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Modeling Location Decisions of Retailers with an Agent-Based Approach

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MATSim
Multi-Agent Transport Simulation

Motivation & Goals

Motivation

- Enhance an existing **transport simulation,** where individuals (demand side) are represented as agents, extending the **agent paradigm** to the **supply** side

Goals

- Introduce **retail agents** having the ability to (re)locate their stores
- Show that stores performance can be **improved** with this methodology

MATSim at a glance

- MATSim: Agent and activity based simulation of transportation demand (Scheduling) and transportation supply (Network).
  - Java-Implemented
  - Open source
  - Jointly developed at ETH Zurich and TU Berlin

www.matsim.org

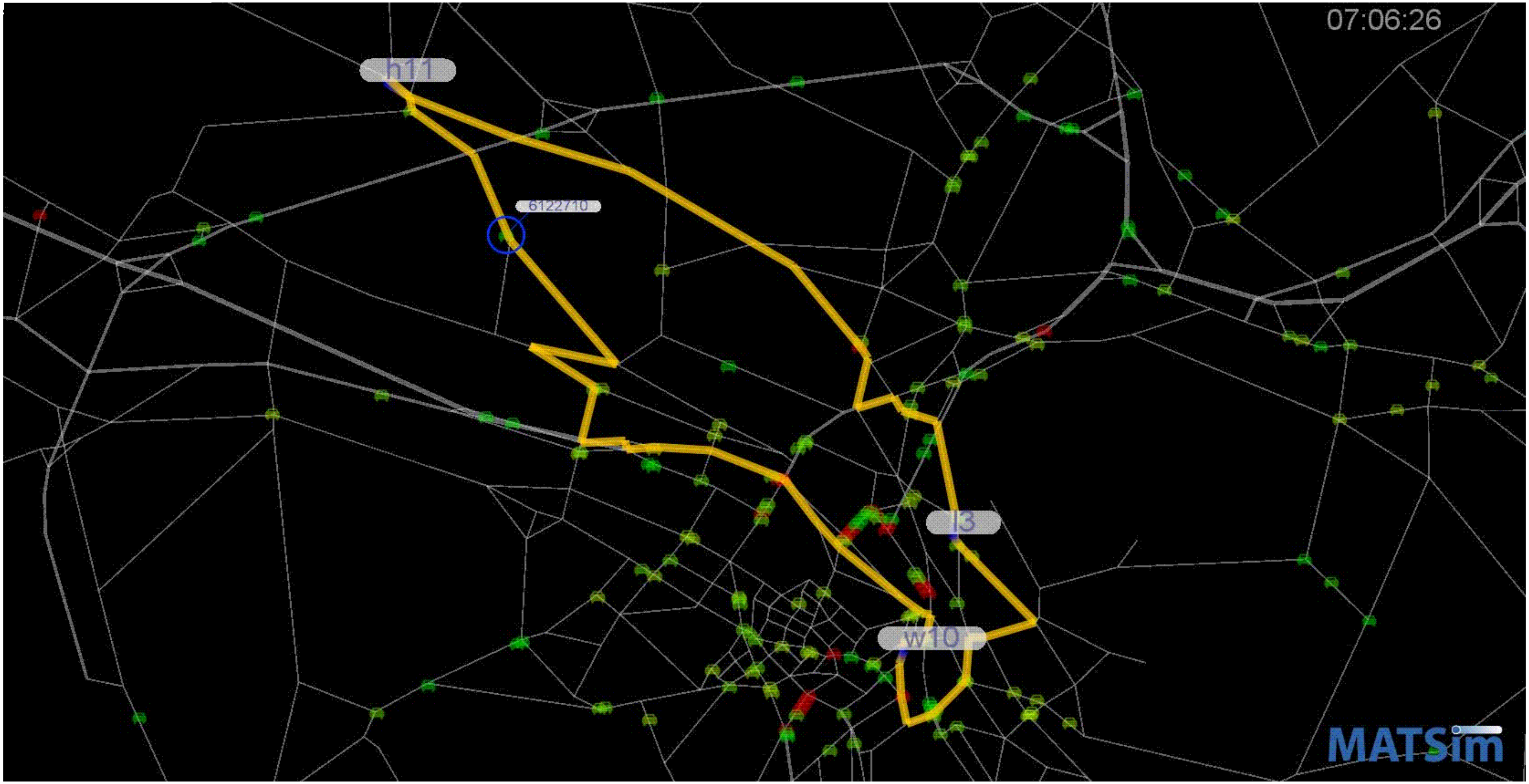
MATSim main features

- Agents are **software abstractions** representing persons **acting in an artificial world**
  - Personal attributes/behavioural rules
  - Goal-oriented
  - Learning ability (experience)
- They are traveling as a consequence of **individual needs** (shopping, work, leisure, etc.)
- Agents are **competing** for the infrastructure
- Iteratively (one day is iteratively simulated) until a steady state is reached.

Advantages:

- Heterogeneity of agents
- Macroscopic behavior emerges from microscopic one
- The model is modular and flexible

Simulation



Why retailers location choice?

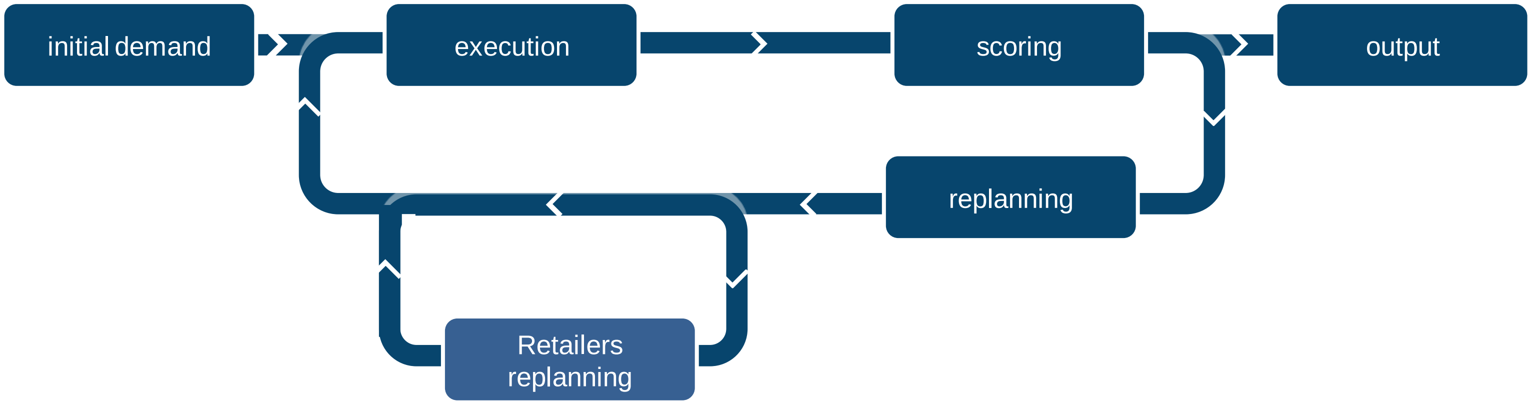
- Retailers have a **clear goal**, profit maximization, and location is acknowledged as the most important single factor of success

Retail agents

Retailer: "Person or entity having the control on one or more shopping facilities (retail stores)"

Goal: Maximize the number of customers

Choice dimension: Location of retail stores



Relocation

Each retailer uses a **genetic algorithm** with the following objective function:

$$\min \sum_{i}^{n} \left(\frac{\sum_{j}^{m} c_{ij}}{m} \right)$$

n = number of stores of the considered retailer
m = the number of potential customers for the store i at the given location
c_{ij} = generalized cost of travel for the individual agent *j* to travel to location *i*

Simulation Scenario

- Area around Zurich

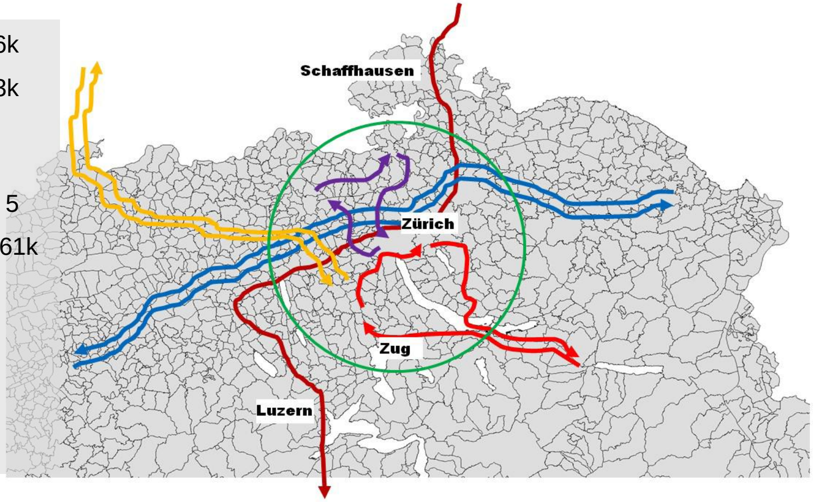
Links: 236k

Nodes: 73k

Facilities: 373k

Activities: 5

Agents: 161k (10%)

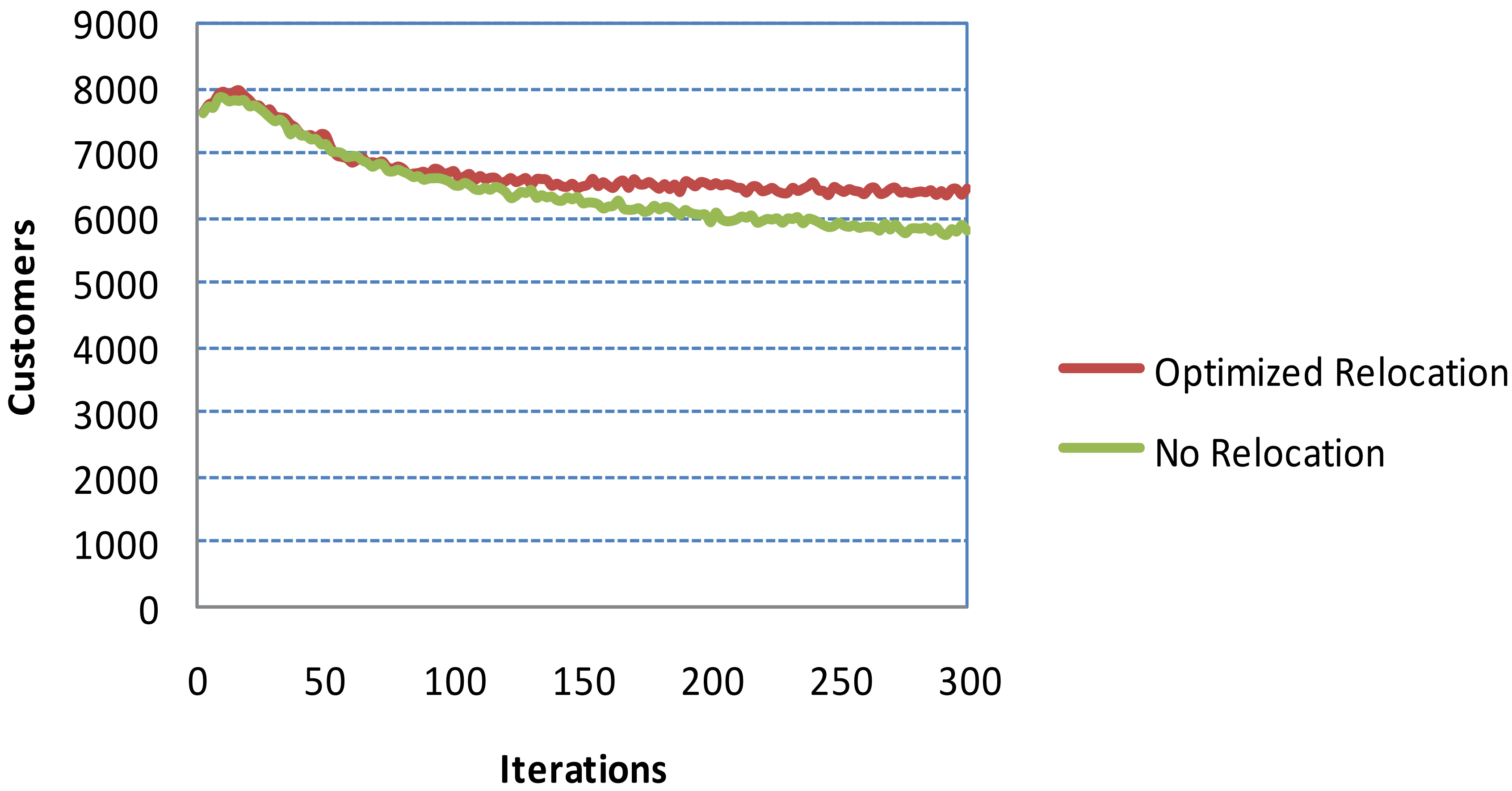


- Two retailers, with respectively 29 and 17 stores
- Initial locations of **two real Swiss retailers**, leaders in the grocery market.
- Locations available have been selected randomly, but accepted under some specific requirements. For each candidate location, an hypothetical caption area around it has been considered and the following has been tested:
  - Potential customers above a given threshold in the area
  - Ratio potential customers/ stores capacity above a given threshold

Main Simulation Parameters

- Frequency of retailers relocation
- Caption area dimension
- Caption area thresholds
- Number of generations (GA)
- Population dimension (GA)

Results (1)



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Results (2)

	Retailer 1	Retailer 2
Number of Shops	29	17
Stores Moved	12	6
Stores Moved %	41%	35%
Customers (Move)	3541	2902
Customers (No move)	3199	2603
Increase %	10.6%	11.4%

Summary

- Creation of specific retailer agents. They can:
  - Collect information on the behavior of individual agents
  - Implement a strategy in order to maximize the number of customers by relocating their shops
- The results for a test scenario, the metro area of the Swiss city of Zurich, show that retail agents in the simulation are able to increase the number of their customers by relocating their shops
- This technique has the potential to become a powerful instrument in the hands of both location planners and policy makers

Future work

- Location optimization
  - Validation regarding the number of customers shopping in specific stores
  - Better calibration for the parameters of the genetic algorithm lying behind the optimization process, which can significantly enhance the results (in terms of gain in customers number).
  - Making the model further realistic (expenditure, prices, differentiation)
- Prediction of Policies' Global outcome
  - Competitive bid process among the different retailers for the available locations.
  - Modeling of the legislative context

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- Questions?

- MATSim project page: www.matsim.org

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