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Can Pseudo-Simulation be used for Modelling Parking Search?

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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 model should be able to help design parking policies

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?

- Treating off-street parking ALWAYS as a last option
  - over-estimation of parking search time
- Only look at residential parking search
- Just one single strategy for all people
- 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

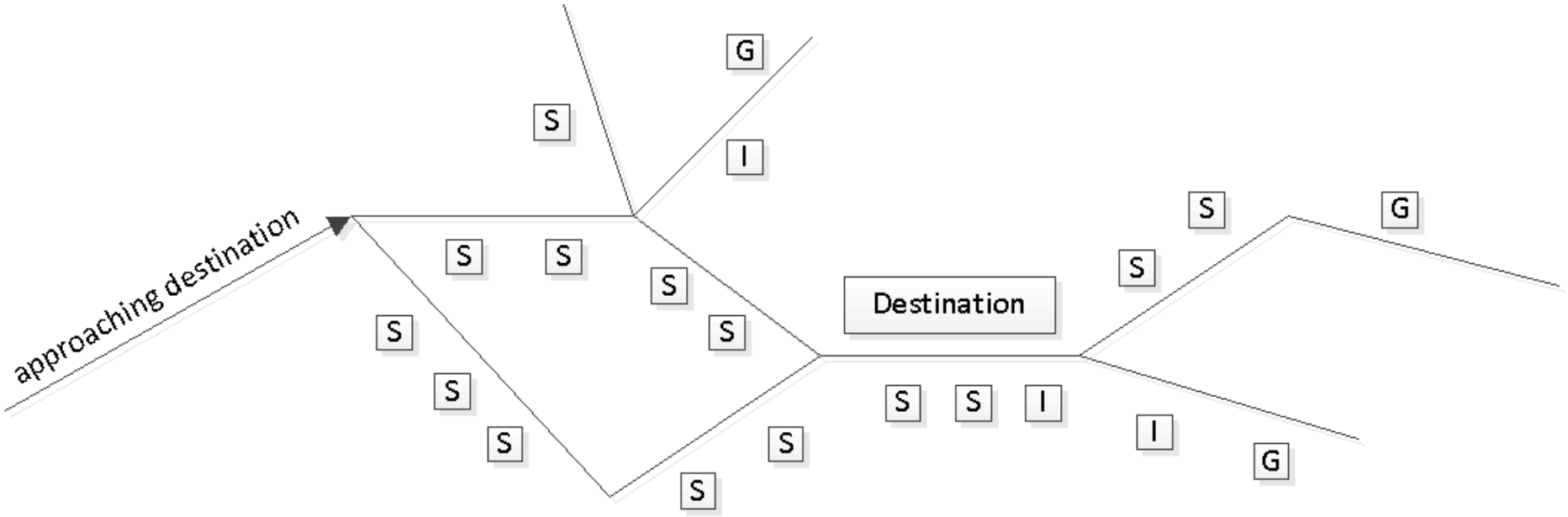
-> circle around destination

-> illegal parking

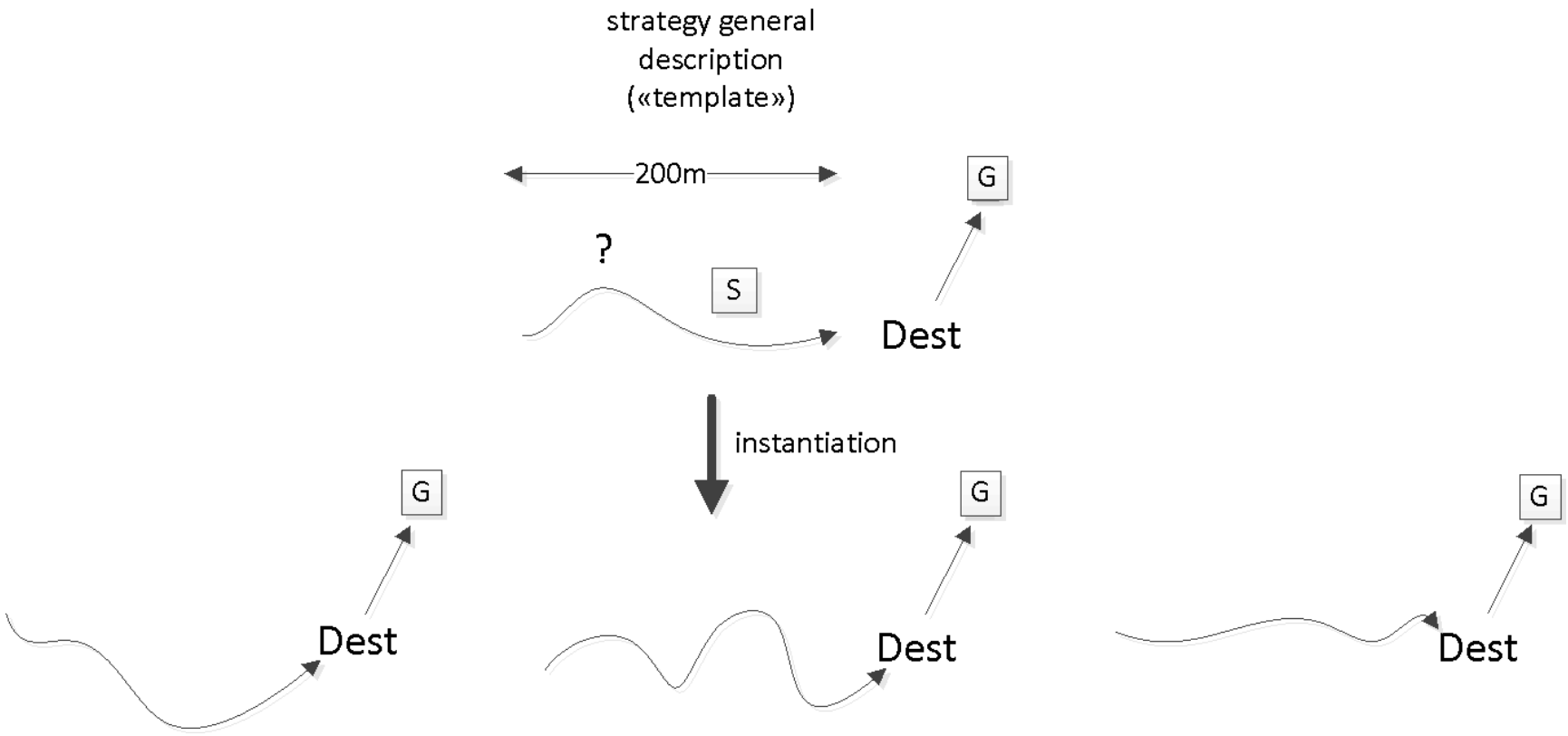
-> combinations

-> Survey to find out which strategies used in Karlsruhe/Birmingham?

General Structure of Parking Search Strategies



Instantiation of Parking Strategy



Utility Function

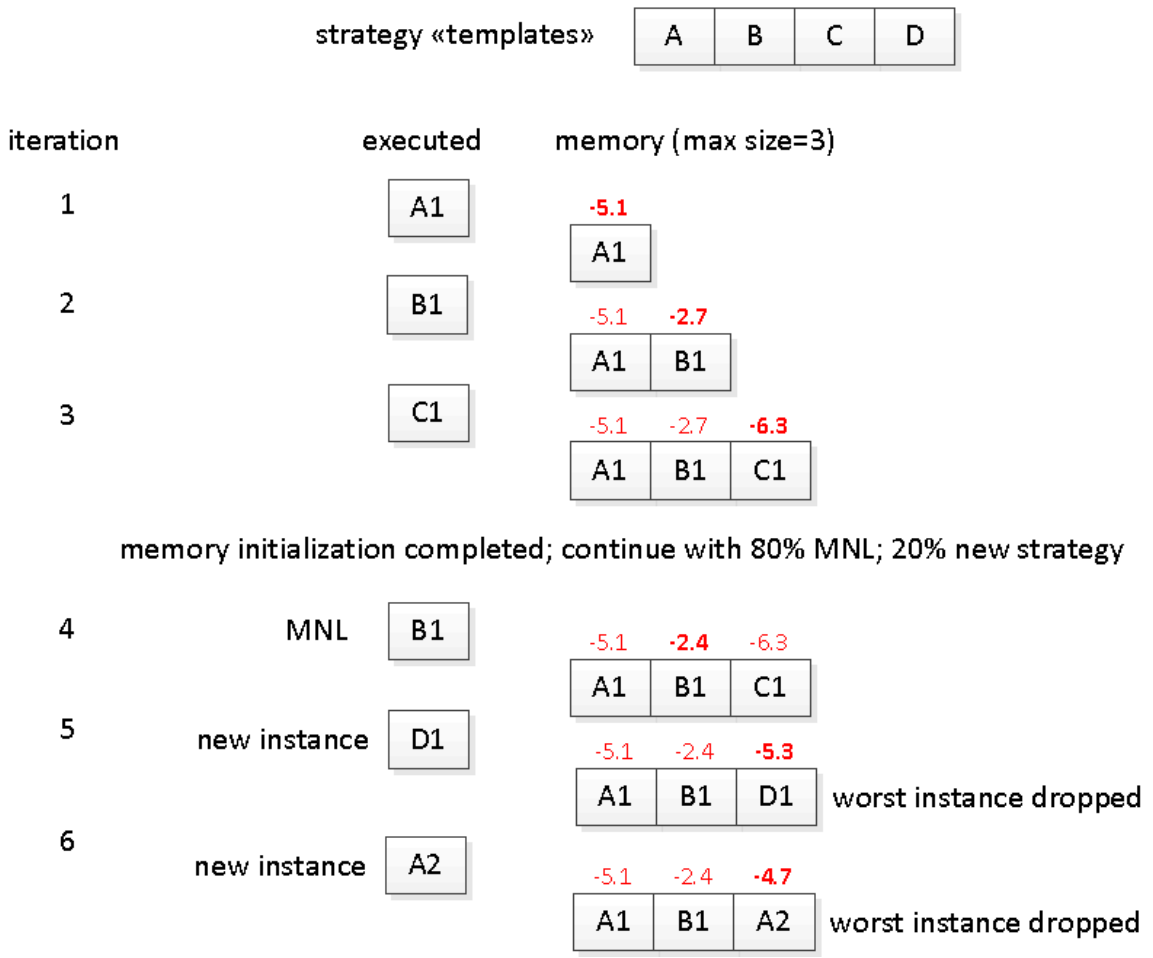
$$U_{parking,i} = U_{P_{cost},i} + U_{P_{searchTime},i} + U_{P_{walk},i} + \epsilon_i \quad (1)$$

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

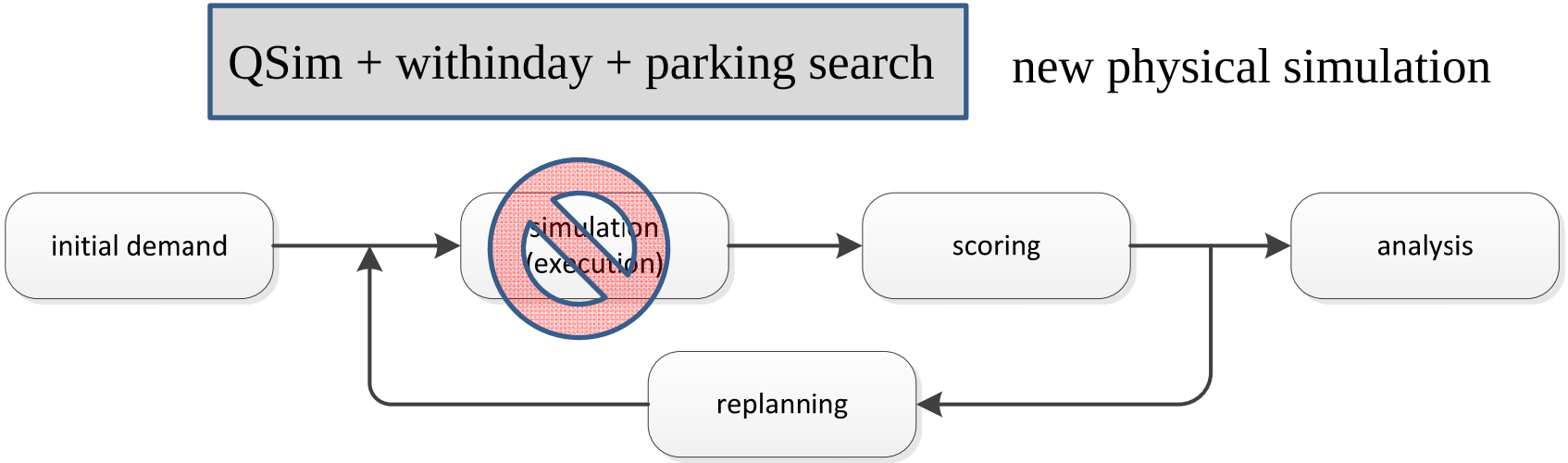
Utility function used: Weis et al. (2013)

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

Optimization (similar to MATSim)



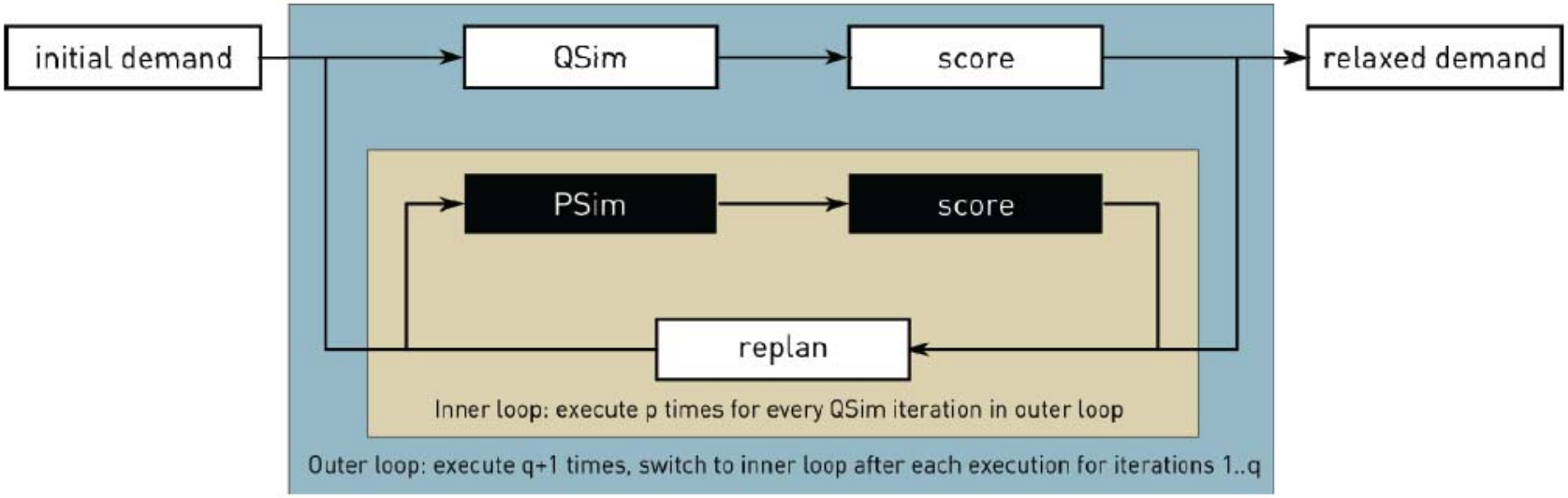
First attempt



Issues:

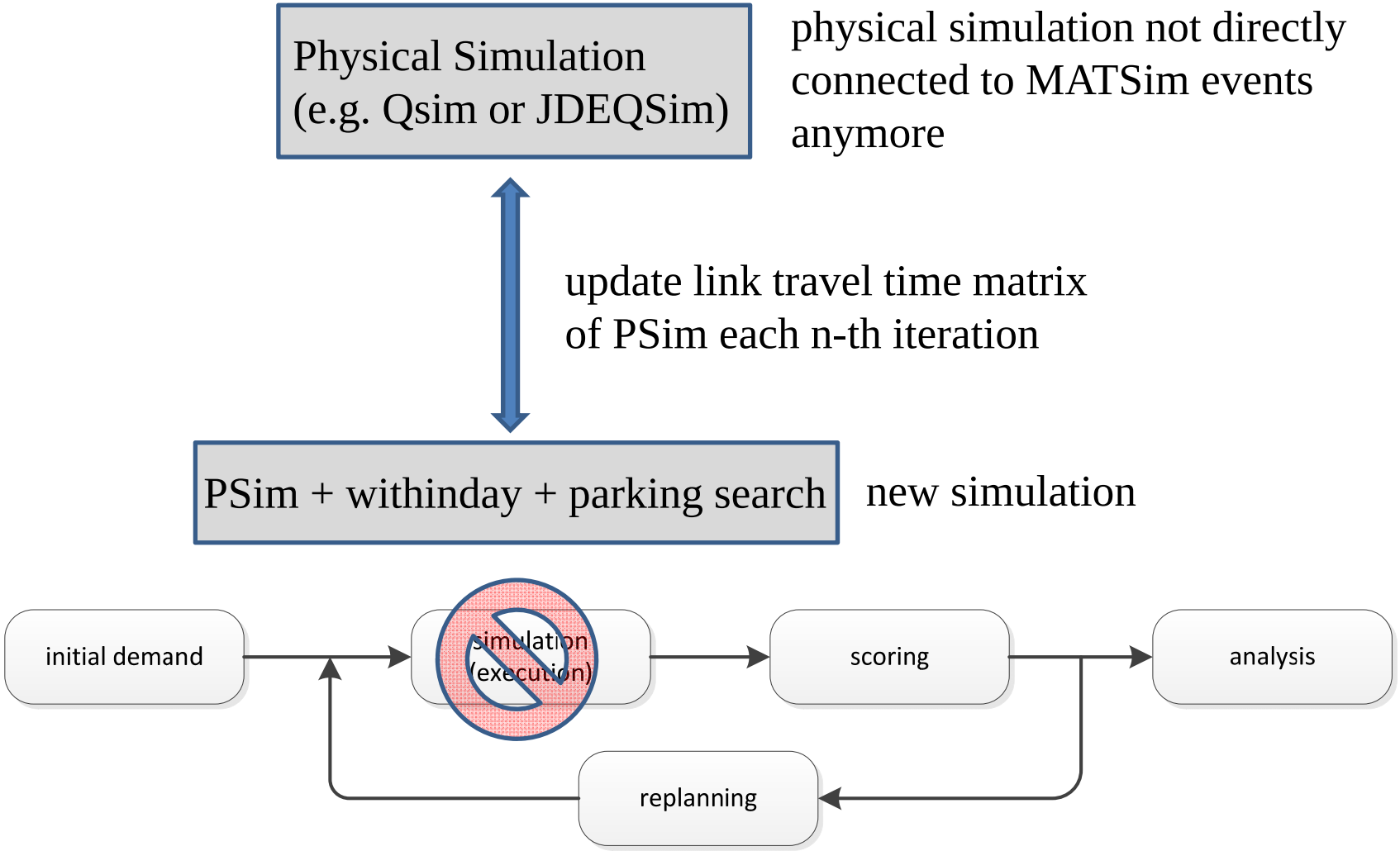
- Performance
- Parallelization/low resolution network/sampling not an option

Pseudosimulation (Psim)



(Fourie et al., 2013)

MATSim Simulation with Parking Search



Performance Gains

- Scenario: ca. 10% scenario of area of interest around ZH city center; ca. 40’000 agents, high resolution network

- With Qsim + Withinday + parking search:
  $\Rightarrow$ 33 min per iteration only simulation (mid. 2012)
  $\Rightarrow$ estimated run-time for 100% run with 100 iterations: **3 weeks**

- New Implementation (PSim + within day + JDEQSim):
  $\Rightarrow$ ca. 80s per Iteration (only simulation)
  $\Rightarrow$ estimated run-time for 100% run with 100 iterations: **1 day**

$\Rightarrow$ 100% scenario possible

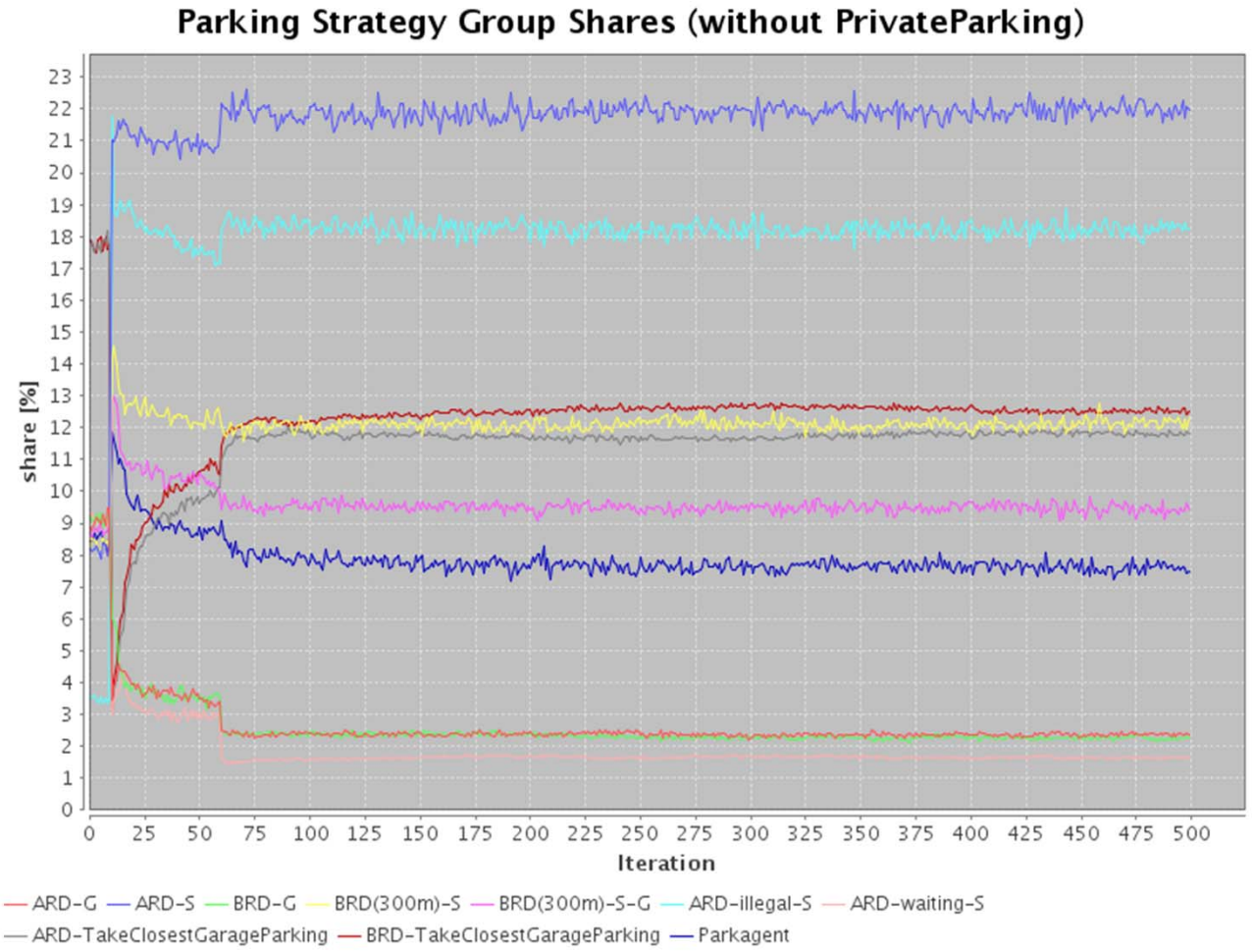
$\Rightarrow$ Qsim run, which is needed from time, to time not considered yet

$\Rightarrow$ There is potential left: Only those parts parallelized, which are easy to implement (E.g. re-routing) – simulation itself is not parallelized yet

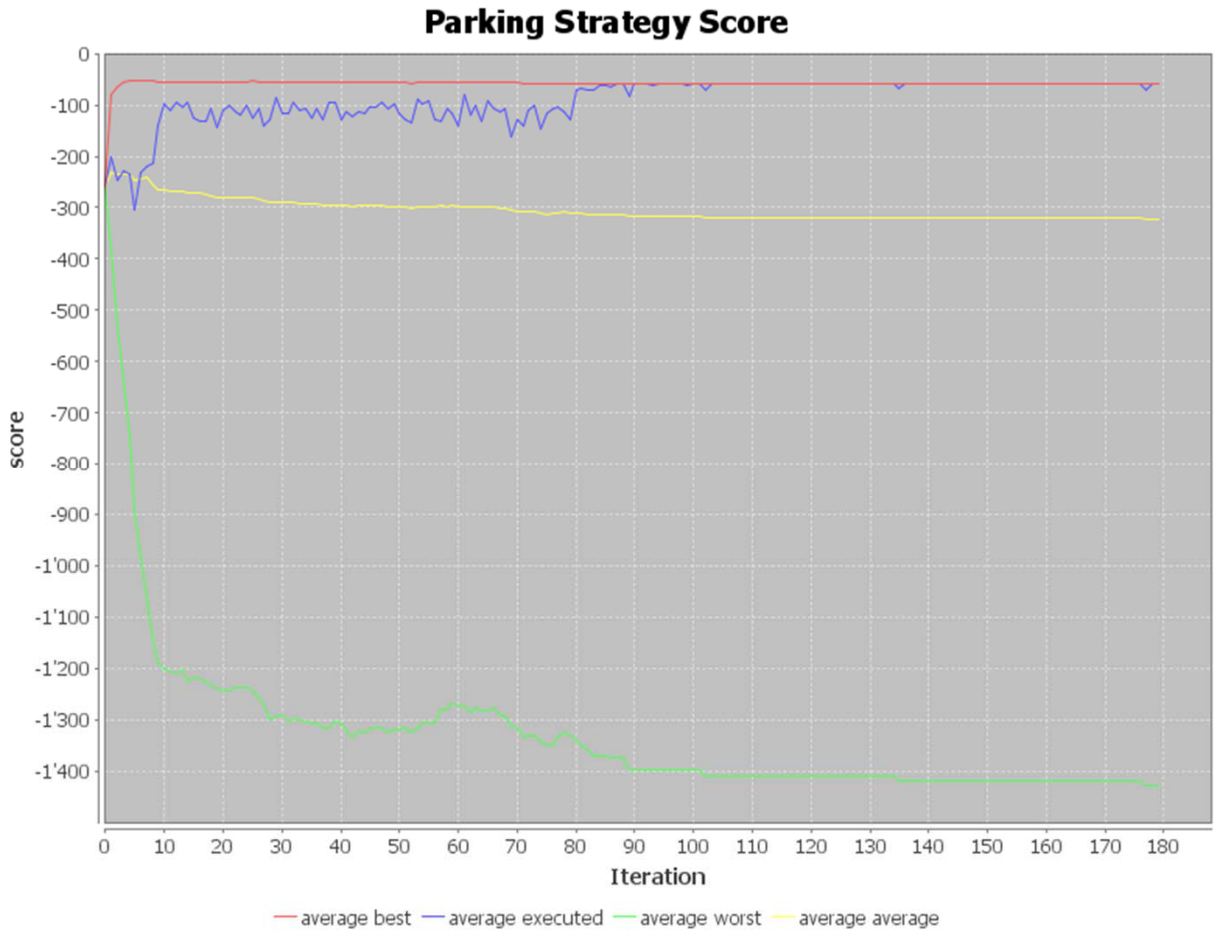
Experiments

- We have implemented around 15 strategies – mostly based on ideas from Axhausen and Polak (1989) + Park Agent + other Heuristics
- Acknowledgment: Shyam Ranganathan (Uppsala, Sweden)
- Preliminary results: Not calibrated yet (especially private parking)
- Scenario: Zürich – replanning only for parking search strategies – other replanning fixed

Parking Strategy Shares



Typical Score Graph

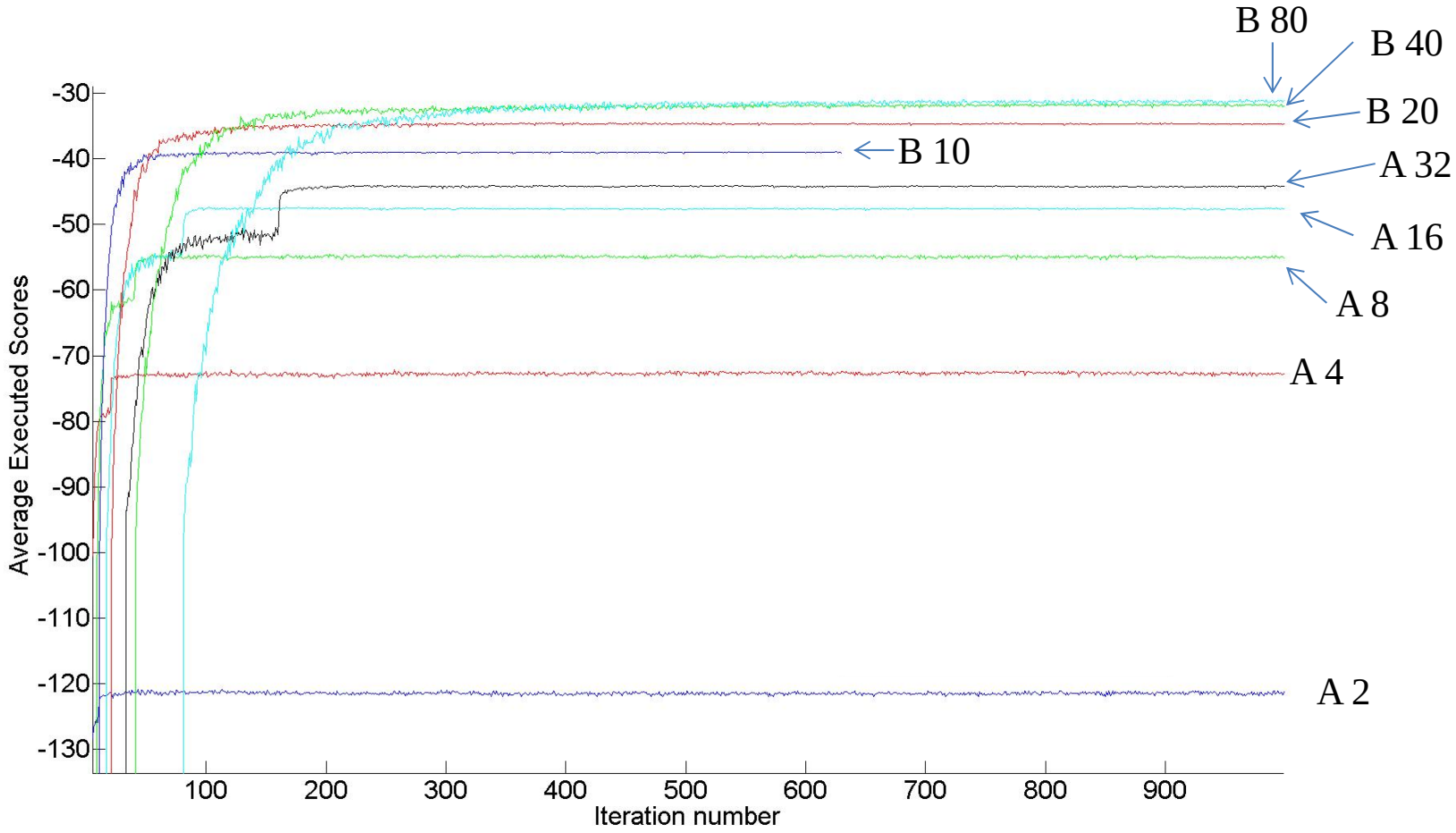


Strategy Quantity vs. Quality

- Only two strategies (scenario A):
  - Take closest garage parking at destination
  - Random parking search after reaching destination

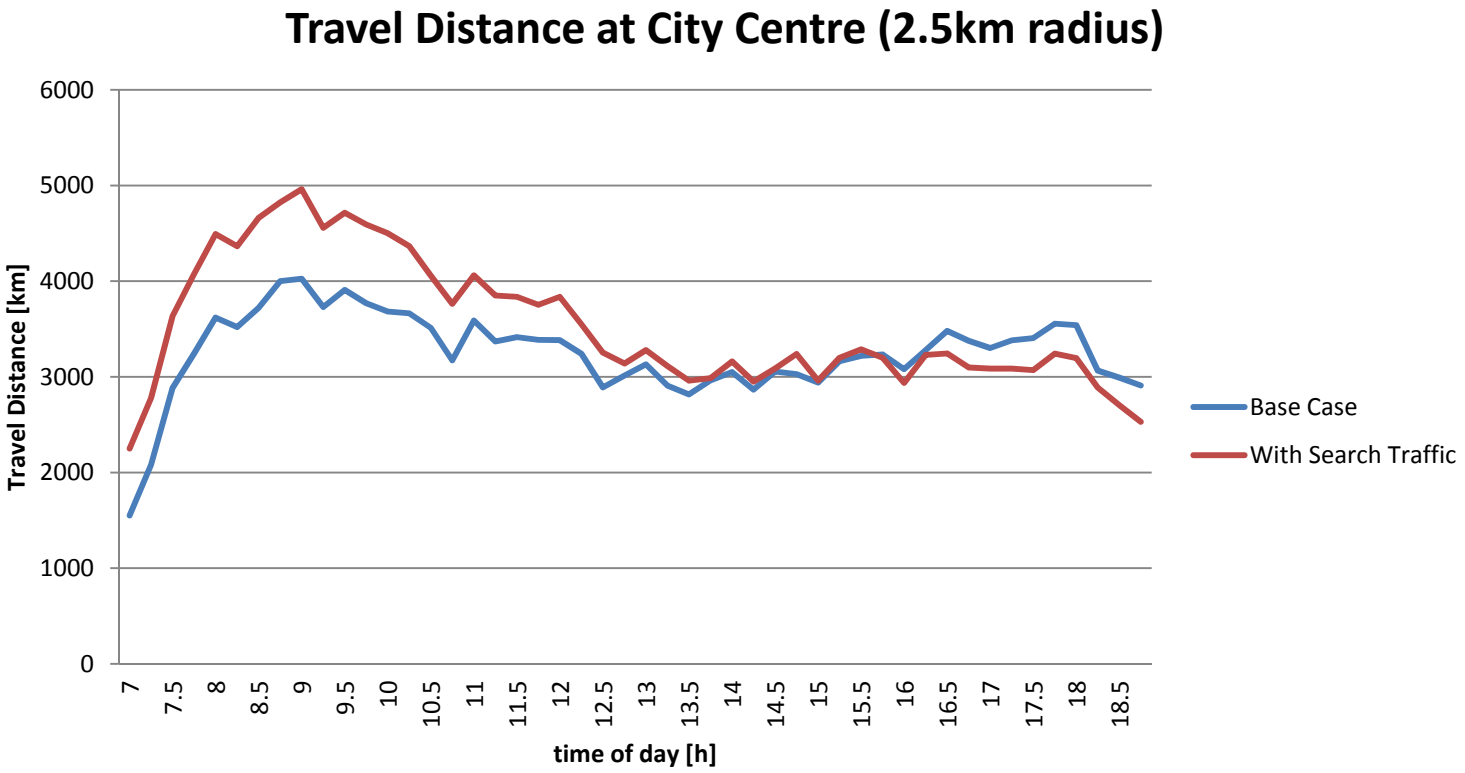
- 10 strategies (scenario B):
  - All strategies represented from Axhausen and Polak (1989) + Park Agent + 2 others

Strategy Quantity vs. Quality (con't)



Parking Search Traffic

(<u>preliminary</u> results: **10%** scenario; **not calibrated**)



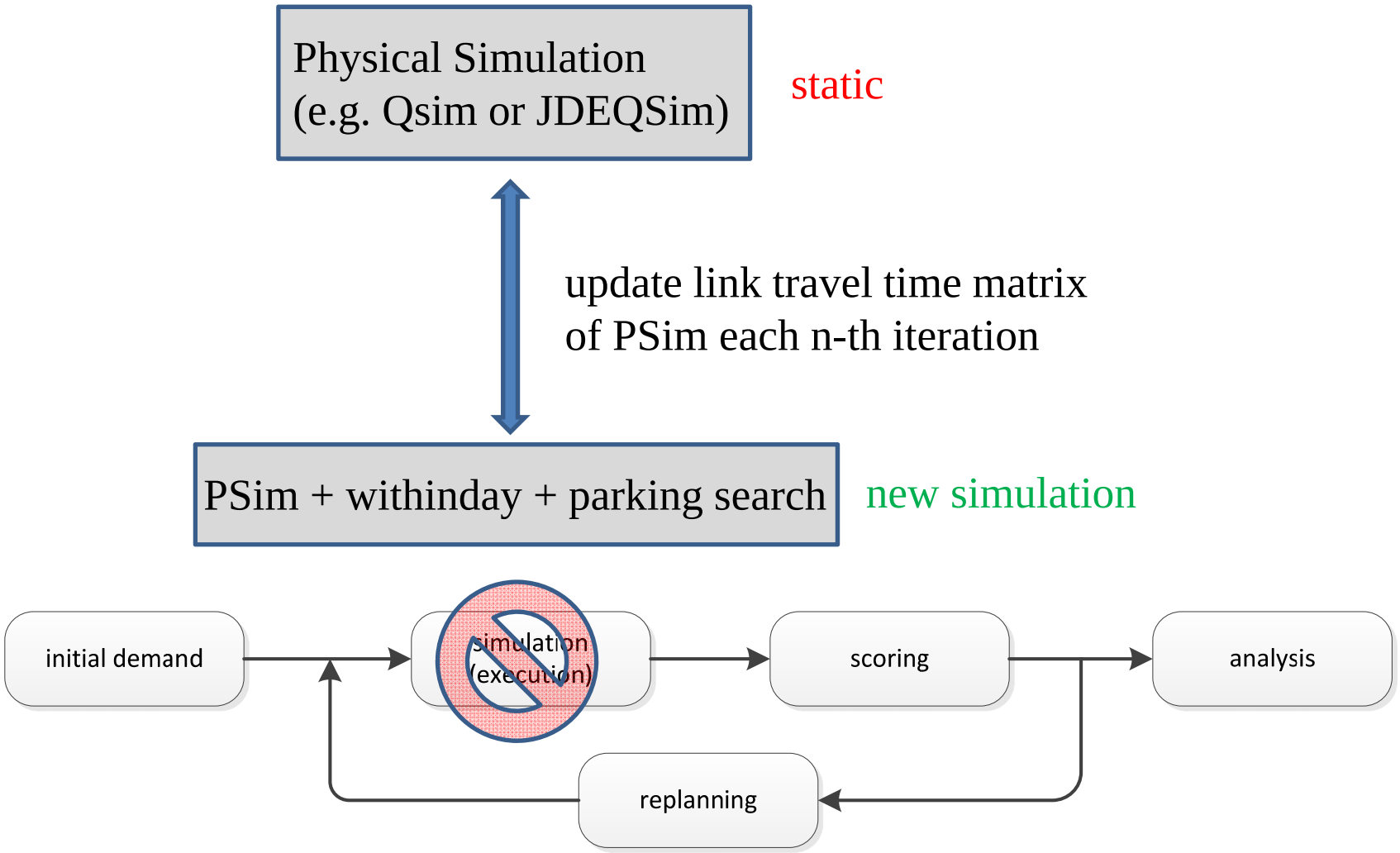
Parking Activity Properties

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

Future Work: 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

Future Work: Integration



only parking search strategy change

Conclusions / Future Work

- After long detour – some hope and progress
- Calibration – do experiments again
- Stepwise Integration in MATSim
  - replanning modules
  - calling physical simulation
  - integrate in existing contrib «parking»

Questions?

References

Axhausen, K.W. and J.W. Polak (1989) The role of parking search strategies in understanding parking behaviour, Transport Studies Unit, University of Oxford, Oxford.

Benenson, I., Martens, K., & Birfir, S. (2008). PARKAGENT: An agent-based model of parking in the city. *Computers, Environment and Urban Systems*, *32*(6), 431-

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