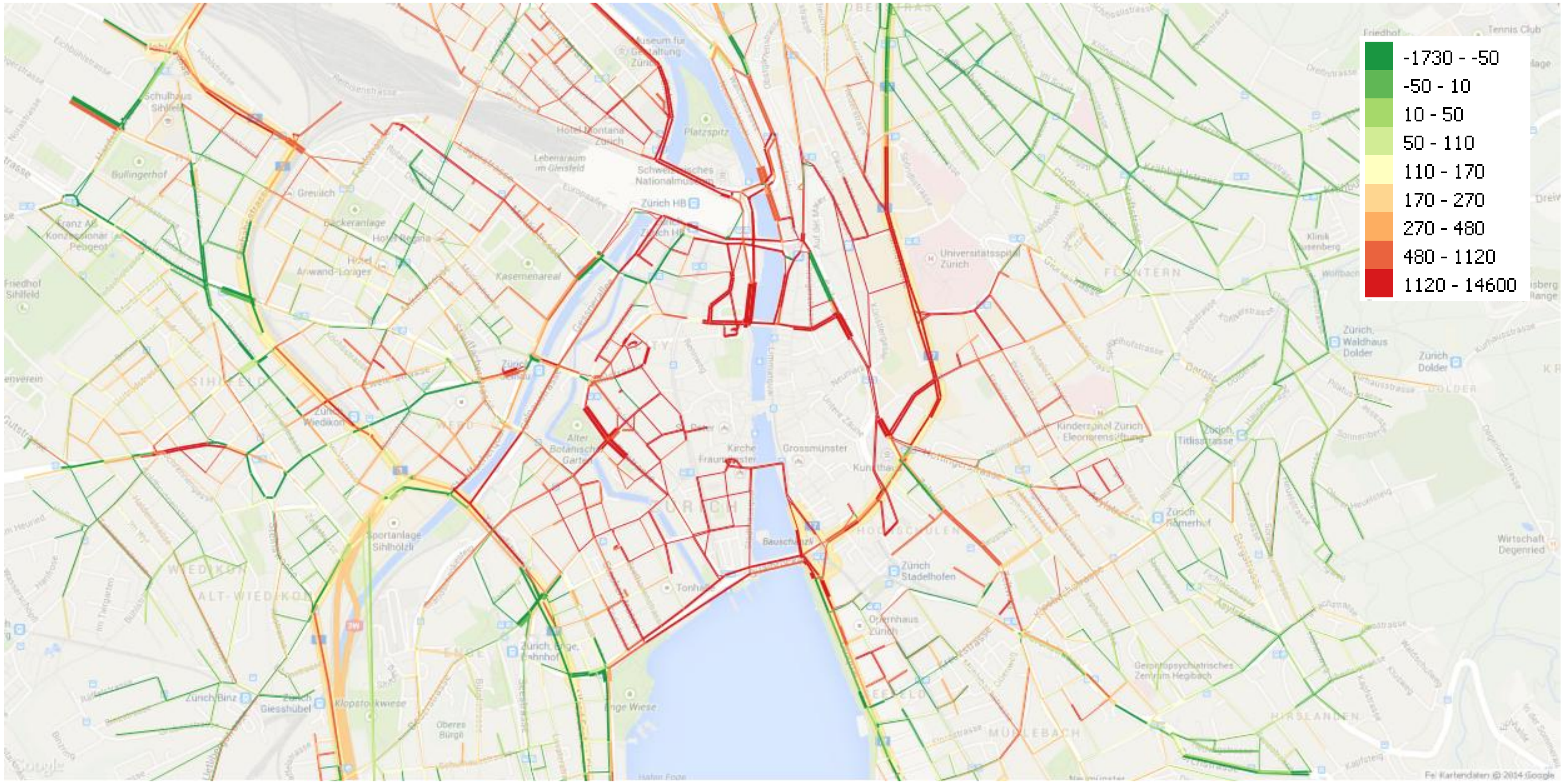
Score Graph


Parking Strategy Score
score
0
-250
-500
-750
-1,000
-1,250
-1,500
-1,750
-2,000
-2,250
-2,500
-2,750
-3,000
-3,250
-3,500
-3,750
-4,000
-4,250
-4,500
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500
Iteration
average best
average executed
average worst
average average

Usage of Garage Parking Strategies



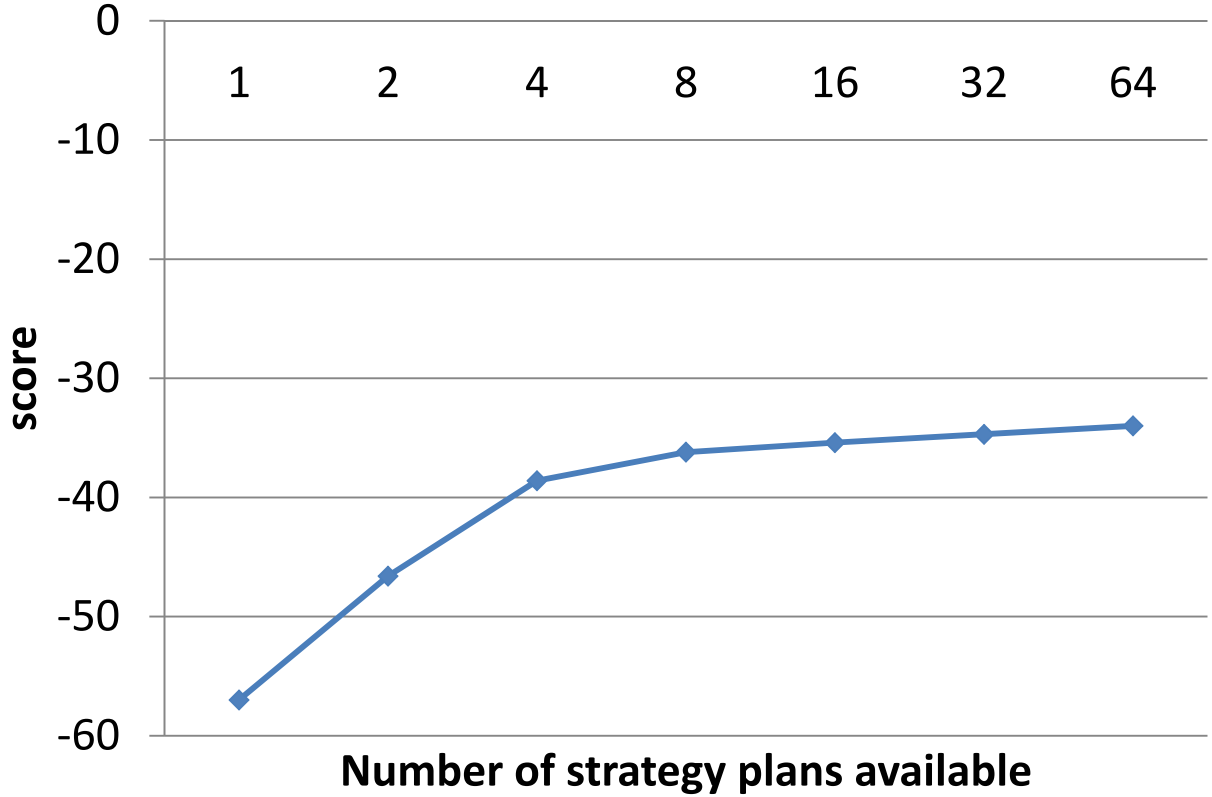
Traffic counts difference due to neglecting Parking Search traffic



Parking Activity Properties

Parking Type	Walk Distance [m]		Search Time [s]		Cost [CHF]		Activity Duration [s]	
	mean	sd	mean	sd	mean	sd	mean	sd
Illegal	87.4	83.22	22.39	44.14	44.8	50.37	467.1	521.76
Street	162.77	182.40	120	1209.5	3.05	8.28	26418	20930
Private	87.6	69.54	0	0	0	0	20865	20415
Garage	330.1	1087.2	80.97	161.52	10.85	7.52	10395	9246.1
Public Outside Zurich	115.2	116.21	24.7	44.48	0	0	24568	20042

Role of Multiple Strategy Plans



Sensitivity Analysis - Strategies

- Reduction of street parking by 33%

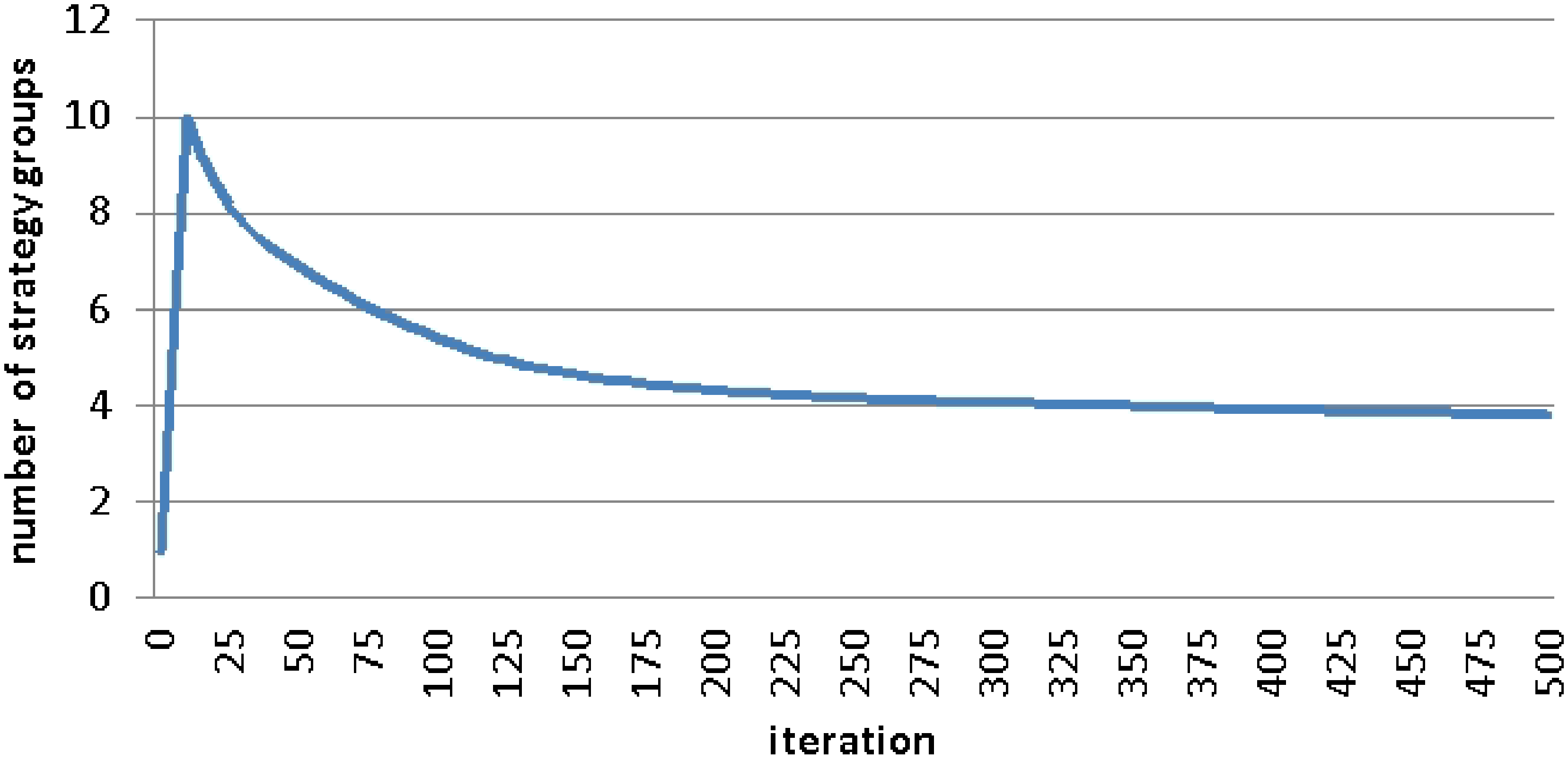
Strategy	access	Change (%)
ARD-G	garage	-0.1
BRD(300m)-G	garage	+0.1
ARD-TakeClosestGarageParking	garage	**+2.4**
BRD-TakeClosestGarageParking	garage	**+3.2**
BRD(300m)-S-G	street -> garage	**-1.2**
Parkagent	street -> garage	-0.4
ARD-S	street	**-2.6**
BRD(300m)-S	street	**-0.7**
ARD-waiting-S	street	+0.3
ARD-illegal-S	street -> illegal	**-1.1**

Stability and Uniqueness of Solution

At relaxed state comparison between iteration i and i + 1 yields:

- ca. 5.5% of the parking locations are switched
- ca. 53 % of strategy plans changed
- ca. 33% percent of strategy groups changed

Keep all Strategy Groups vs. Unconstrained Evolution



Future Work

- Keep all strategy groups vs. unconstraint evolution
  - Stability of solution, if changes happen
- Toll Pricing & Parking Search
  - Toll aware parking strategies => try to park vehicle outside toll area walk from there
  - => see, how this strategy competes with other strategies
- Integration in MATSim
  - replanning modules
  - physical simulation

Conclusions

- Show, how parking search could be modelled as part of a user equilibrium model (as a sub-game)
- First analysis of the various properties of such a model

Questions?