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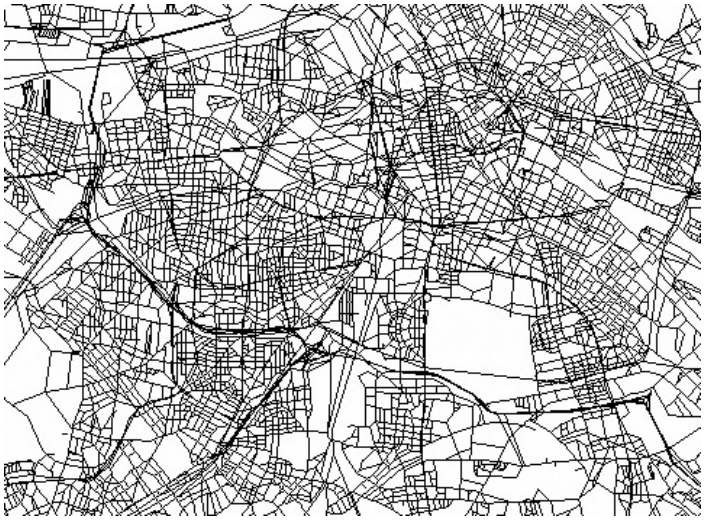
Efficient methods to synthetically create and calibrate MATSim scenarios

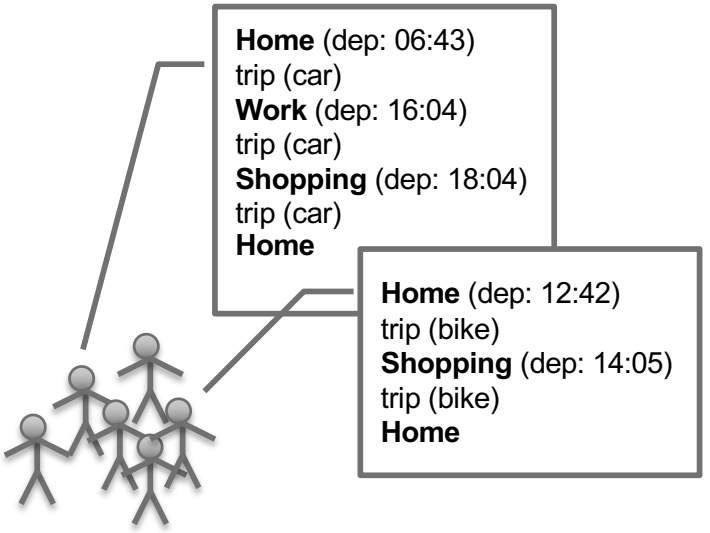
Dominik Ziemke

Workshop Modéliser les transports d'aujourd'hui et de demain
Paris, 26 September 2019

MATSim scenarios

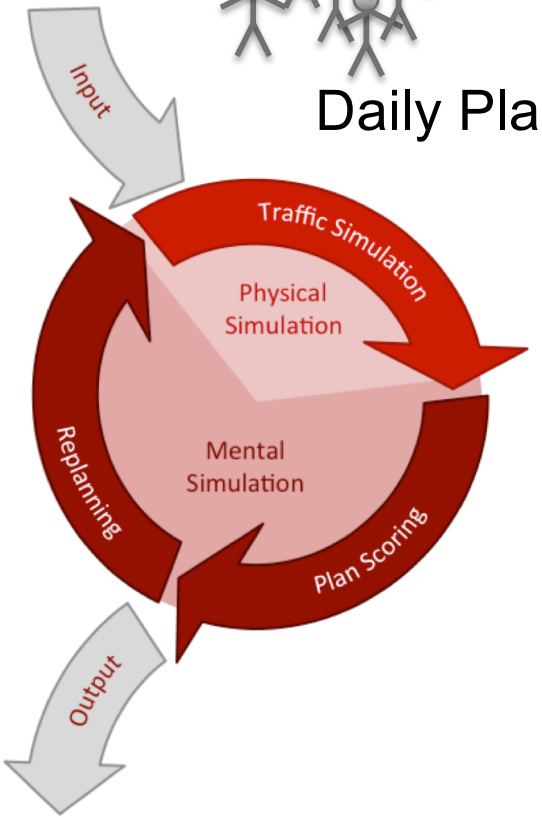


Network



Daily Plans

Transport Supply



Transport Demand

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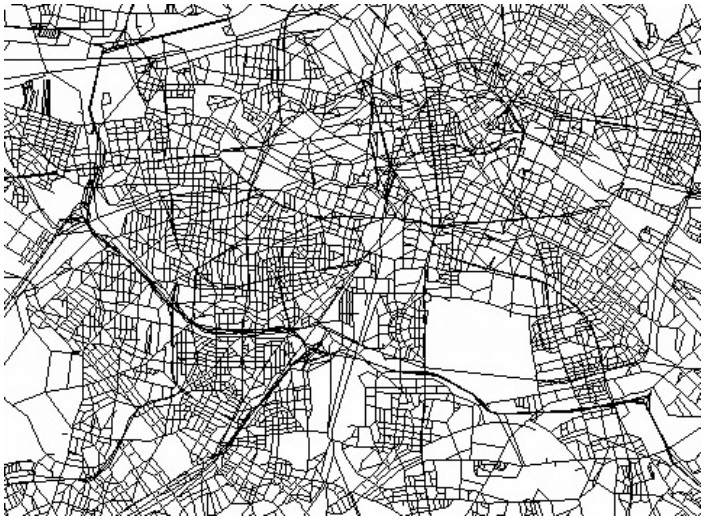
MATSim scenarios



Network

Home (dep: 06:43)
trip (car)
Work (dep: 16:04)
trip (car)
Shopping (dep: 18:04)
trip (car)
Home

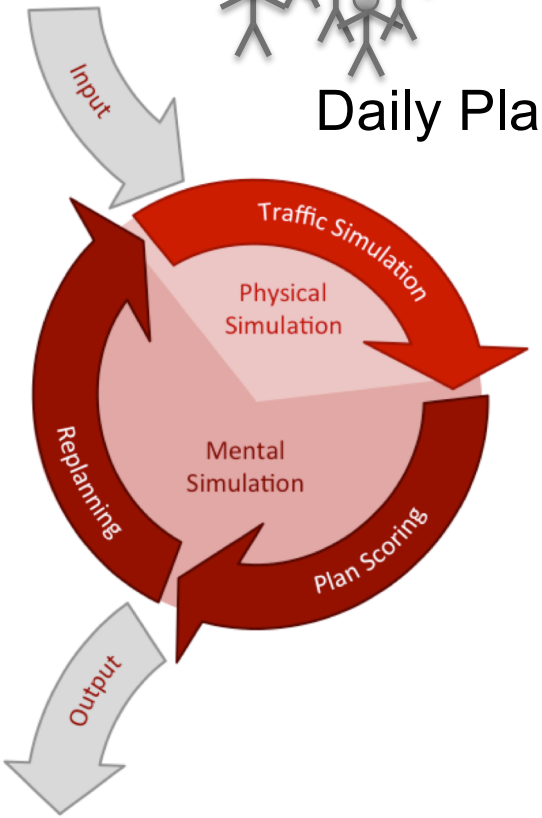
Home (dep: 12:42)
trip (bike)
Shopping (dep: 14:05)
trip (bike)
Home

Daily Plans

Transport Supply

GTFS

...



Transport Demand

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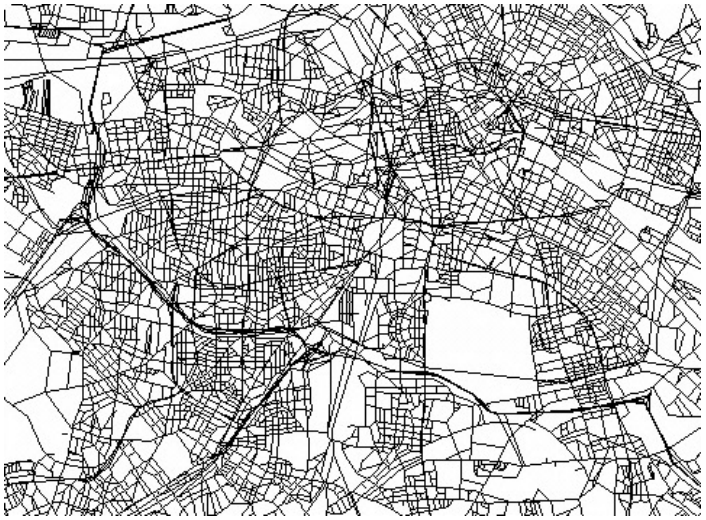
MATSim scenarios



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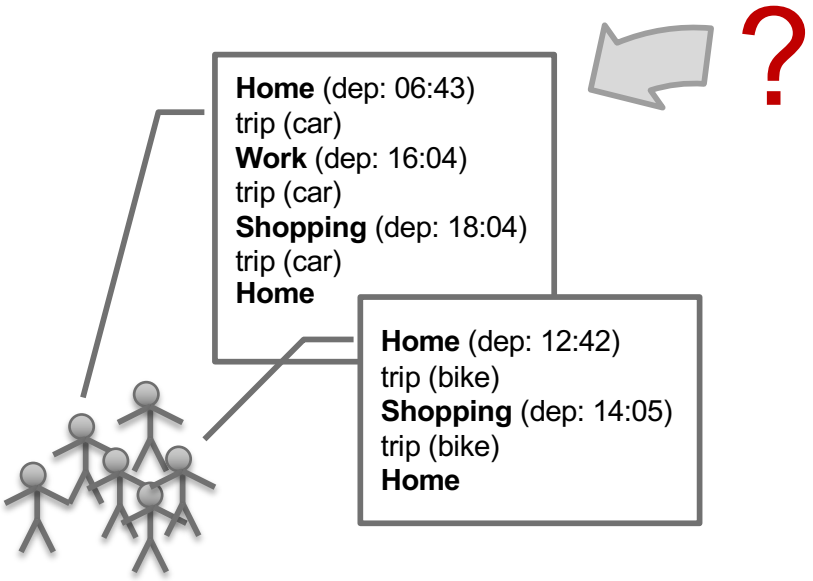
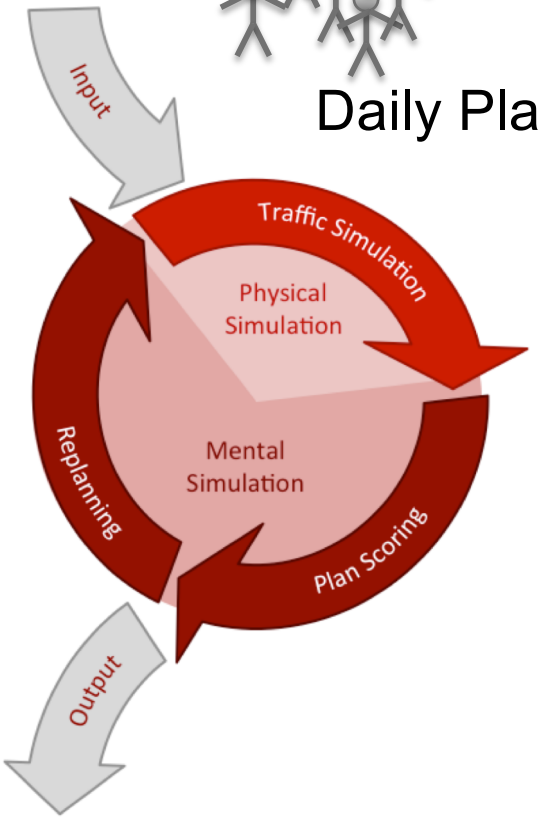


Daily Plans

Transport Supply

GTFS

...



Transport Demand

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Generation of daily plans

- Trip diaries
  - often not openly available
- Big data
  - cell-phone data
  - Twitter
- Transport demand models (activity scheduling models)
  - Some model activity sequences of individuals

MATSim: The beginning or the end of a transport model?

- “Typical” approach to microscopic transport modeling
  - Activity-based demand generation (ABDG)
    - Model demand for transport
  - Dynamic Traffic Assignment (DTA)
    - Assign traffic to network

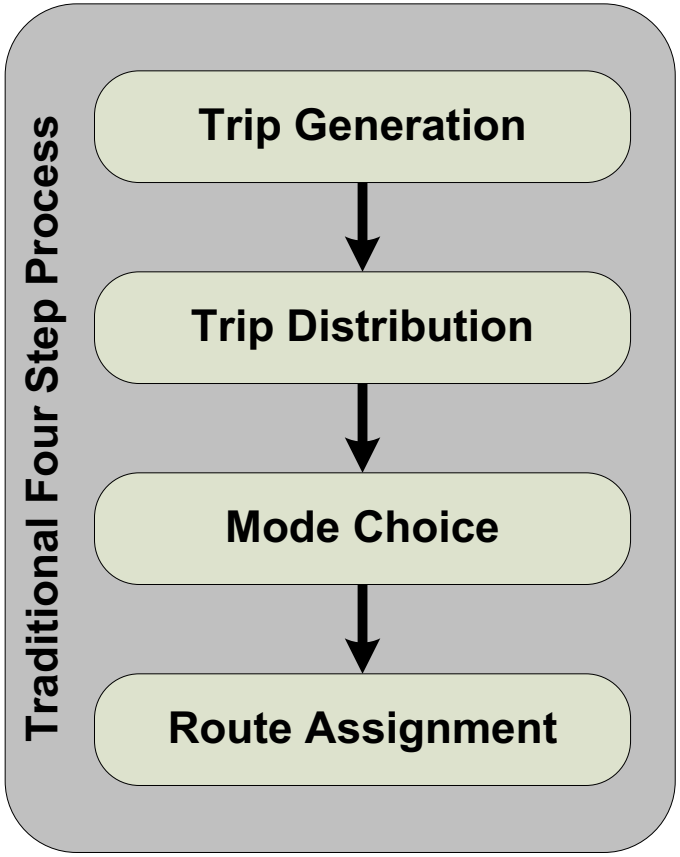
MATSim: The beginning or the end of a transport model?

- "Typical" approach to microscopic transport modeling
  - Activity-based demand generation (ABDG)
    - Model demand for transport
  - Dynamic Traffic Assignment (DTA)
    - Assign traffic to network

- MATSim contains
  - Activity-based demand adaptation
  - Dynamic Traffic Assignment
  - …

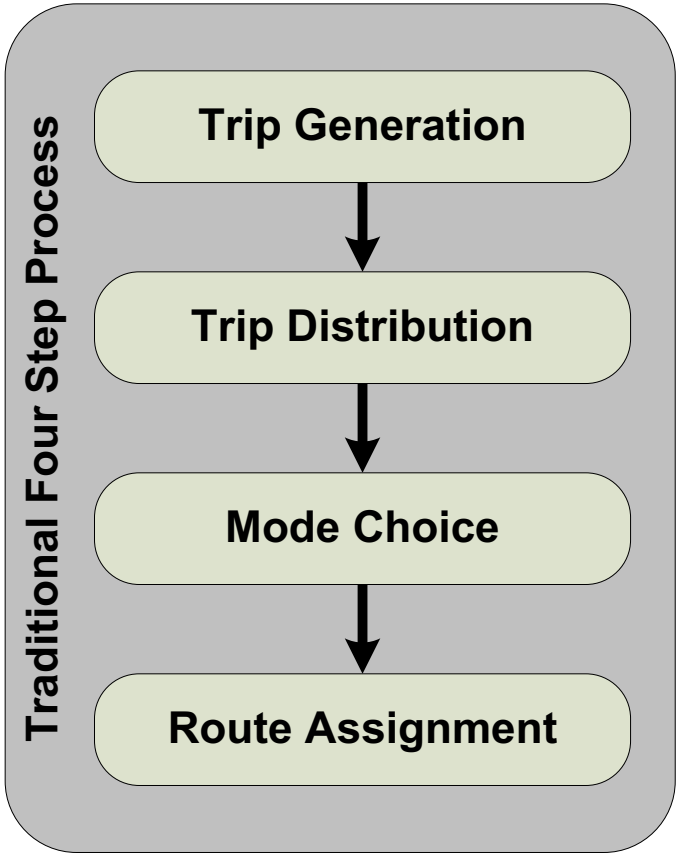
Demand adaptation

Recall/Compare: Macroscopic case



Demand adaptation

Recall/Compare:
Macroscopic case

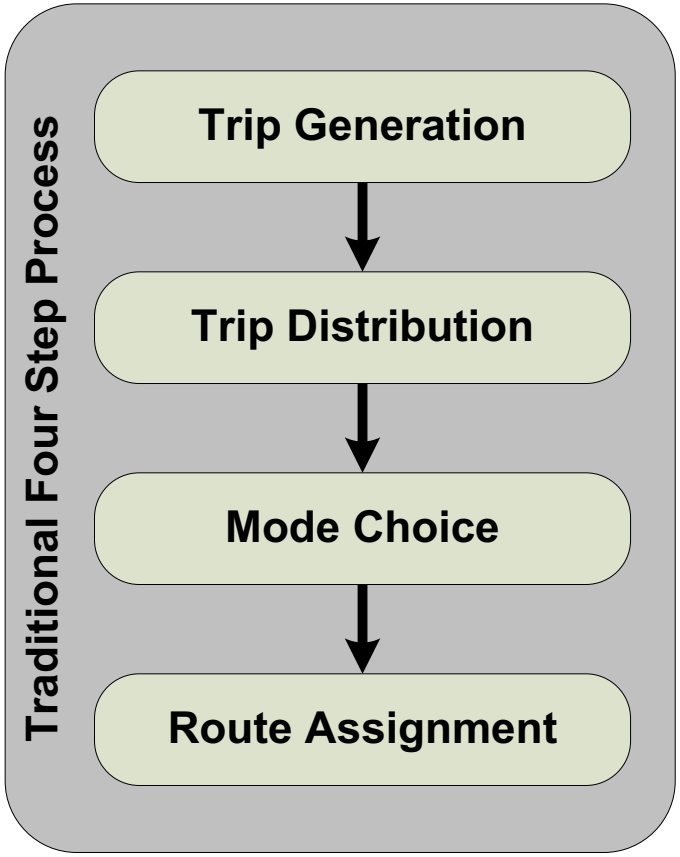


Behaviorally:
"Choice dimensions"

- Who? / How many?
- Where to?
- By what mode?
- When?
- Which route?

Demand adaptation

Recall/Compare:
Macroscopic case



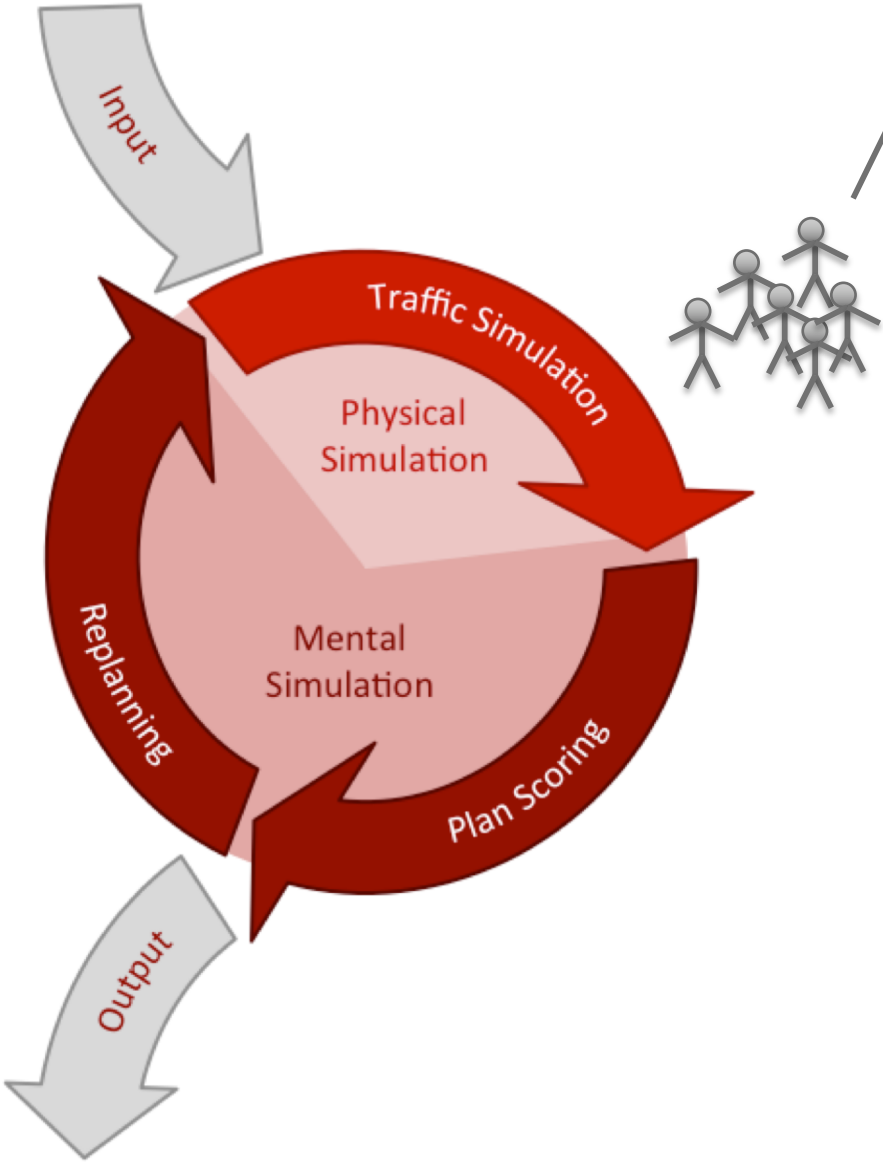
Behaviorally:
"Choice dimensions"

- Who? / How many?
  - Agents
- Where to?
  - Activities + locations
- By what mode?
  - Mode choice
- When?
  - Departure time choice
- Which route?
  - Routing

Demand adaptation

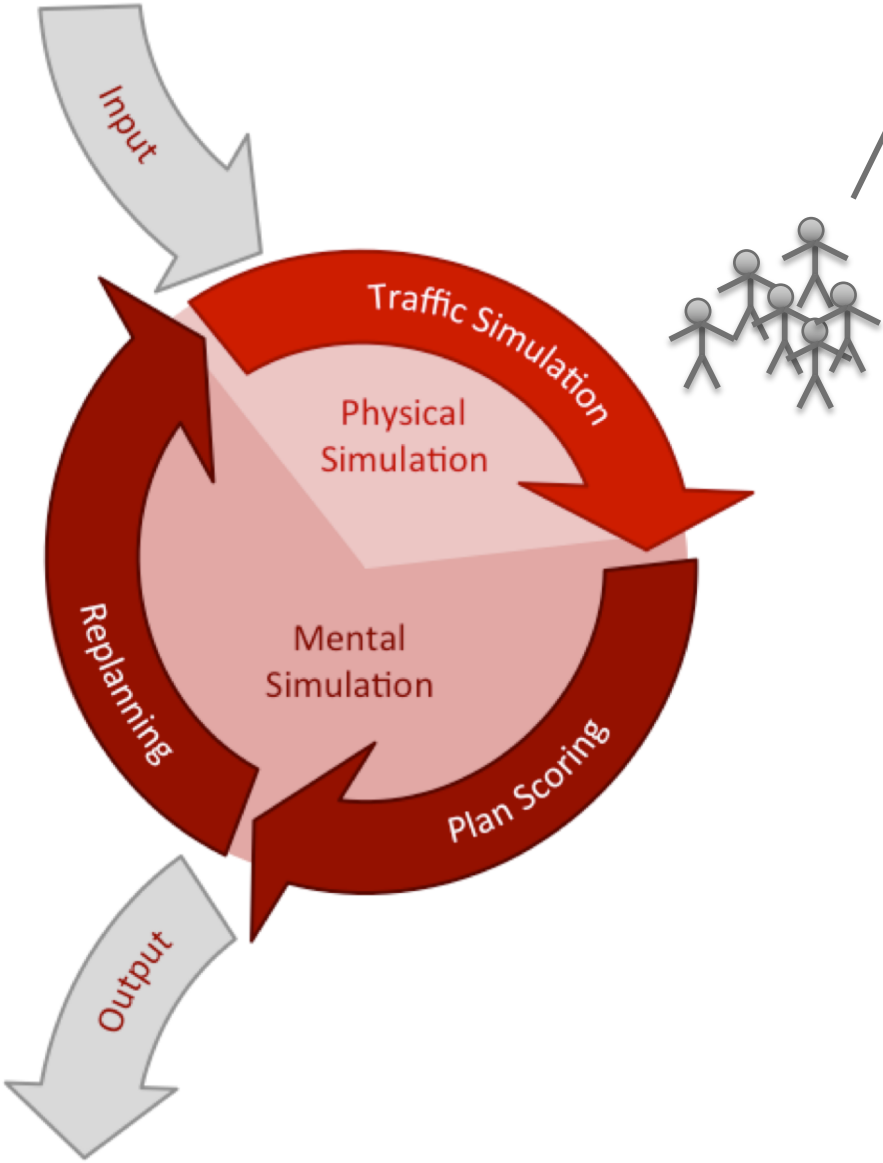
Responsible component	Behaviorally: "Choice dimensions"
"Typical" micro setup	• Who? / How many?
ABDM	• Agents
ABDM	• Where to?
ABDM	• Activities + locations
ABDM	• By what mode?
ABDM	• Mode choice
DTA	• When?
	• Departure time choice
	• Which route?
	• Routing

Demand adaptation in MATSim



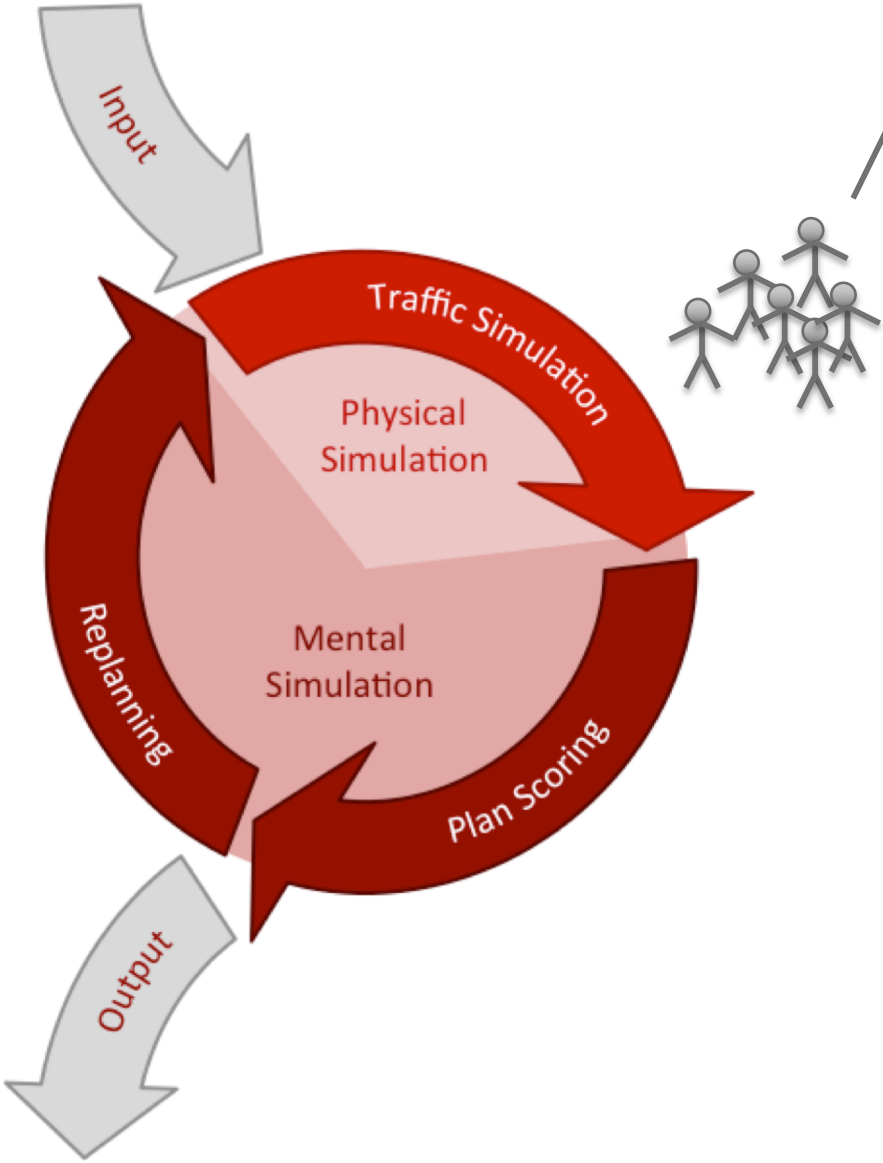
Home (dep: 06:43)
trip (car, route x)
Work (dep: 16:04)
trip (car, route y)
Shopping (dep: 18:04)
trip (car, route y)
Home

Demand adaptation in MATSim: Route choice



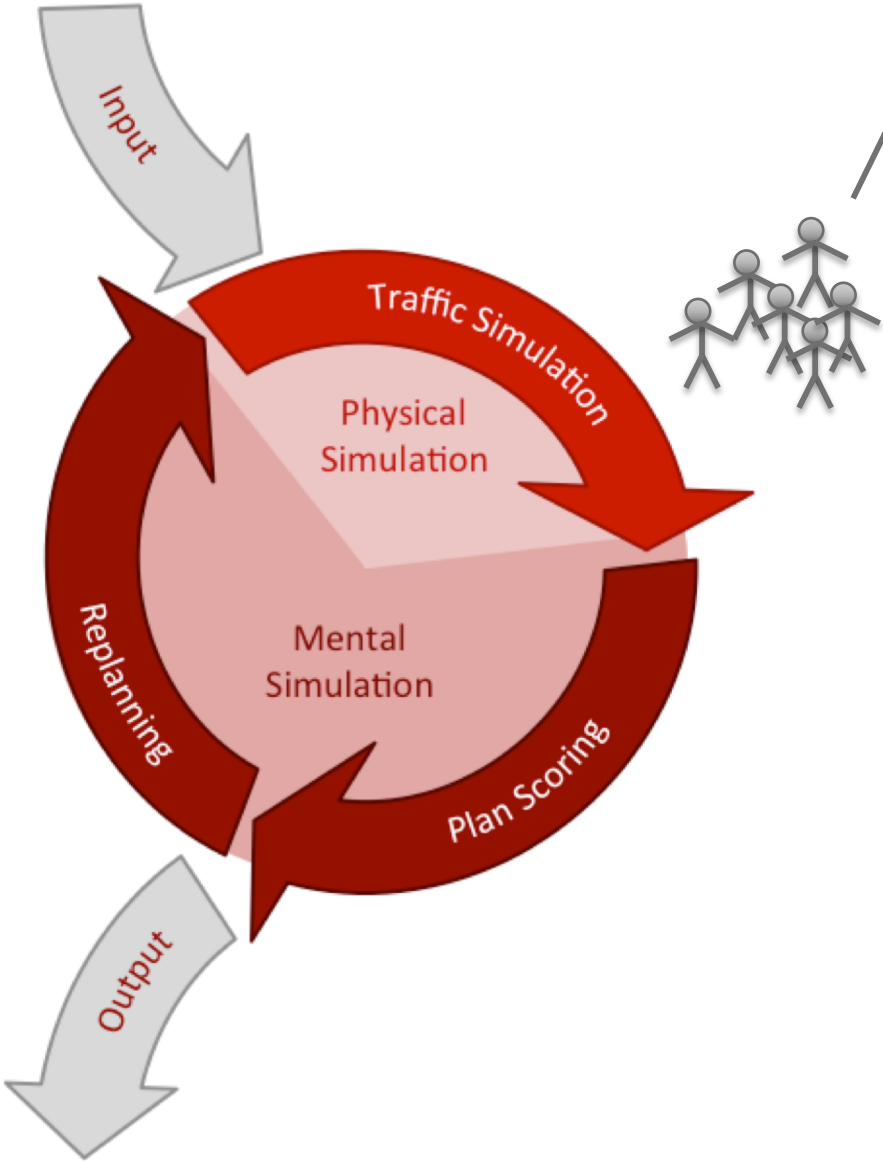
Home (dep: 06:43)
trip (car, **route a**)
Work (dep: 16:04)
trip (car, **route b**)
Shopping (dep: 18:04)
trip (car, **route c**)
Home

Demand adaptation in MATSim: Departure time choice



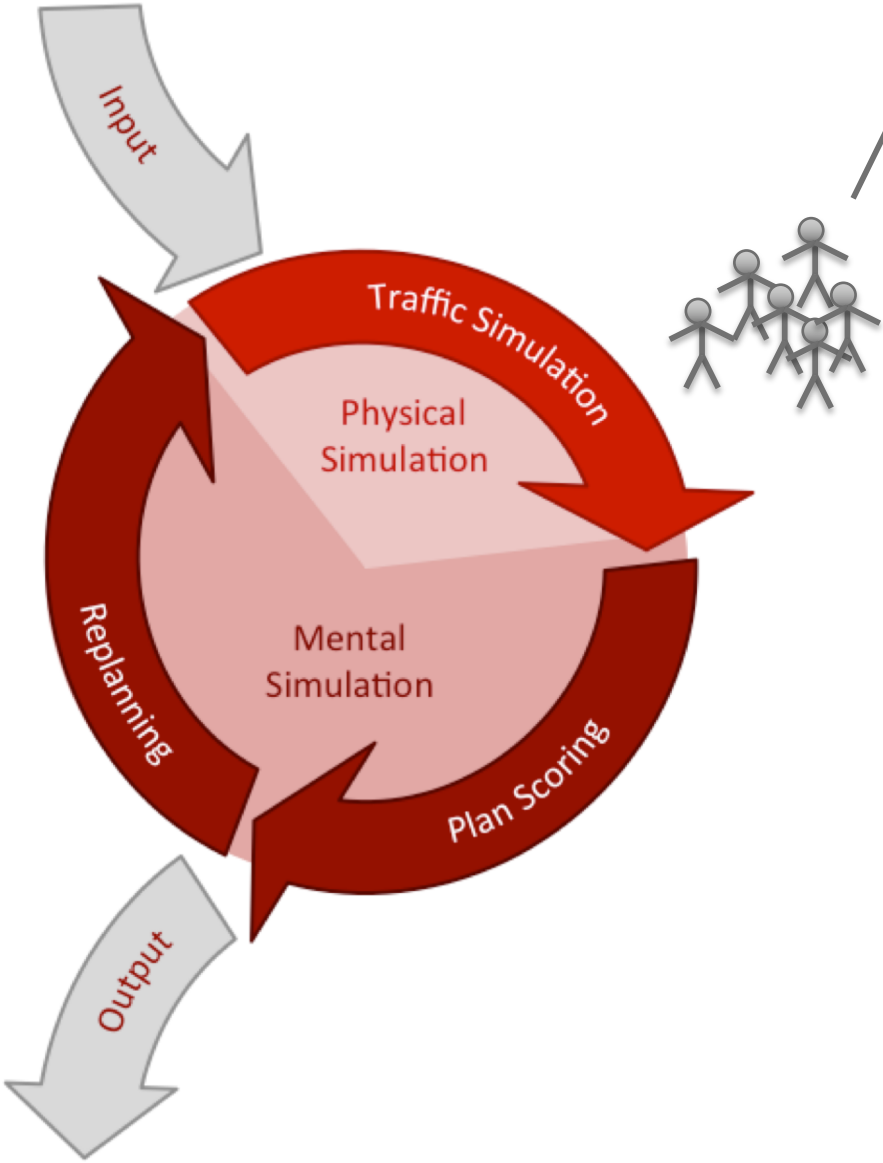
Home (dep: **06:38**)
trip (car, route x)
Work (dep: **16:15**)
trip (car, route y)
Shopping (dep: **18:20**)
trip (car, route y)
Home

Demand adaptation in MATSim: Mode choice



Home (dep: 06:43)
trip (**bike**, route x)
Work (dep: 16:04)
trip (**bike**, route y)
Shopping (dep: 18:04)
trip (**bike**, route y)
Home

Demand adaptation in MATSim: Destination choice



Home (dep: 06:43)
trip (car, route x)
Work (dep: 16:04)
trip (car, route y)
Shopping (dep: 18:04)
trip (car, route y)
Home

Demand adaptation

Responsible component	Behaviorally: "Choice dimensions"
"Typical" micro setup	• Who? / How many?
ABDM	• Agents
ABDM	• Where to?
	• Activities + locations
ABDM	• By what mode?
	• Mode choice
ABDM	• When?
	• Departure time choice
DTA	• Which route?
	• Routing

Demand adaptation

Responsible component	
MATSim setup	"Typical" micro setup
?	ABDM
MATSim	ABDM
MATSim	ABDM
MATSim	ABDM
MATSim	DTA

Behaviorally:
"Choice dimensions"

- Who? / How many?
  - Agents
- Where to?
  - Activities + locations
- By what mode?
  - Mode choice
- When?
  - Departure time choice
- Which route?
  - Routing

Intermediate summary

- MATSim models much more than a pure DTA model
  - “more” = more choice dimension
- MATSim does not cover ALL choice dimensions of an ABDM
  - “Demand adaptation model”
- Innovative strategy modules (in “replanning” step)
  - Update agents’ choice concerning specific choice dimension during the iterations

EXAMPLE 1
OPEN BERLIN SCENARIO

ABDM in Open Berlin Scenario: CEMDAP

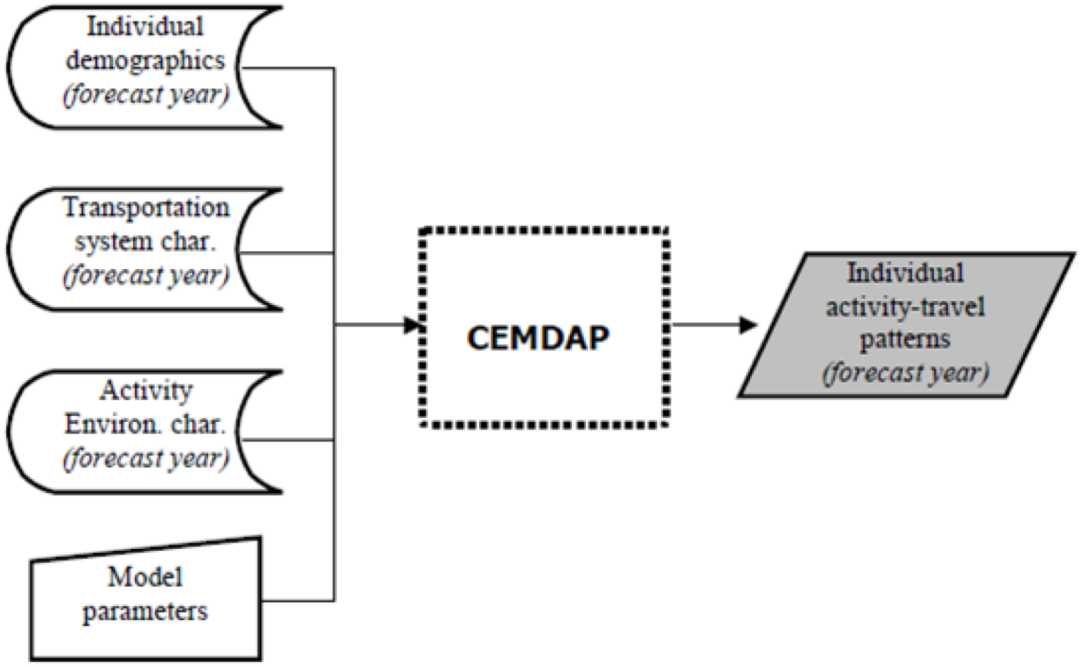
- Comprehensive Econometric Microsimulator for **Daily Activity-Travel Patterns**
- C. Bhat et al., University of Texas

Input

- Disaggregate Demographics
- Model Specification

Output

- Daily Activity-Travel Patterns for each individual



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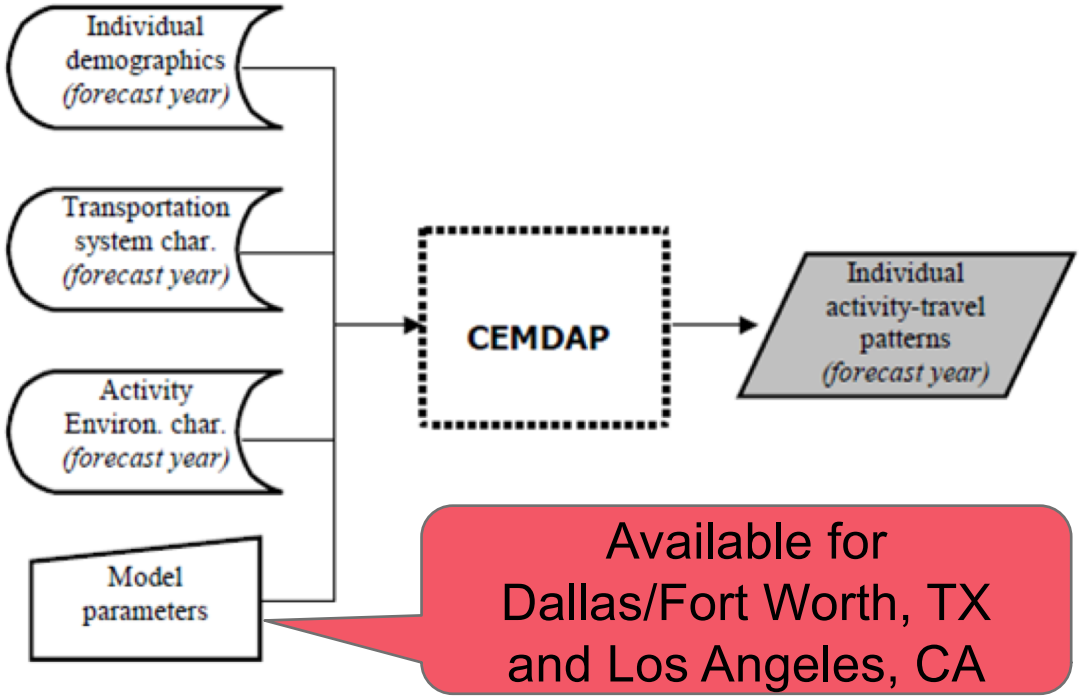

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Demand adaptation in Open Berlin Scenario

Responsible component	Behaviorally: "Choice dimensions"
MATSim setup	• Who? / How many? • Agents
Census + commuter stat.	• Where to? • Activities + locations
CEMDAP / ?	• By what mode? • Mode choice
CEMDAP / MATSim	• When? • Departure time choice
CEMDAP / MATSim	• Which route? • Routing
MATSim	

Demand adaptation in Open Berlin Scenario

Responsible component

MATSim setup

Census + commuter stat.

CEMDAP / ?

Work Locations?

CEMDAP / MATSim

CEMDAP / MATSim

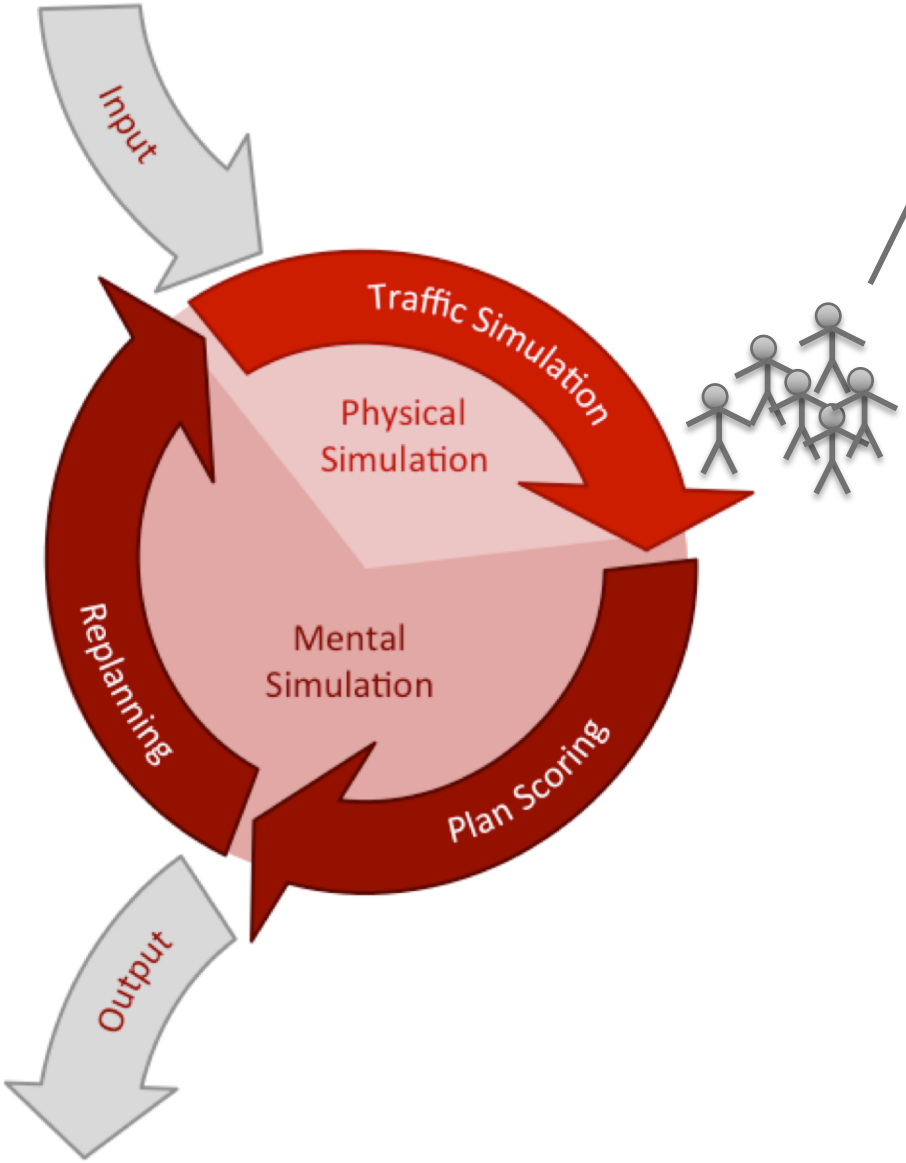
MATSim

Behaviorally:
"Choice dimensions"

- Who? / How many?
  - Agents
- Where to?
  - Activities + locations
- By what mode?
  - Mode choice
- When?
  - Departure time choice
- Which route?
  - Routing

Demand adaptation in MATSim: Mode choice

Repetition



Home (dep: 06:43)
trip (**bike**, route x)
Work (dep: 16:04)
trip (**bike**, route y)
Shopping (dep: 18:04)
trip (**bike**, route y)
Home

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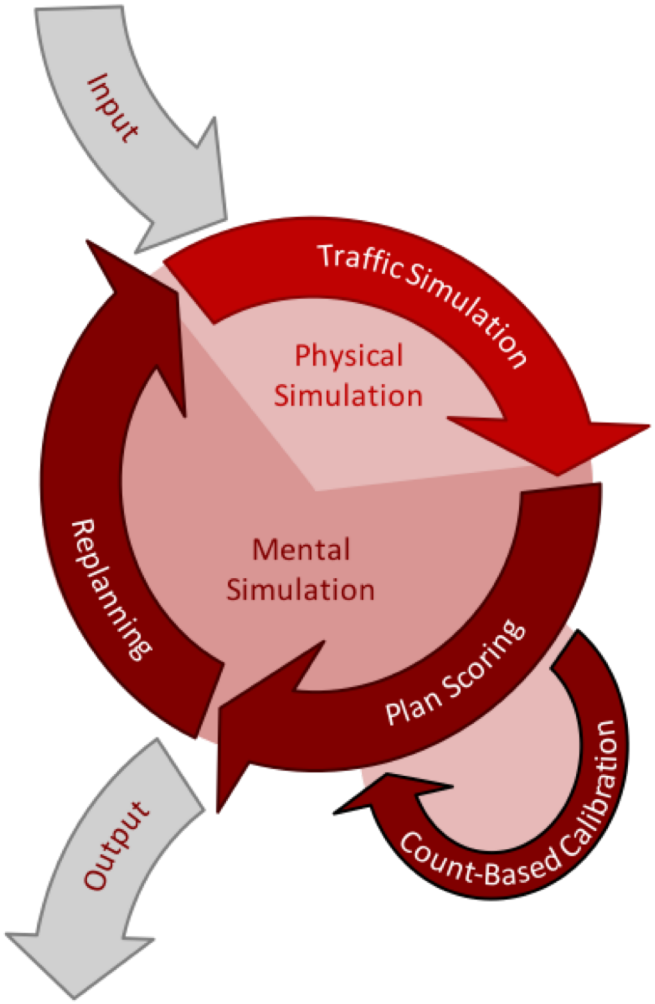
MATSim: Simulation and calibration

Set of multiple initial plans



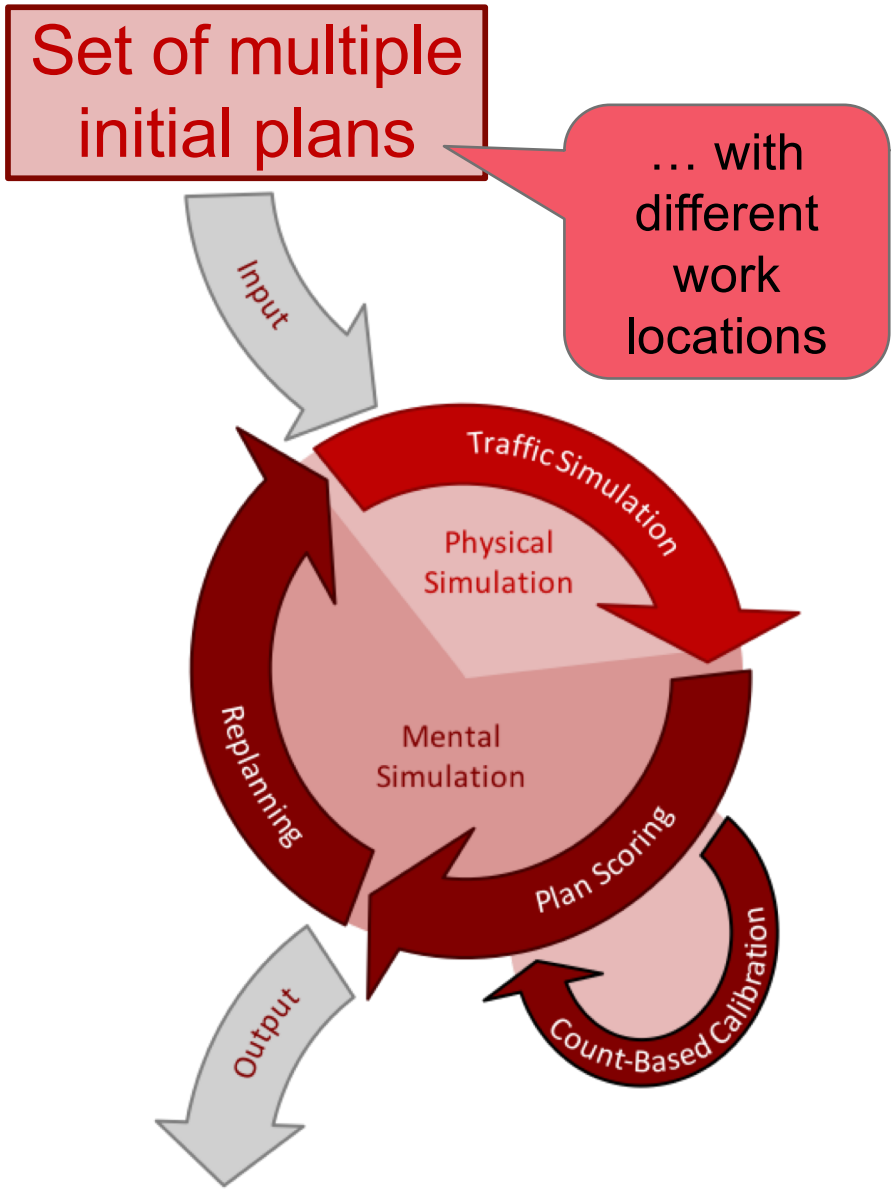
CaDyTS

- calibration integrated into MATSim's genetic algorithm

"Extended" Plan Scoring

- Agents score their executed activities and trips
  - behaviorally
  - in terms of match with real-world observations

MATSim: Simulation and calibration



CaDyTS

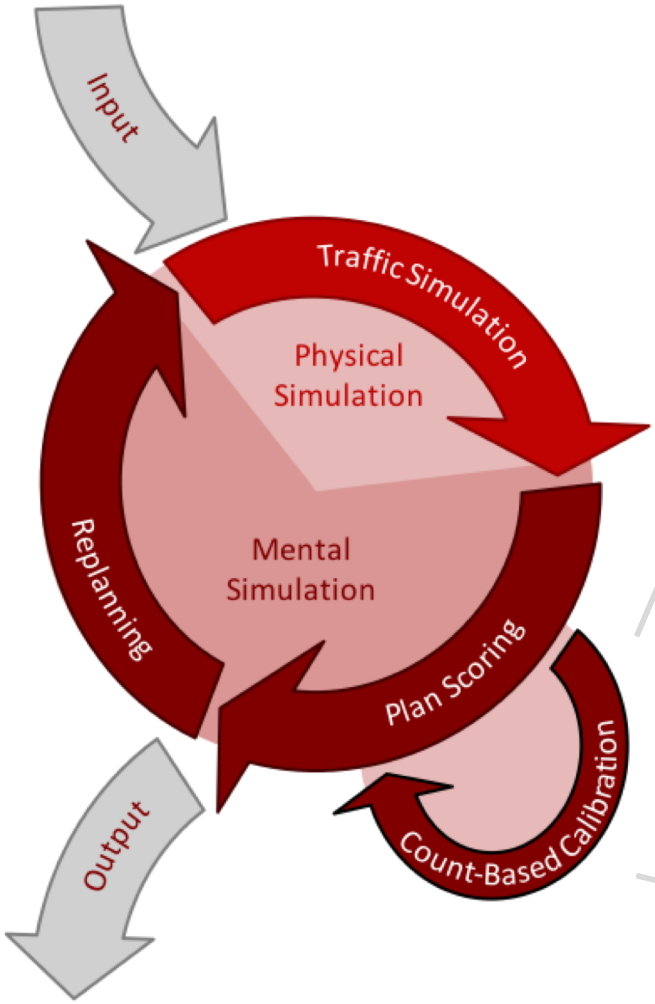
- calibration integrated into MATSim's genetic algorithm

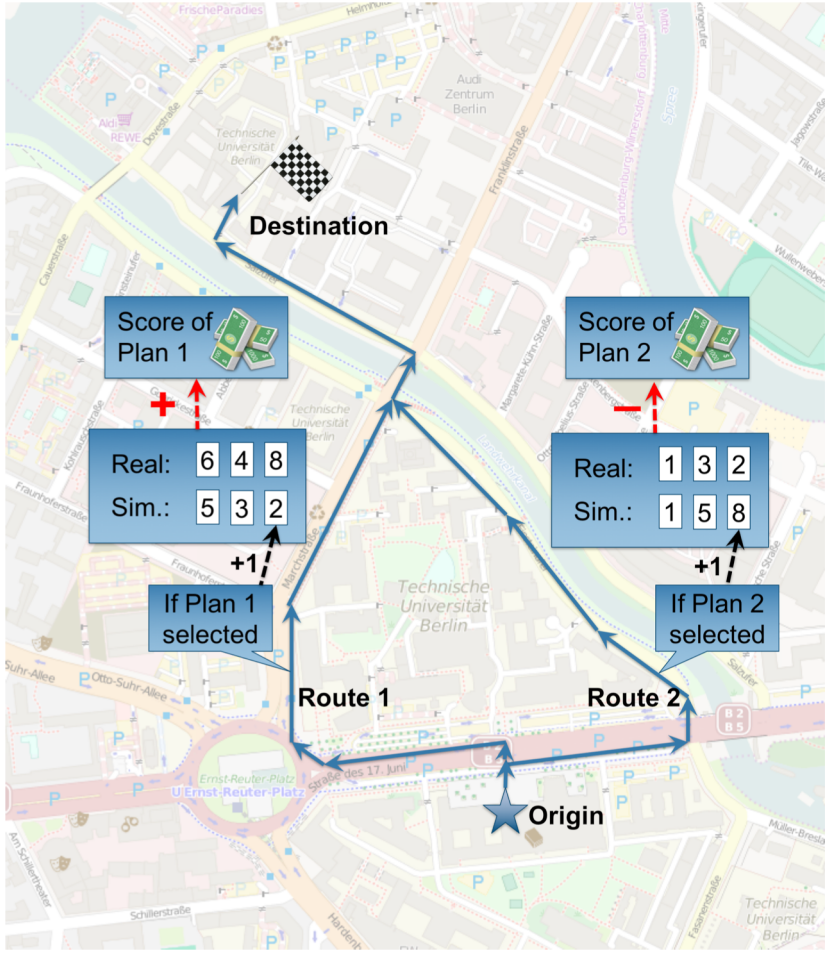
"Extended" Plan Scoring

- Agents score their executed activities and trips
  - behaviorally
  - in terms of match with real-world observations

MATSim: Simulation and calibration

- Cadyts as additional component of MATSim‘s scoring
- „Rewards“ plans which contribute to reproduction of reality





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Relation to other methods

- Macroscopic models
  - use initial rough OD matrix
  - use traffic counts
  - make OD matrix more appropriate for a region

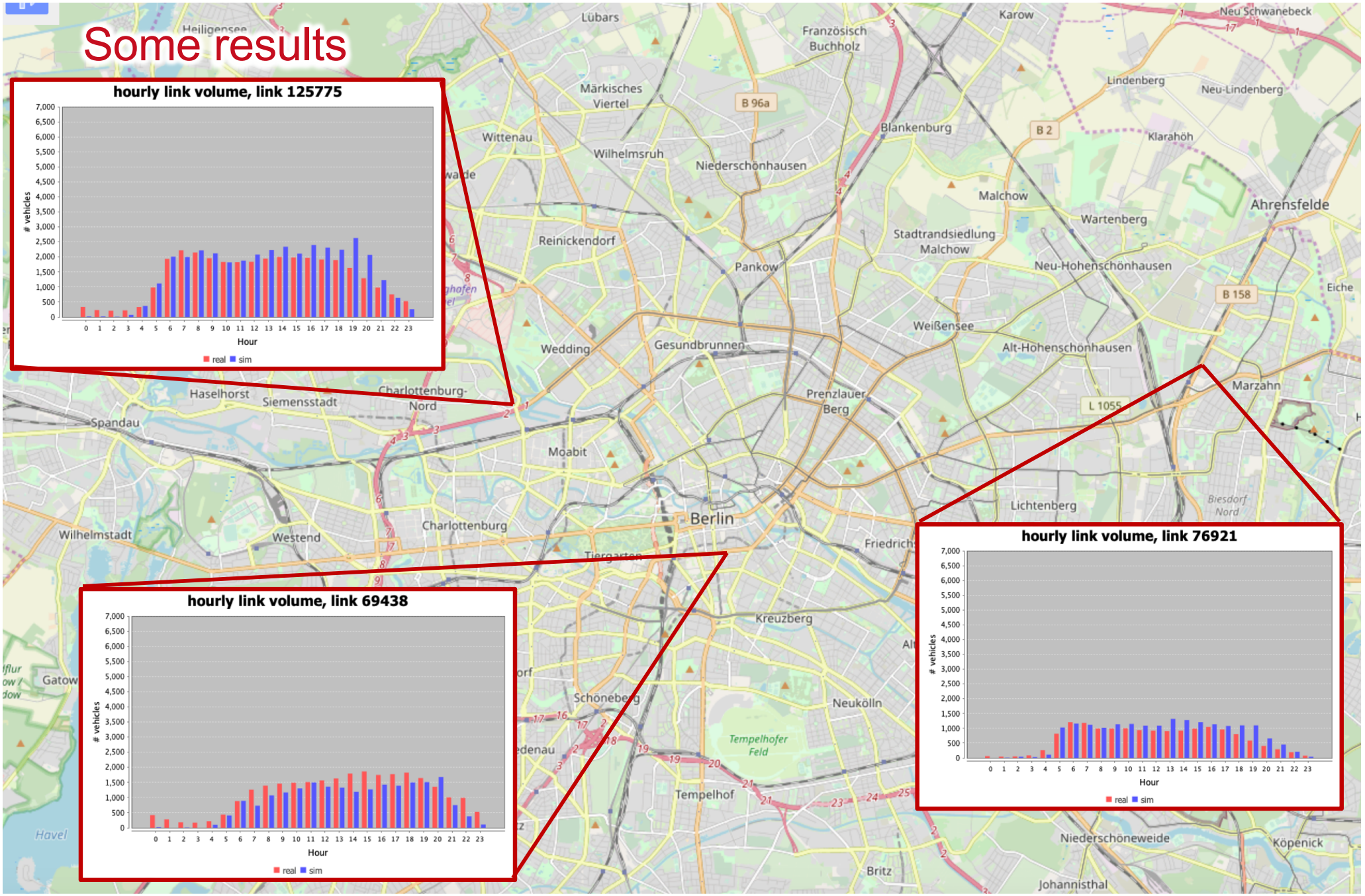
  → “OD matrix estimation”

- Microscopic models (here: MATSim)
  - set of initial daily plans
  - use traffic counts
  - select most appropriate plans

Summary of method

1. Create synthetic population (in CEMDAP format) 5x
    - Demographic according to census
    - Residential and work locations based on commuter matrix
    - Different refined work location in different syn. pop. versions
2. Run CEMDAP for each synthetic population 5x
    - Result: 5 potential daily activity-travel pattern for each agent
3. Convert and combine into MATSim plans
    - Results: Plans for all agents with 5 daily plans
4. Run MATSim incl. Cadyts
    - Agents choose plans based on
        - assumptions of activity participation and travel behavior
        - reproduction of real-world observations
5. Plans at end of simulation = travel demand of study region
    - Perform validation

Some results



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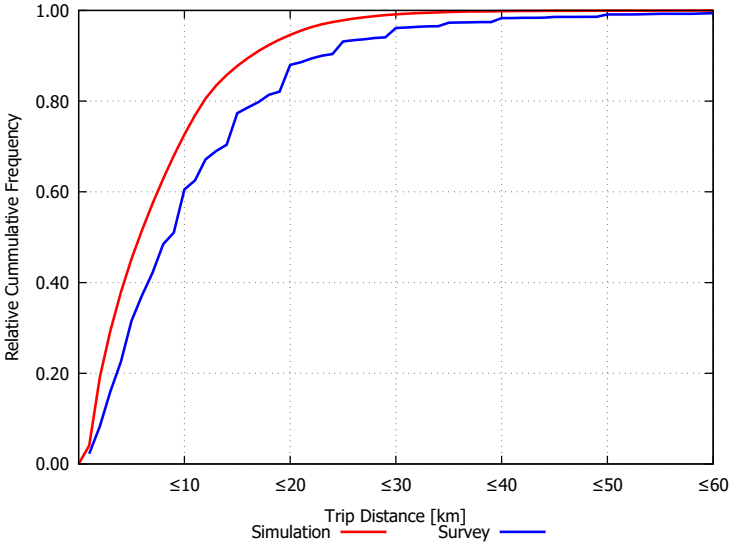
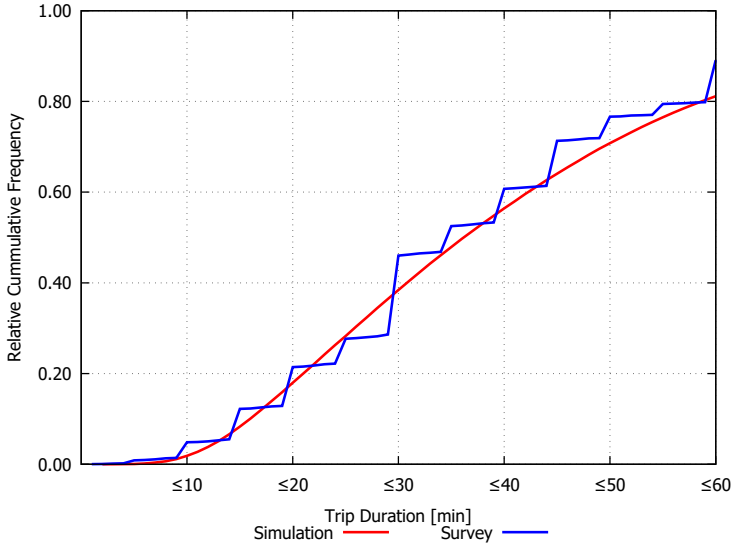
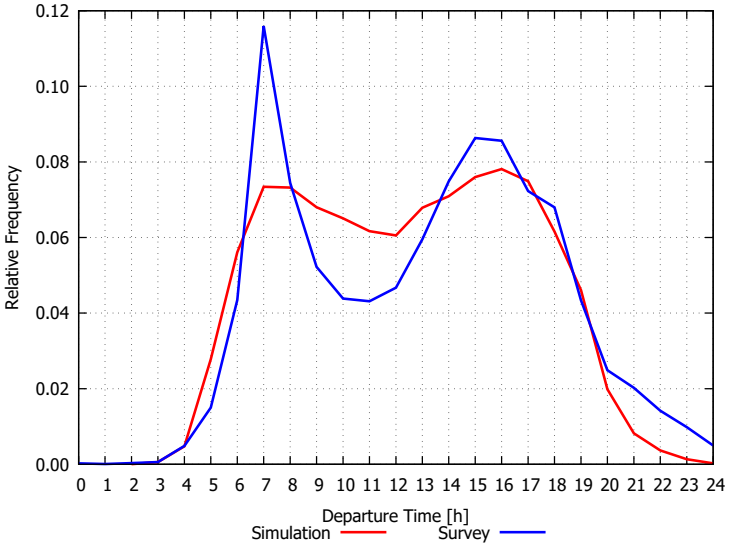
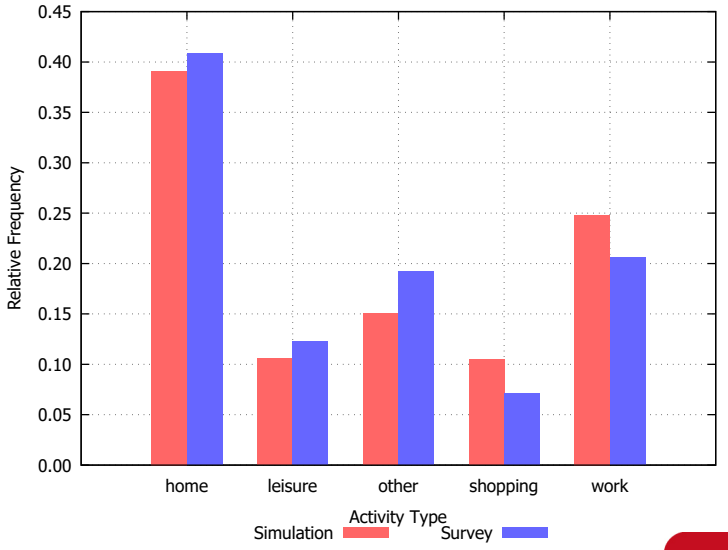
Results / Public transport statistics









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EXAMPLE 2
SNF BIG DATA PROJECT

SNF Big Data Project

- **Efficiently** create transport simulation scenario (Switzerland)
- Based on **mobile-phone-data-based OD trip matrices**
- Other **data** must be almost **universally available**
- Set up an efficient and **transferable toolchain**

Proposed toolchain

1. Synthetic population
2. Workplaces (SwissCom mobile phone OD matrix)
3. Generation of activity chains
4. Location Choice
5. Scenario Calibration (SwissCom)

SwissCom OD Matrix

- 12 monthly x 24 hourly trip matrices
- Numbers of trips
- Municipality-municipality relation
- For workdays

00:00-01:00	Munic. 1	Munic. 2	…	Munic. n
Munic. 1	#trips	#trips	…	#trips
Munic. 2	#trips	#trips	…	#trips
…	…	…	…	…
Munic. n	#trips	#trips	…	#trips

SwissCom OD Matrix

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Munic. 2	#trips	#trips	…	#trips
…	…	…	…	…
Munic. n	#trips	#trips	…	#trips

- Time slices of morning peak (e.g. 6:00 to 10:00)
  - Inform commutes, i.e. work municipalities
- Other time slices
  - Calibration

Demand adaptation

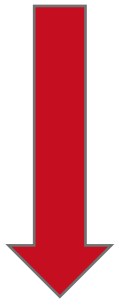
Responsible component	
MATSim setup	"Typical" micro setup
?	ABDM
MATSim	ABDM
MATSim	ABDM
MATSim	ABDM
MATSim	DTA

Behaviorally:
"Choice dimensions"

- Who? / How many?
  - Agents
- Where to?
  - Activities + locations
- By what mode?
  - Mode choice
- When?
  - Departure time choice
- Which route?
  - Routing

A more **efficient** way to create a scenario

Responsible component	
MATSim setup	"Typical" micro setup
?	ABDM
MATSim	ABDM



Activity sequences + locations

Behaviorally:
"Choice dimensions"

- Who? / How many?
  - Agents
- Where to?
  - Activities + locations
- By what mode?
  - Mode choice
- When?
  - Departure time choice
- Which route?
  - Routing

ABDMs

	CEMDAP	FEATHERS	ActiTopp
Developer	University of Texas	Universiteit Hasselt	Karlsruhe Inst. of Technology
Language	C++	C++	Java
Code	.exe (one version can be inspected)	.exe	Open source (GitHub)
Interaction with MATSim	File-based + database (man.)	File-based (with integration test)	Code-based
Estimation cont.	Los Angeles	Flanders	Germany (MOP)
Input	Many variables	Various variables	A few variables
Output	Full activity-travel patterns for each individual	Full activity-travel patterns for each individual	Activity sequence with dummy trips; no locations, but commute dist.
Spatial transfer and application	Count-based calibration for Berlin	Use in est. context (Flanders)	Use in est. context (Germany)

Other models: ALBATROSS, TASHA, TAPAS, …

ABDMs

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ActiTopp

- models activity chains*
- based on basic demographic information
- estimated on German mobility panel (MOP)
- developed at KIT (Karlsruhe)
- part of the mobiTopp suite
- written in Java
- open source

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***Activity chains** = pure activity chains

- No information on location
- No information on intervening trips

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***Activity chains** = pure activity chains

- No information on location ➔ Destination choice
- No information on intervening trips

ActiTopp: Person specification

- Id
- Age
- Gender
- Locality type
- Children aged 0-10 in the hh
- Children aged <18 in the hh
- Occupation type
- Number of cars in the hh
- Commuting distance

ActiTopp: Person specification

- Id
- Age
- Gender
- Locality type
- Children aged 0-10 in the hh
- Children aged <18 in the hh
- Occupation type
- Number of cars in the hh

Synthetic population

- Commuting distance

OD matrix

Thank you!

Description of methods

- Ziemke, D., Nagel, K. & Bhat, C.; Integrating CEMDAP and MATSim to increase the transferability of transport demand models; Transportation Research Record, 2015, 2493, 117-125.

- Ziemke, D. and K. Nagel. Development of a fully synthetic and open scenario for agent-based transport simulations – The MATSim Open Berlin Scenario. VSP Working Paper 17-12, TU Berlin, Transport Systems Planning and Transport Telematics, 2017. URL: http://www.vsp.tu-berlin.de/publications.

- Ziemke, D., Kaddoura, I. & Nagel, K. **The MATSim Open Berlin Scenario**: A multimodal agent-based transport simulation scenario based on synthetic demand modeling and Open Data, ABMTrans 2019

Find the Open Berlin Scenario

- https://github.com/matsim-vsp/matsim-berlin