MOBi.plans – activity-based agent plans for MATSim

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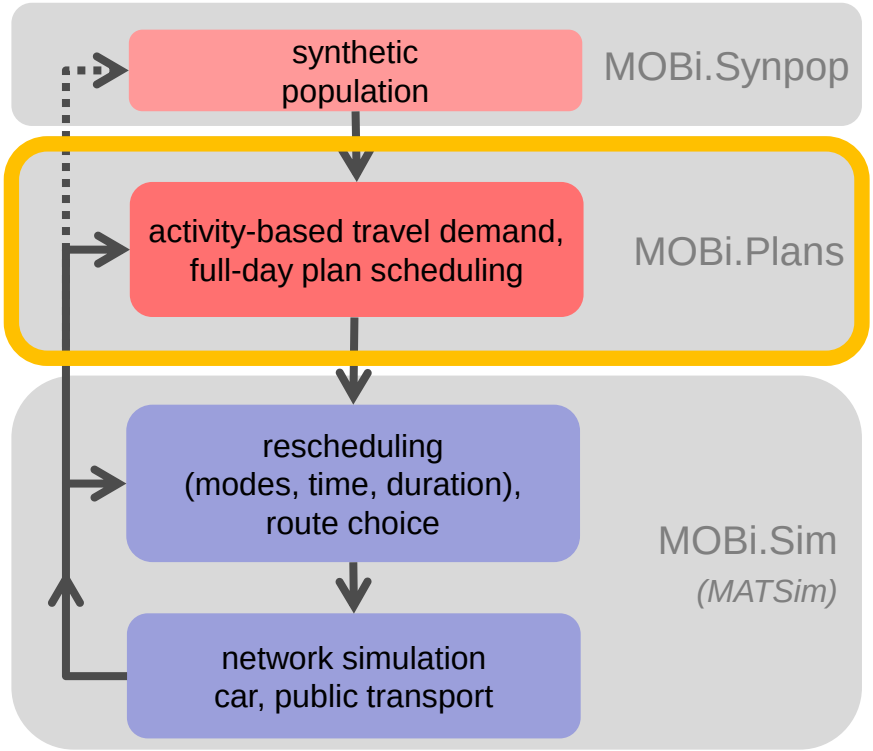
Agenda

1. Travel simulation @ SBB
2. MOBi.plans – activity-based demand model
3. MOBi.sim – new insights into our MATSim model

Purpose and Mission of Travel Modeling at SBB

- Important requirements:
  - Mid-term forecasts (2020 ... 2025)
  - Long-term forecasts (2040, 2050) for long investment cycles
  - Consistent coverage of rail demand and rail production
  - Representation of future mobilities, technological and socio-economic change
  - Numerical precision and prediction success
- Purpose: models support business decisions and feed corporate processes in:
  - service planning
  - fleet and infrastructure planning
  - financial planning
  - corporate strategy

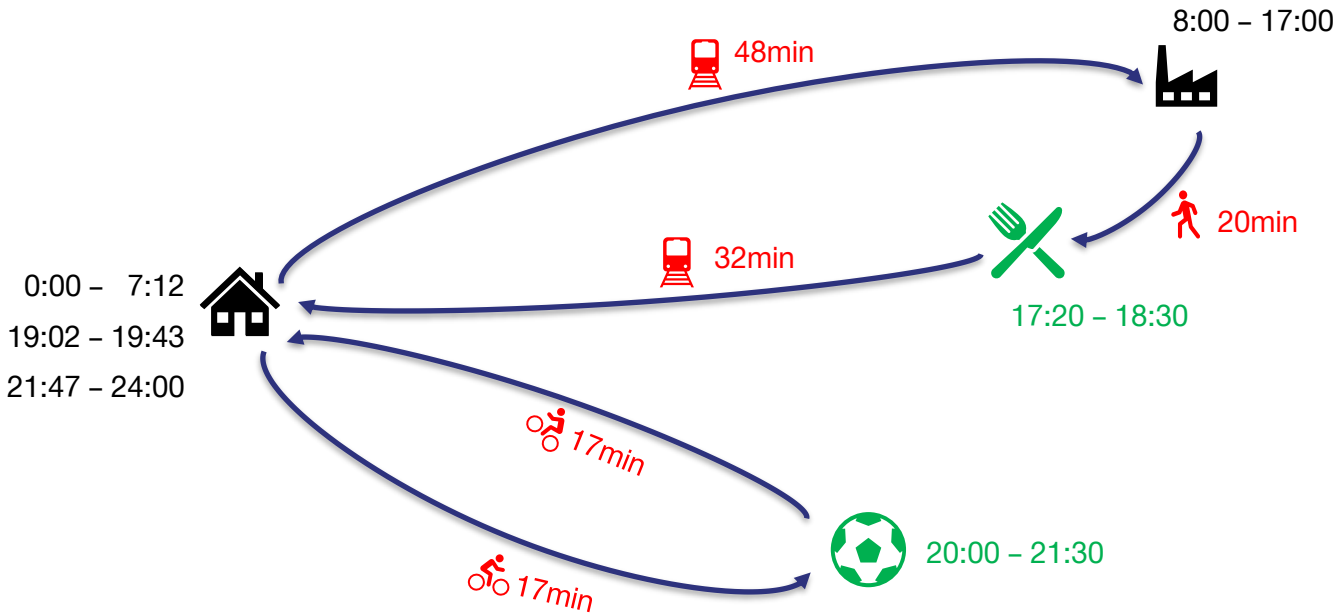
SIMBA MOBi: microscopic travel simulation of Switzerland



- MOBi 1.0:
  - released April 2018
  - synpop and agents' plans given by senozon/ETH
- MOBi 2.0:
  - release May 2019
  - the microscopic circle is complete: from synpop over travel demand through network simulation

MOBi.plans: Synthetic plans

MOBi.Plans' output: individual day plans

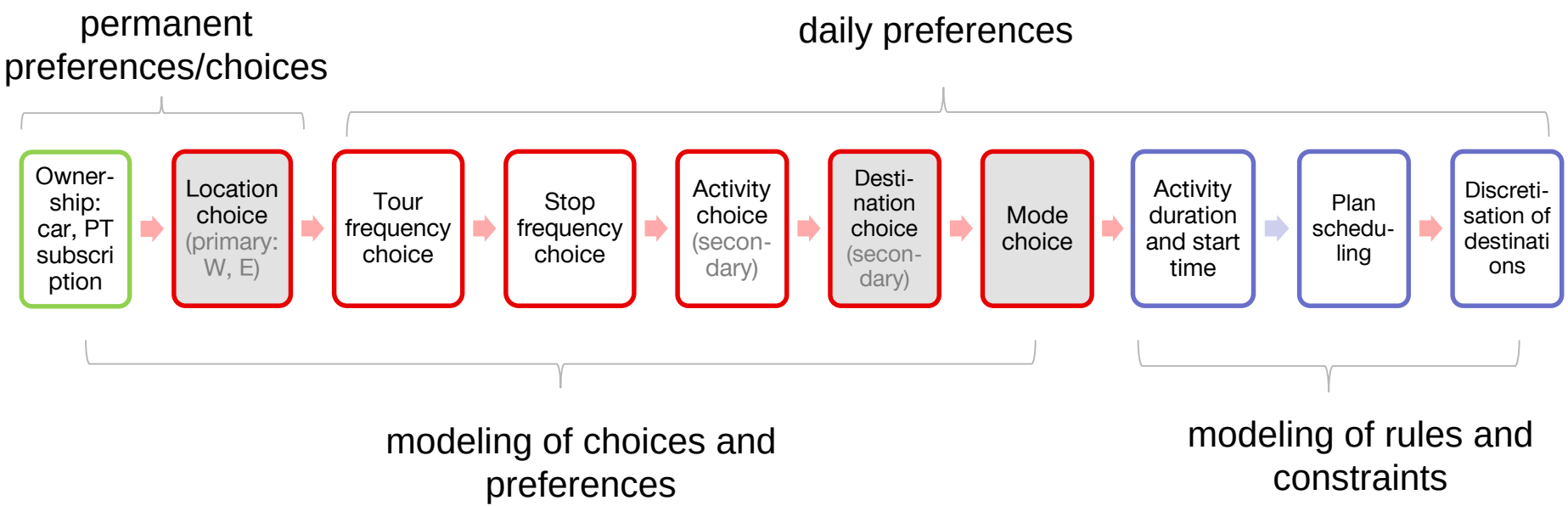


Each individual plan contains:

- the permanent location of primary activities (work, education)
- the desired number and kind of activities a person wishes to perform in a day
- the pattern of how those activities are bundled in tours
- the sequence of tours and the sequence of the activities within each tour
- the exact geographic location where each activity will be performed
- the mode choice for each tour or subtour
- the duration and time of day for each desired activity

MOBi.Plans: microscopic travel demand

➔ A sequence of steps to construct individual day plans

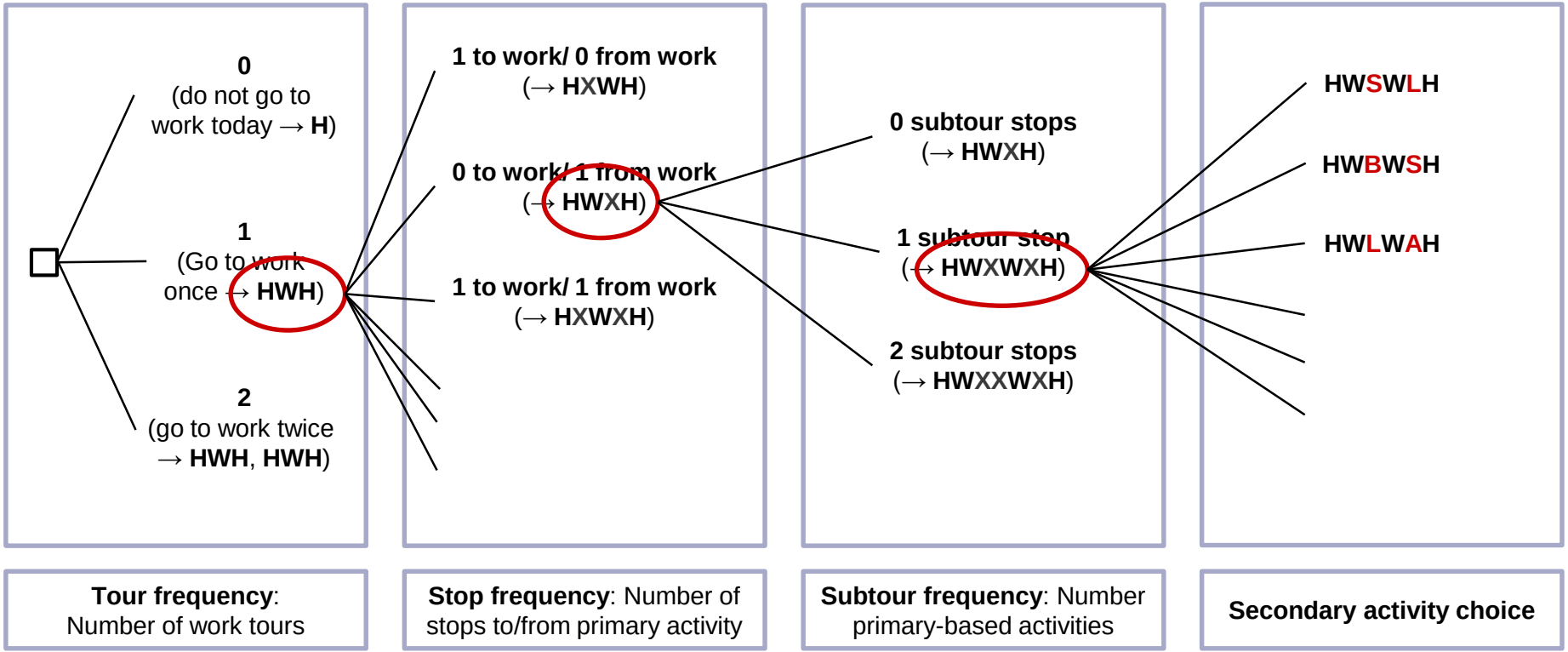


Tour and activity generation: definitions

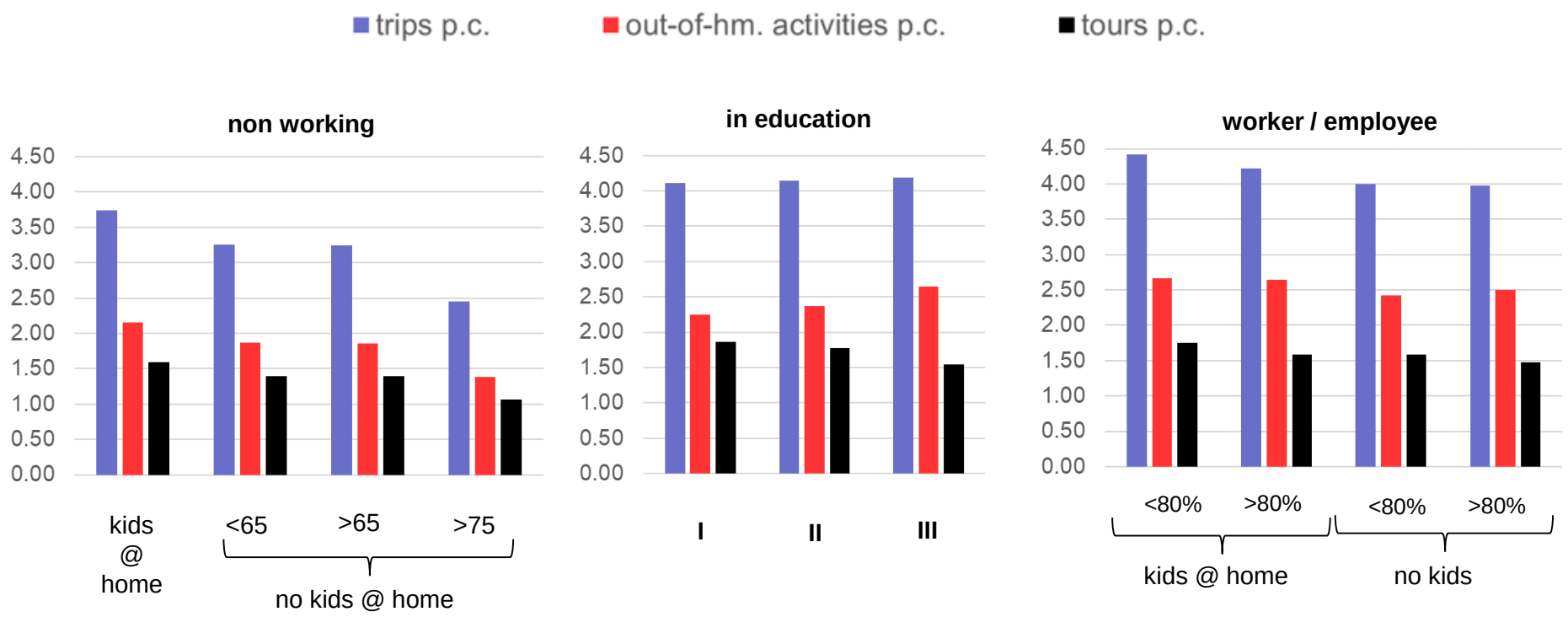
- **Tour types:**
  - work tour
  - education tour
  - business tour
  - secondary tour

- **Primary activities:**
  - work (W)
  - education (E)
- **Secondary activities:**
  - Leisure (L)
  - Shopping (S)
  - Business (B)
  - Education (EC)
  - Accompany, escort (A)
  - Other (O)

Sequence of discrete choice models



The impact of age and other person attributes



Nested destination/location and mode choice

m: mode [bike, car, pt, ride, walk]
i: origin range(0, 7978)
j: destination range(0, 7978)
$\mathbf{V_{ijm}}$: utilitiy of m for ij
$\mathbf{A_j}$: attraction of destination j

- Mode choice (depending on LOS):

$$P(m|ij) = \frac{exp(V_{ijm})}{\sum_k exp(V_{ijk})}$$

- Expected max. utility (**EMU**) over all modes from origin i to destination j:

$$EMU_{ij} = ln\left\{\sum_m [exp(V_{ijm}/\theta)]\right\}$$

- **Probability** for destination j from origin i:

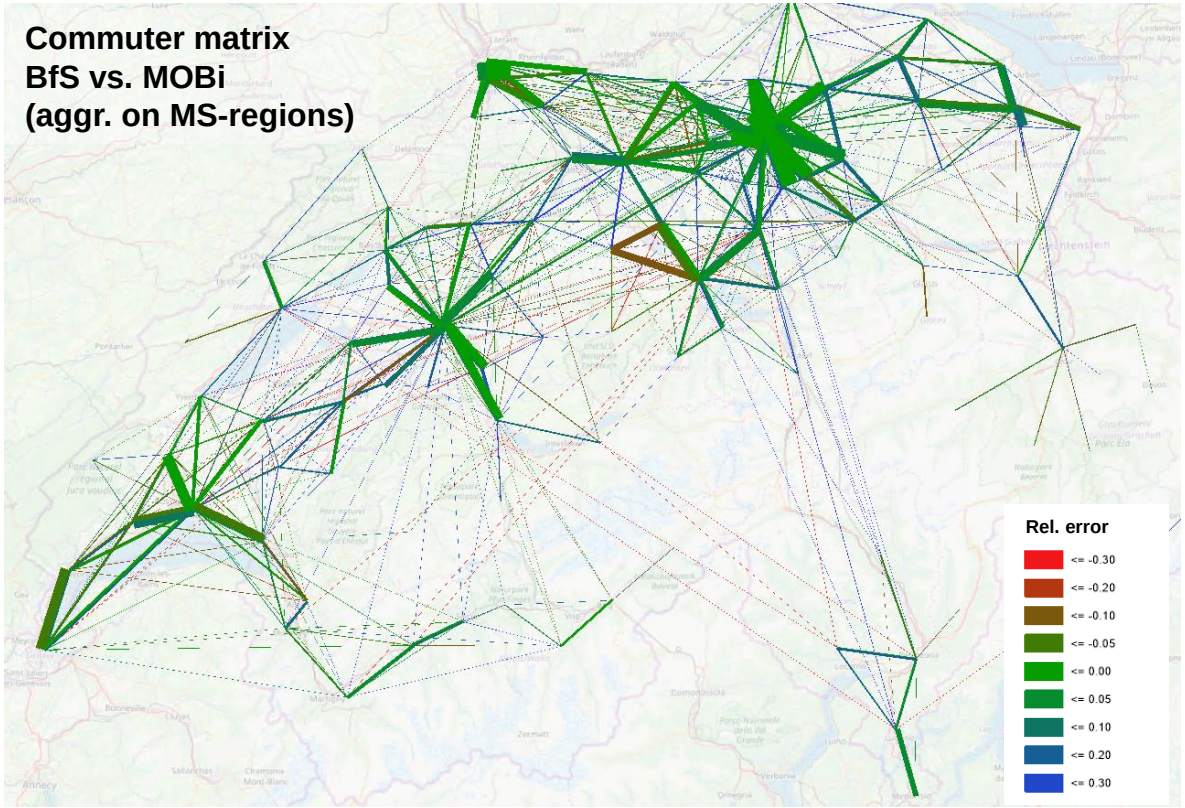
$$P(j|i) = \frac{exp(ln(A_j) + \theta \cdot EMU_{ij})}{\sum_k [exp(ln(A_k) + \theta \cdot EMU_{ik})]}$$

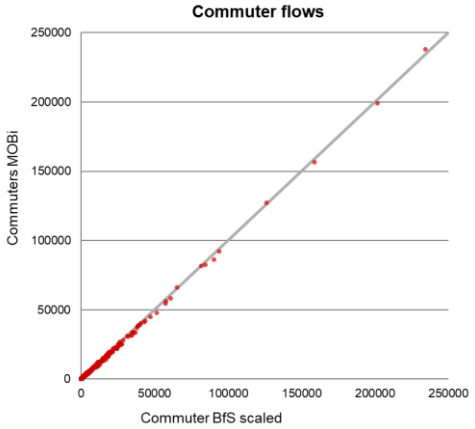
- **Shadow-pricing**

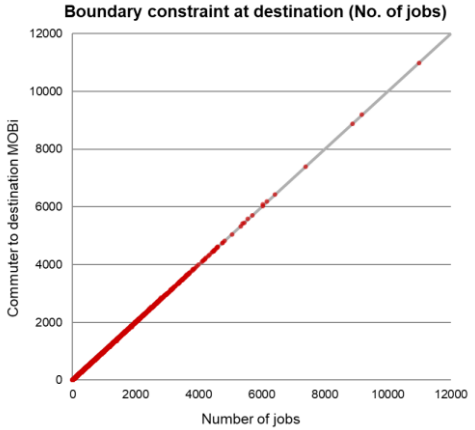
$$V(j|i) = ln(A_j) + \theta \cdot EMU_{ij} + \lambda_j + \lambda_{ij}$$

- **Rubber-banding** for secondary activities

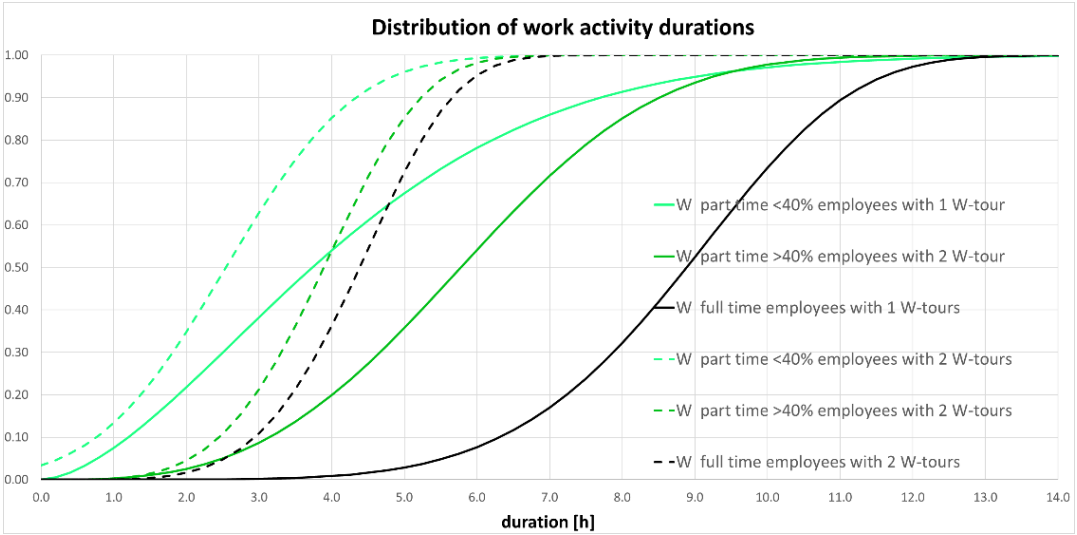
Validation of the commuter matrix







Desired activity durations



Both duration and start times are descriptive probabilities, depending on:

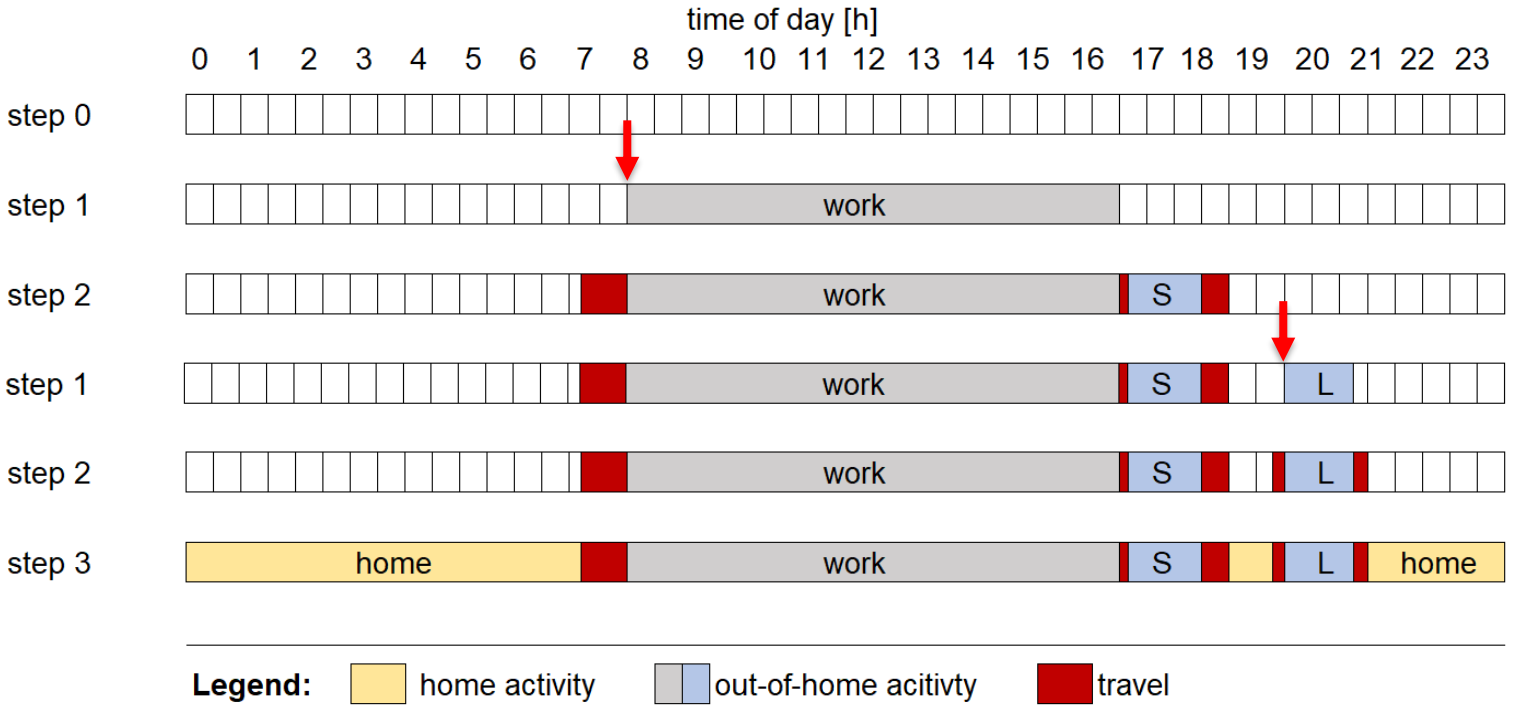
- ➔ the type of activity
- ➔ socio-economic attributes of the person
- ➔ the frequency of an activity in one plan (e.g. the workplace is visited once or twice)

Rule-based adjustment of plan components

The integrity of the plan requires constraints:

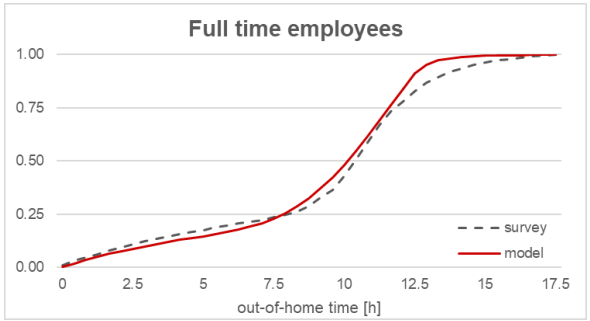
- activities start and end within 0:00 - 24:00
- an agent can perform one activity or one trip at a time only
- Time budgets:
  - total travel time <= X
  - total activity time <= Y
  - total activity+travel <= Z
- Adjustment: **iterative review** of destinations and durations

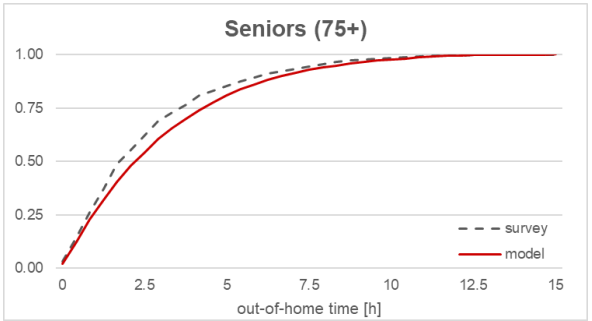
Scheduling procedure



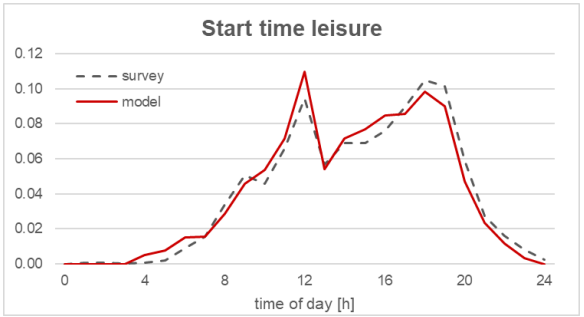
Validation

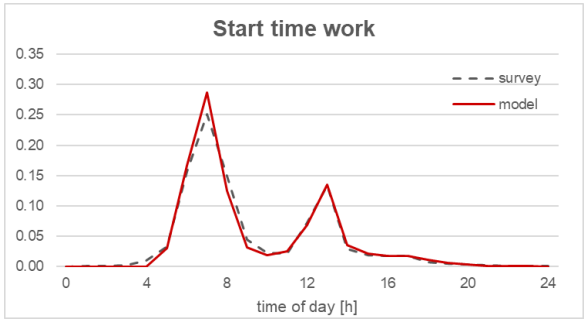
Total out-of-home time per capita





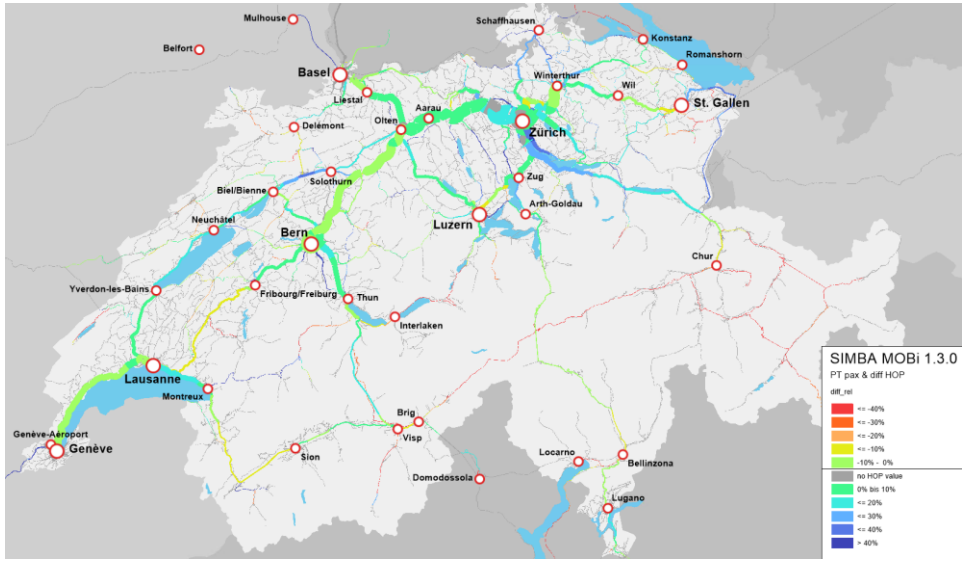
Time of day distribution of trips



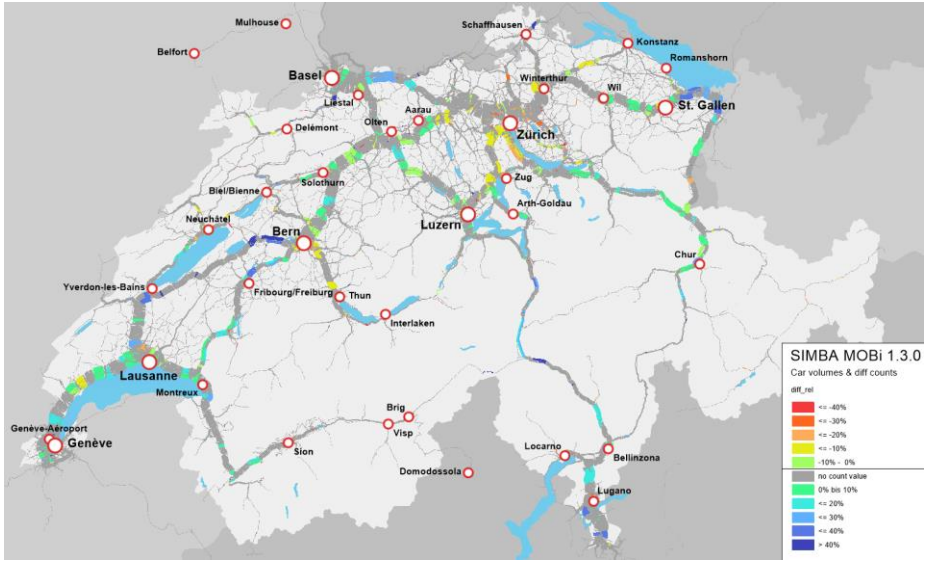


Validation after simulation with MATSim

Public transport passenger loads



Car volumes on street network



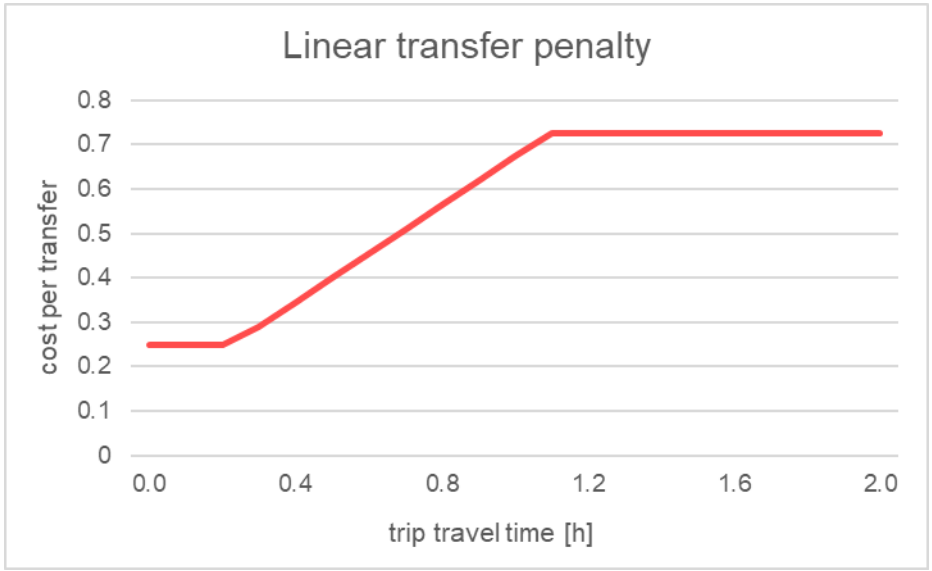
Properties of the model

- → Activity-based approach
- → Microscopic simulation through all model steps
- → High resolution of time and space
  - aggregated zones in intermediary steps
  - final demand has exact geographic locations
- → Person-based simulation
  - household properties included persons' decisions
  - but not modelling household interactions explicitly
- → Representation of 24 hours of the average weekday
- → Strong integrity (time and space) of activities and travel along 24-hour plans
- → Focus on variables explaining choice of public transportation
- → **A strong effort in model calibration**

New insights into our MATSim model

Trip-based scoring (since MATSim 11)

➔ Example: utility of transfers as a function of travel time (whole trip)



Calibrating time of day distribution

- → typical durations (inspired by open Berlin scenario) in sub-activities
- → latest start time and opening time for special activities:
  - education and work: morning peak
  - home activity: evening peak

daily plan with sub-activities

```
<activity type="home_720" facility="H_38899" x="729760.0" y="277870.0" end_time="07:15:08" > </activity>
<leg mode="car"> </leg>
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<leg mode="car"> </leg>
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<leg mode="walk"> </leg>
<activity type="shopping_120" facility="B_128200" x="729496.0" y="278121.0" start_time="17:51:01" end_time="19:37:01" > </activity>
<leg mode="walk"> </leg>
<activity type="home_720" facility="H_38899" x="729760.0" y="277870.0" start_time="19:39:23" > </activity>
```

Further information

- matsim-sbb-extensions
- Paper:
  - Wolfgang Scherr, Chetan Joshi, Patrick Manser, Nathalie Frischknecht and Denis Métrailler. MOBi.Plans: A Microscopic, Activity-Based Travel Demand Model of Switzerland. Paper presented at STRC 2019
- Contact:
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  - wolfgang.scherr@sbb.ch

Connecting Switzerland

Tour and activity generation

➔ A set of sequentially estimated LOGIT models

	Tour frequency				Sub tour frequency	Stop frequency		
	Number of primary tours		Number of secondary tours		On primary tour	Number of stops on primary tour		Number of stops on secondary tour
	Work	*Education*	*Business*	*Other*		*Outbound*	*Inbound*	
Constant	X	X	X	X	X	X	X	X
Employment level	X	X	X	X	X	X	X	X
Main occupation is student/pupil		X		X	X			
Age	X	X	X	X	X	X	X	X
Is in management			X					
Presence of kids in HH (<18)	X			X	X	X	X	X
Car available	X		X	X	X	X	X	X
Public transport subscription	X	X	X	X	X	X	X	X
Car distance to primary location	X	X	X			X	X	
Number of total tours					X	X	X	X
Number of primary tours				X				
Is a work tour					X	X	X	
Is a business tour								X
Accessibility home location	X	X		X		X	X	X
Accessibility work/edu location			X		X			

Tour and activity generation

	Number of other tours per day				Number of stops during an other tour			
	0	1	2	3	1	2	3	4
Constant	0.000	+1.861***	+1.603***	-0.140	0.000	-2.645***	-4.060***	-5.590***
Employment level = 0%	0.000	+0.051	-0.229	-0.276	0.000	-0.108	-0.375*	-0.065
Employment level 1%-39%[1]	0.000	-0.008*	-0.011*	-0.007	0.000	-0.006	-0.011*	-0.003
Employment level 40%-79%[1]	0.000	-0.014***	-0.017***	-0.026***	0.000	+0.004***	+0.006	+0.005
Employment level >= 80%[1]	0.000	-0.005*	-0.017***	-0.020***	0.000	-0.016***	-0.015**	-0.011
Age < 18[1]	0.000	-0.022	-0.047*	-0.038	0.000	+0.057***	+0.104***	+0.132***
18 <= age < 25[1]	0.000	-0.078***	-0.059***	+0.059*	0.000	+0.012*	-0.008	-0.010
25 <= age < 65[1]	0.000	-0.002	-0.000	-0.003	0.000	-0.003	-0.004	-0.005
65 <= age < 75[1]	0.000	-0.019*	-0.016	-0.061***	0.000	+0.003	-0.005	-0.040*
Age > 75[1]	0.000	-0.048***	-0.091***	-0.099***	0.000	-0.003	-0.027	-0.025
Presence of kids in the HH (<18)	0.000	+0.035	+0.256***	+0.554***	0.000	+0.001	+0.016***	-0.011
Is student	0.000	-0.726***	-0.625***	-0.882***				
Is apprentice	0.000	-0.390***	-0.154	+0.303				
Is pupil	0.000	-0.727***	-0.587***	-0.453				
Car available	0.000	+0.452***	+0.854***	+1.053***	0.000	+0.003	+0.088	+0.269**
PT subscription	0.000	-0.094**	-0.141***	-0.230***	0.000	+0.123**	+0.281***	+0.489***
Number of primary tours	0.000	-0.807***	-1.850***	-2.566***				
Number of total tours					0.000	-0.006***	-0.007***	-0.007***
Tour is a business tour						0.845	1.800	1.980
Car distance primary location								
Accessibility (home, multimodal)	0.000	+0.023***	+0.039***	+0.032*	0.000	+0.018***	0.000	0.000
Accessibility * car_available[2]	0.000	-0.035***	-0.032***	-0.015***				
	Number of observations : 38149				Number of observations : 37503			
	Rho-square: 0.22				Rho-square: 0.468			
[1] piecewise linear variable								
[2] interaction term of 2 variables								
* P ≤ 0.05								
** P ≤ 0.01								
*** P ≤ 0.001								

- ➔ Number of tours:
  - 0 = I do not leave home
  - 1,2,3 = ..
- ➔ Number of stops:
  - secondary activities on the tour
  - complexity of the tour