First Results of a Household Joint Activity-Travel Multi-agent Simulation Tool

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Introduction

- most travel simulation tools simulate behavior of *isolated* individuals
  - individuals make decisions independently, given traffic conditions influenced by others
- in reality, individuals coordinate their travel behavior with social contacts
  - household: joint activities, limited number of cars, altruism
  - social contacts: joint activities
  - car-pools: pick-up and drop-off times and locations
- such coordinated behavior has a quite important empirical influence
  - joint trips
    - MZ2010: 18% daily traveled distance as "car passenger"
    - MZ2010: 32.5% all car stages done with 2+ persons in the car
  - leisure location choice

Aim of this presentation

- present an approach to integrate coordination mechanisms in the MATSim framework
- analyze the results of runs on scenarios for the Zurich area
- identify directions of future work

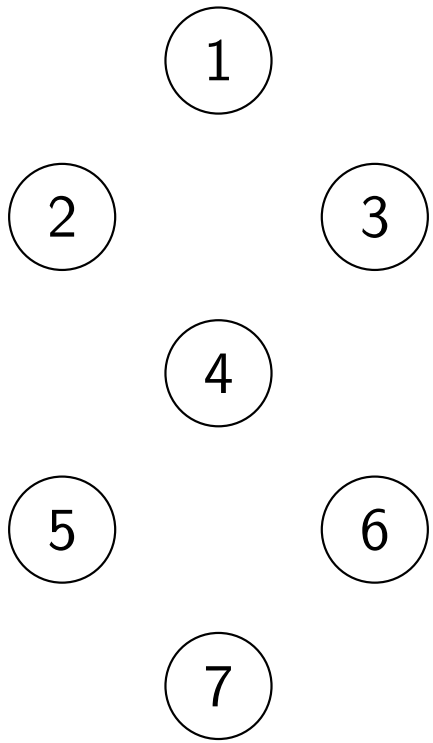
The MATSim View of (Individual) Decision Making

- agents try to optimize their daily plan given their knowledge of the state of transport system
- this state depends on other agent's behavior
  - random from the agent's perspective
- search for a good daily plan by a co-evolutionary algorithm: all agents perform an EA simultaneously
  - start with an initial plan
  - iteratively:
    - execute plan, score it
    - delete worst plan if more plans than allowed
    - select a past plan randomly based on score
    - (optional) copy it and modify it

Introduction of Coordination

- need to link plan choice for certain plans of certain agents
- no need to link plan choice for unrelated plans: risks on convergence (slow / toward a wrong state)
- $\Rightarrow$ individual plans needing coordination are grouped in "joint plans": sets of individual plans to be selected together.
- $\Rightarrow$ "incompatibility" between (joint) plans
- redefine replanning:
  1. identify groups of agents to replan together
  2. remove plans part of the worst "non-blocking" plan combination if needed
  3. select feasible combination of individual plans based on scores
  4. (optional) copy and modify those plans

Group Identification



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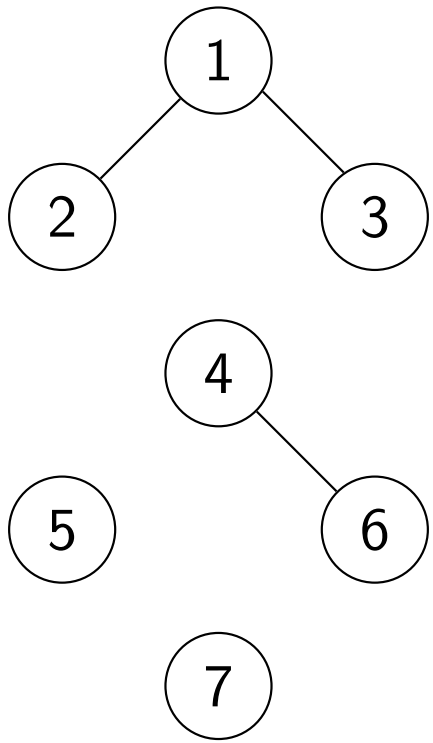

- some agents have joint plans

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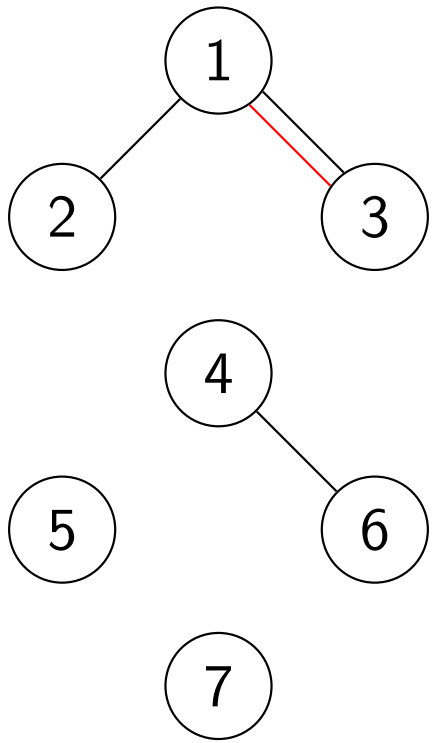

- some agents have joint plans
- or use common resources

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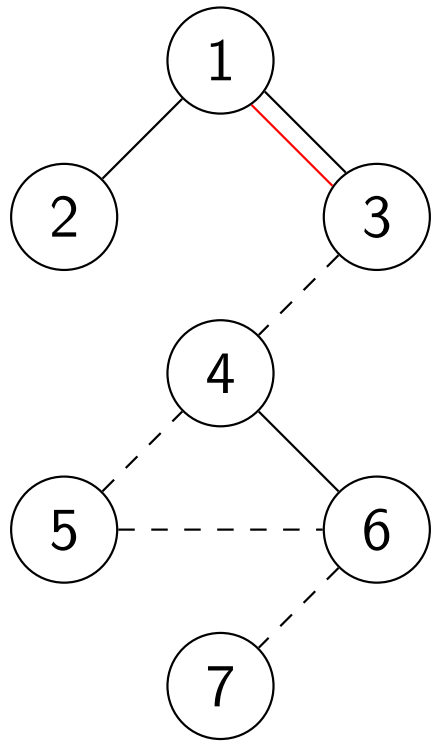

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- "social ties" along which coordination behavior can be created

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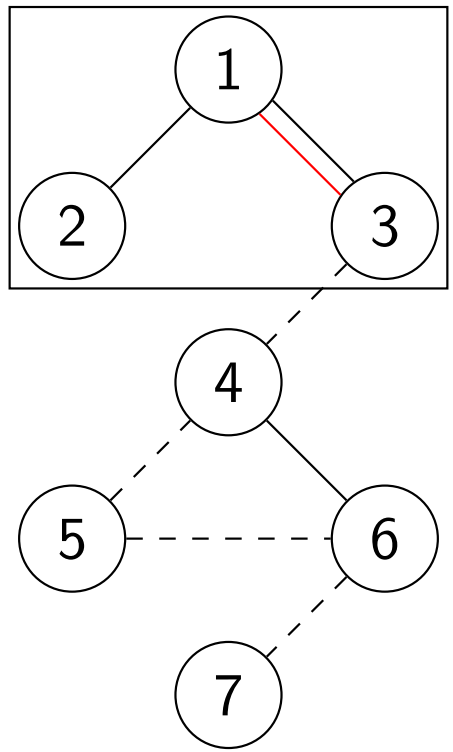

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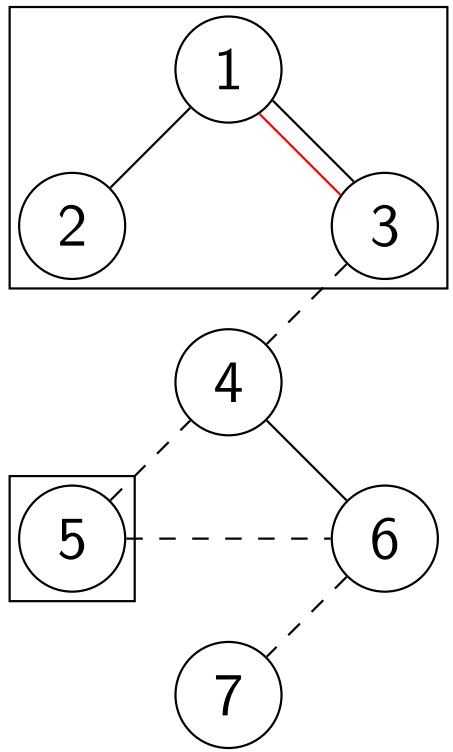

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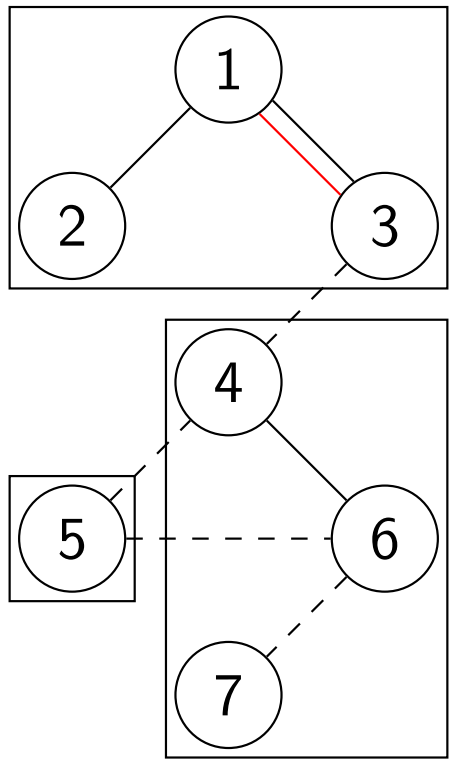

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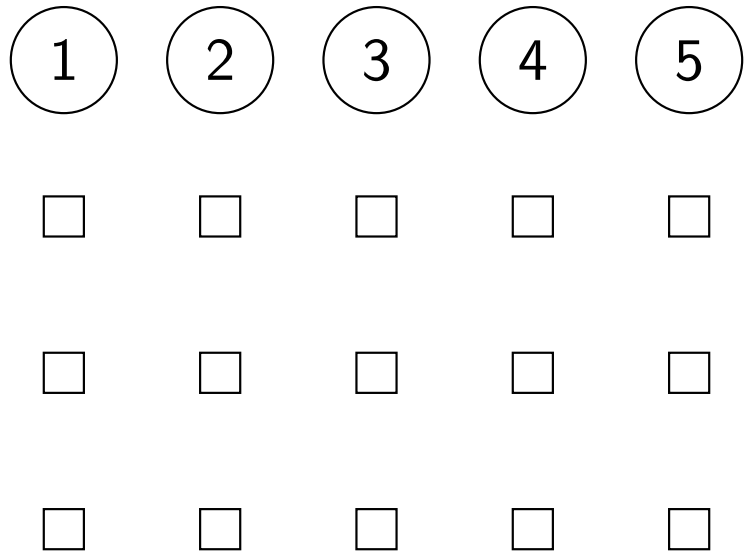

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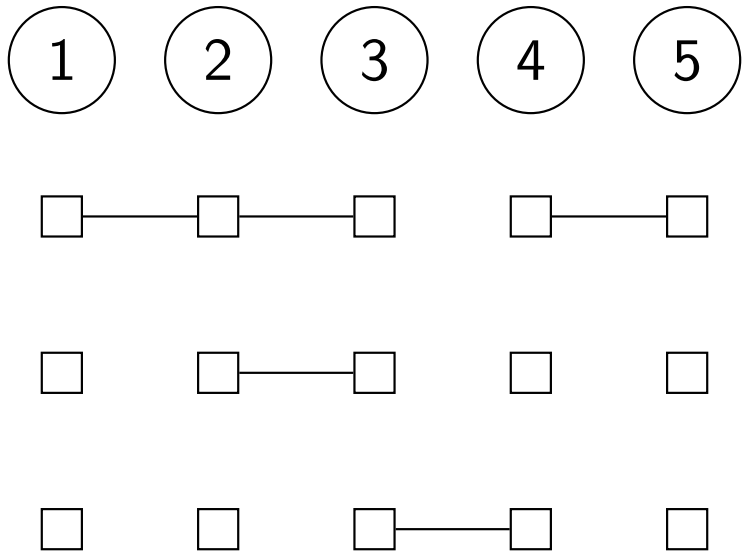

- agents have plans
- joint plans constraints

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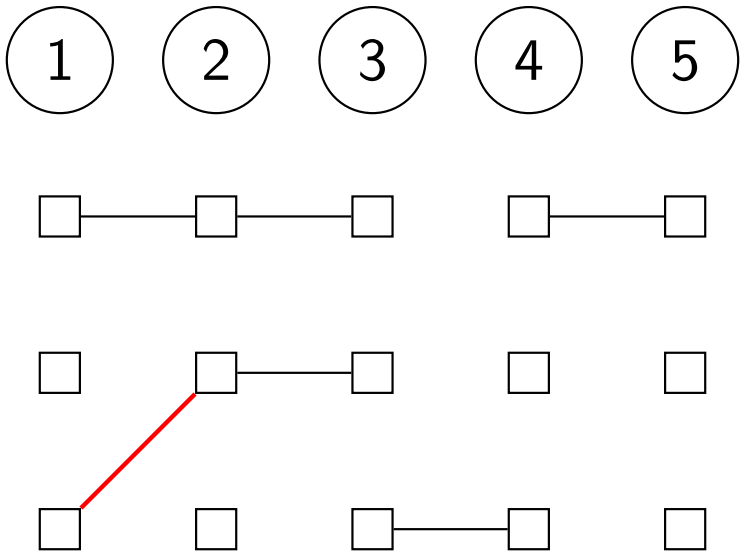

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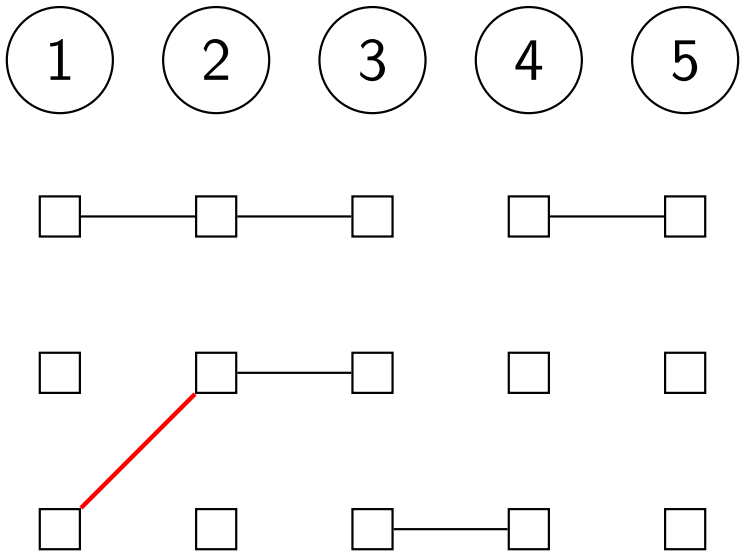

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- aim: model the choice of individual plans, given the constraints

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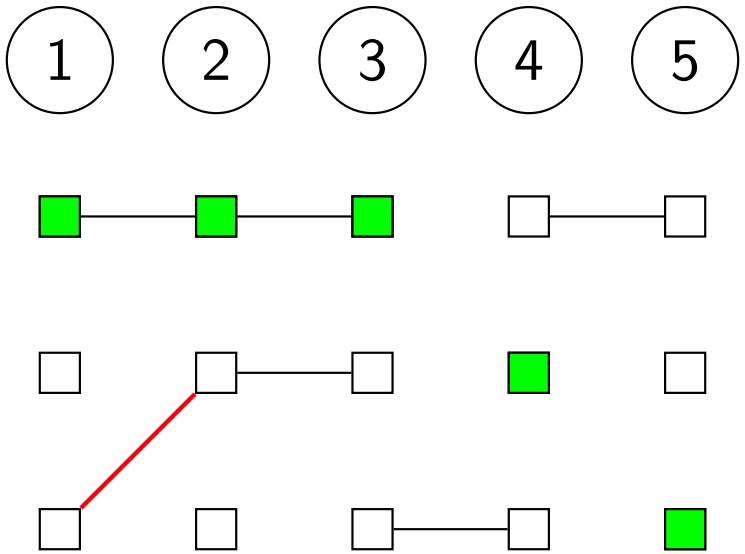

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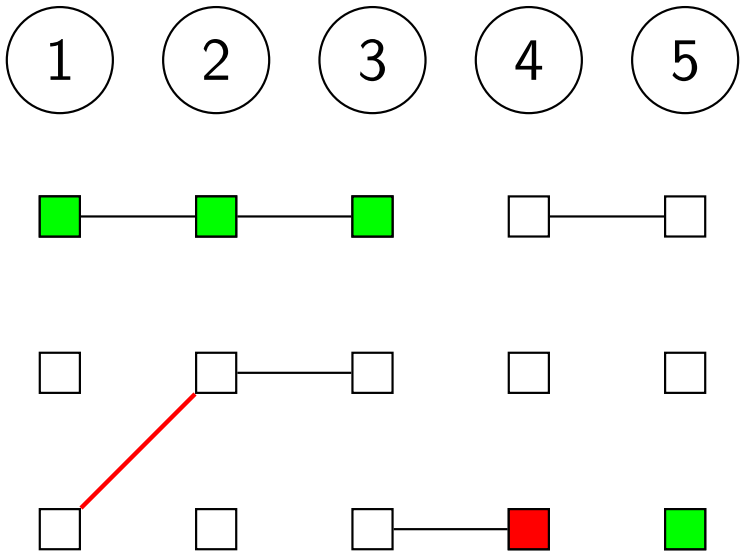

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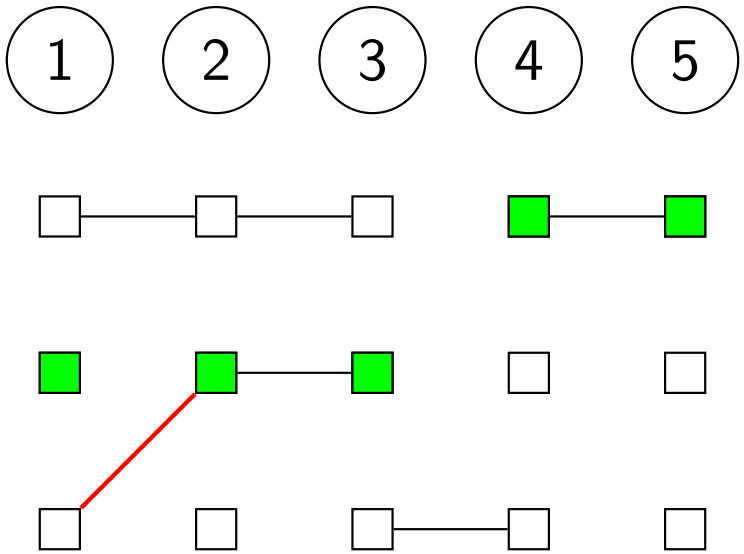

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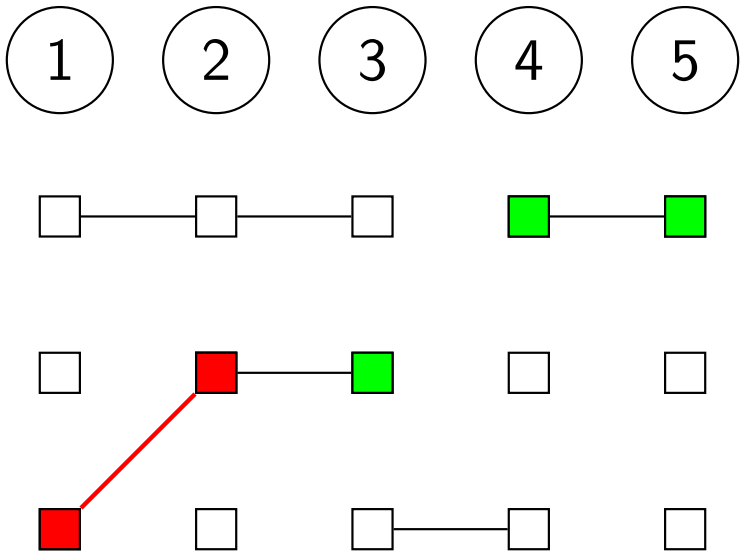

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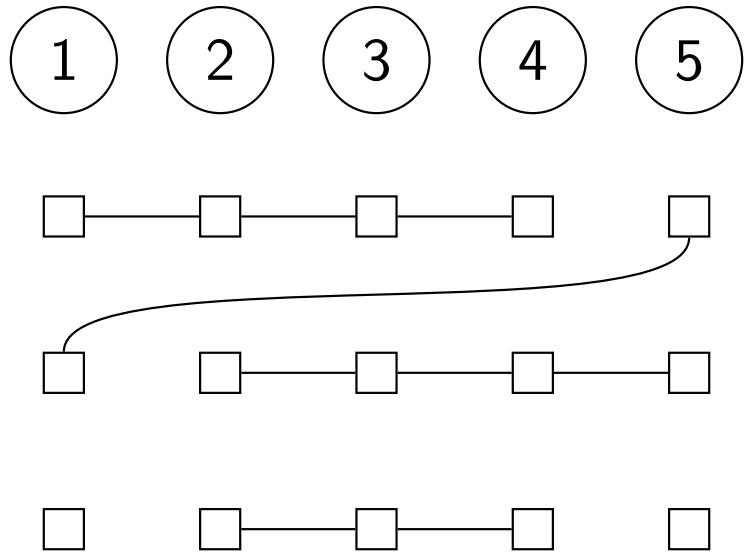
Plan Selection for Removal



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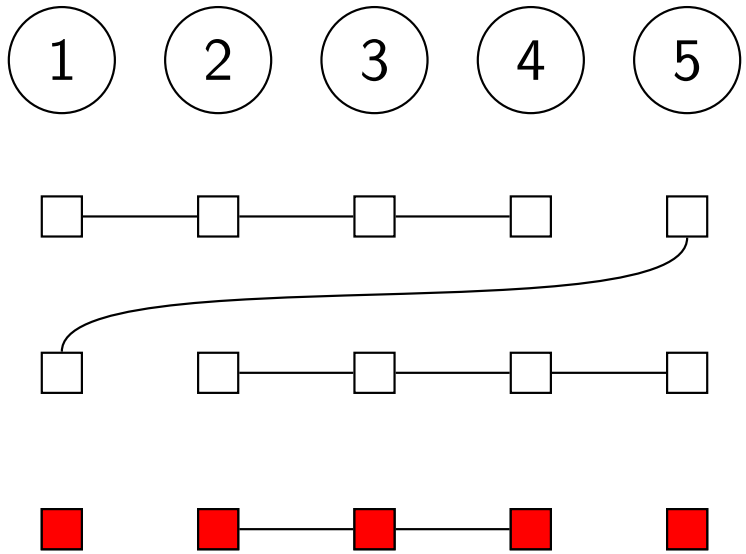

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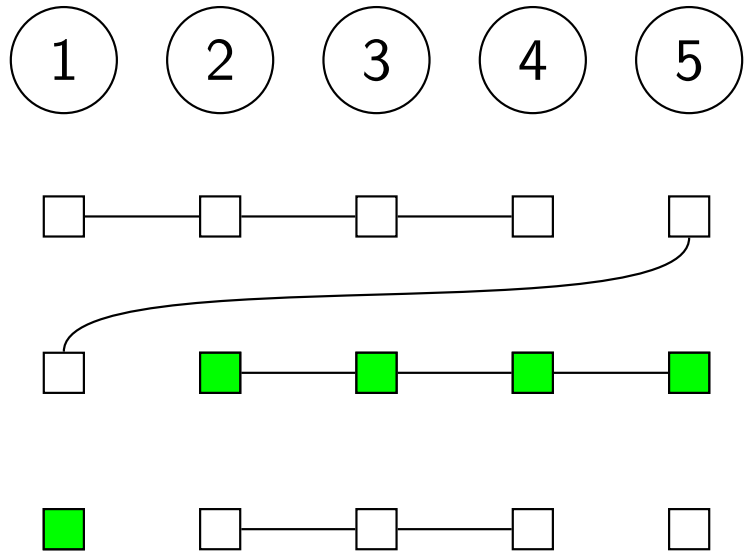

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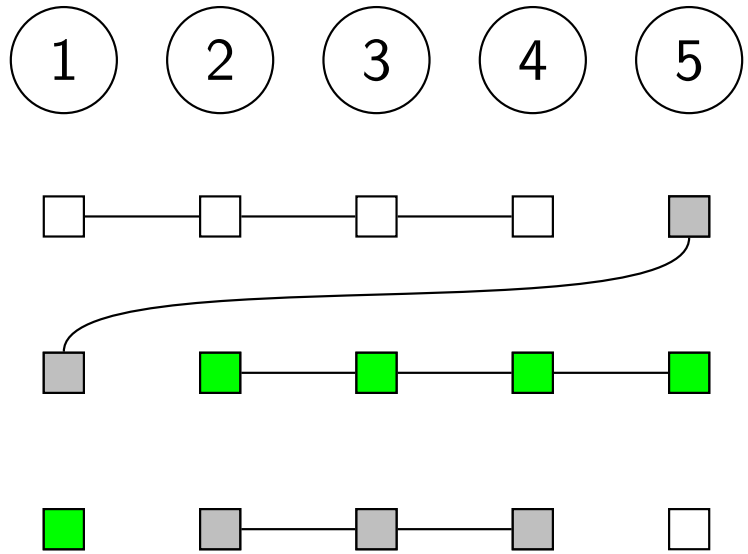

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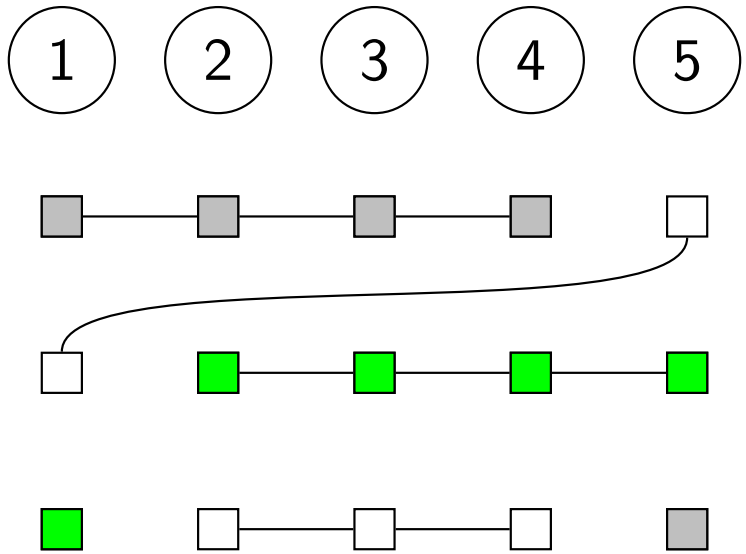

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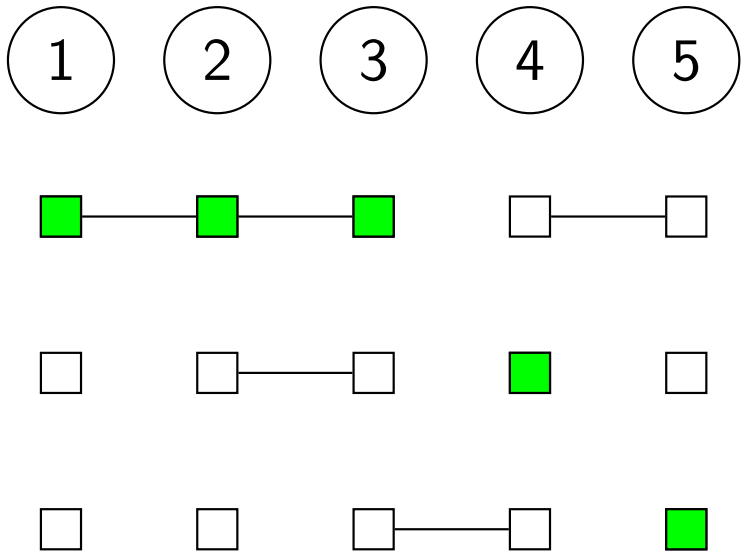
Plan Selection

- weighted selection: select the feasible combination which maximizes the sum of weights of individual plans
  - scores
  - Gumbel distributed (Logit-like)
  - random
- "utility transfers" in joint plans
- without contraints, same as selecting the plan of highest weight for each agent
- can be done efficiently (branch-and-bound)

Plan Mutation



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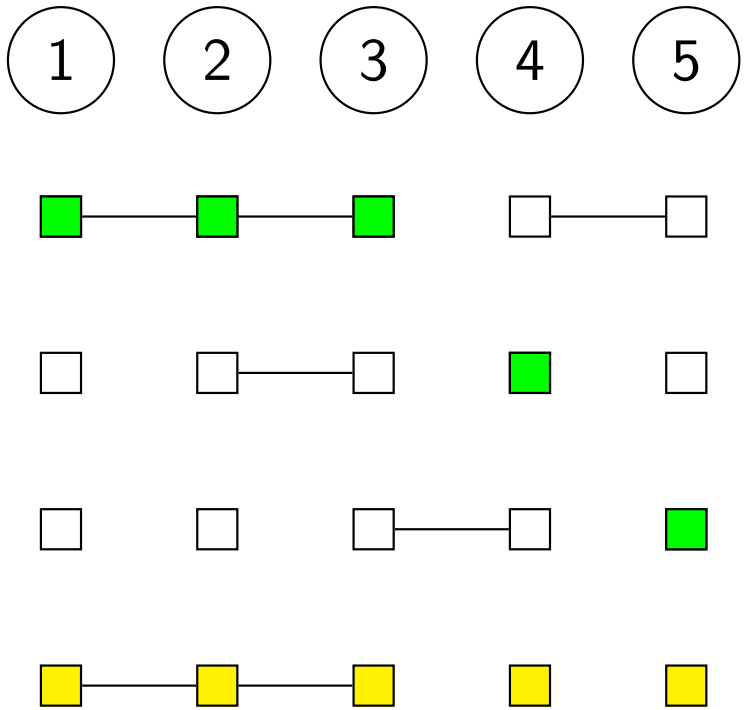

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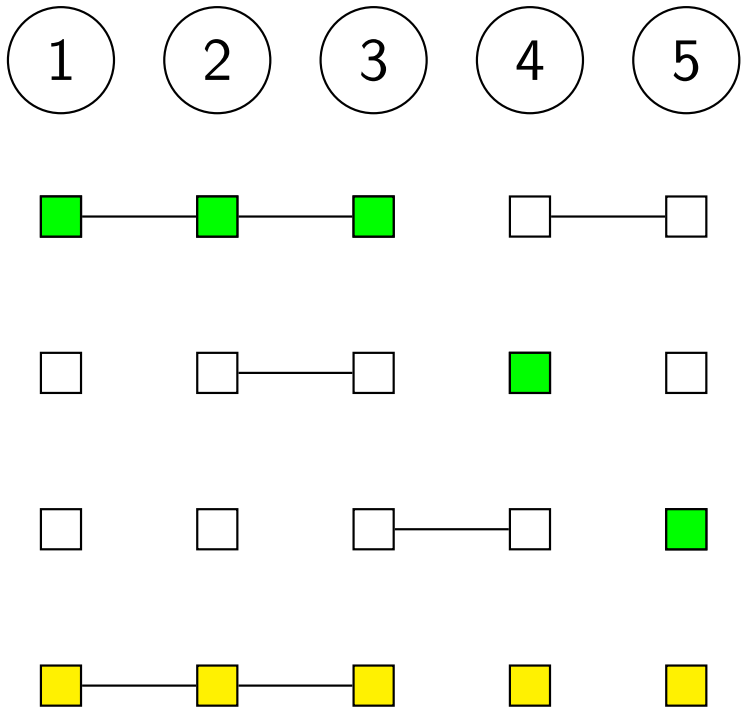

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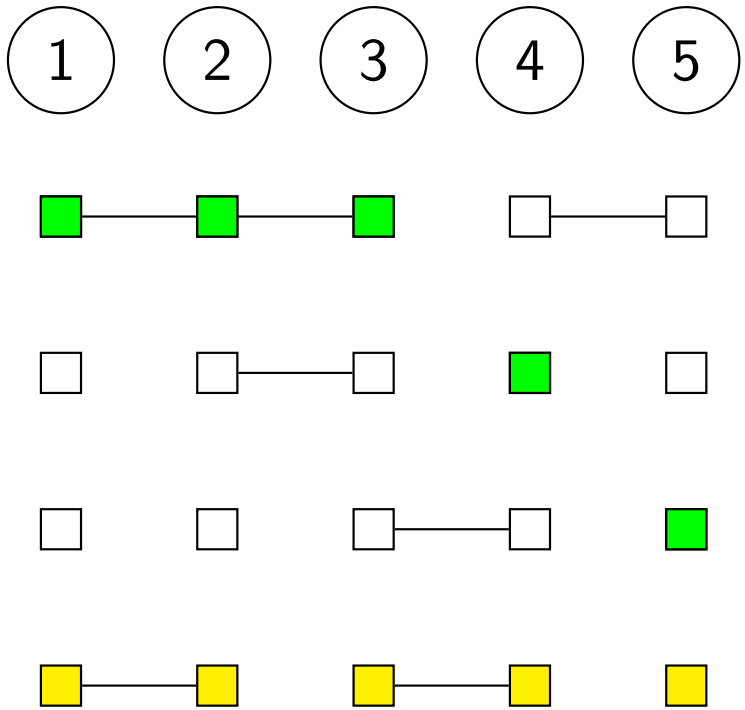

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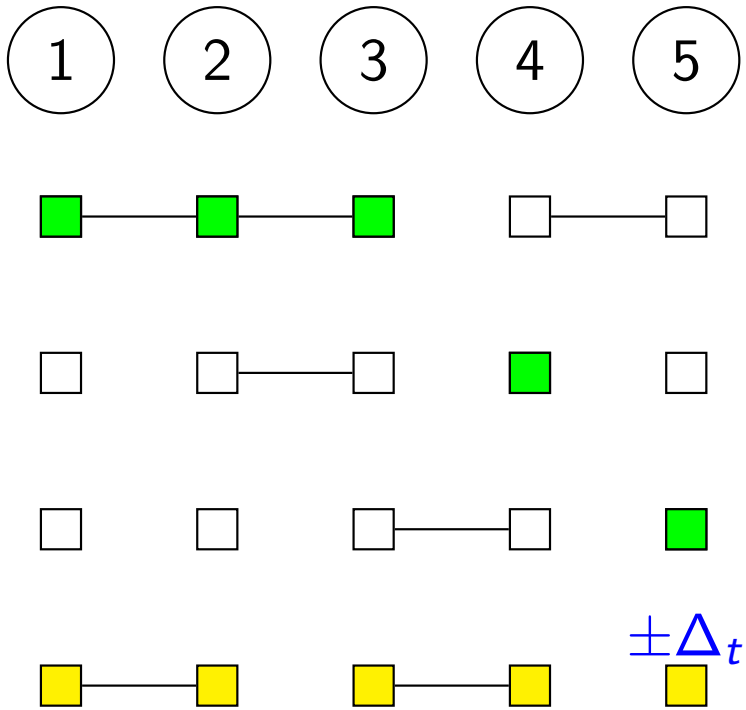


- copy
- modify:
  - agents interations
  - other dimensions

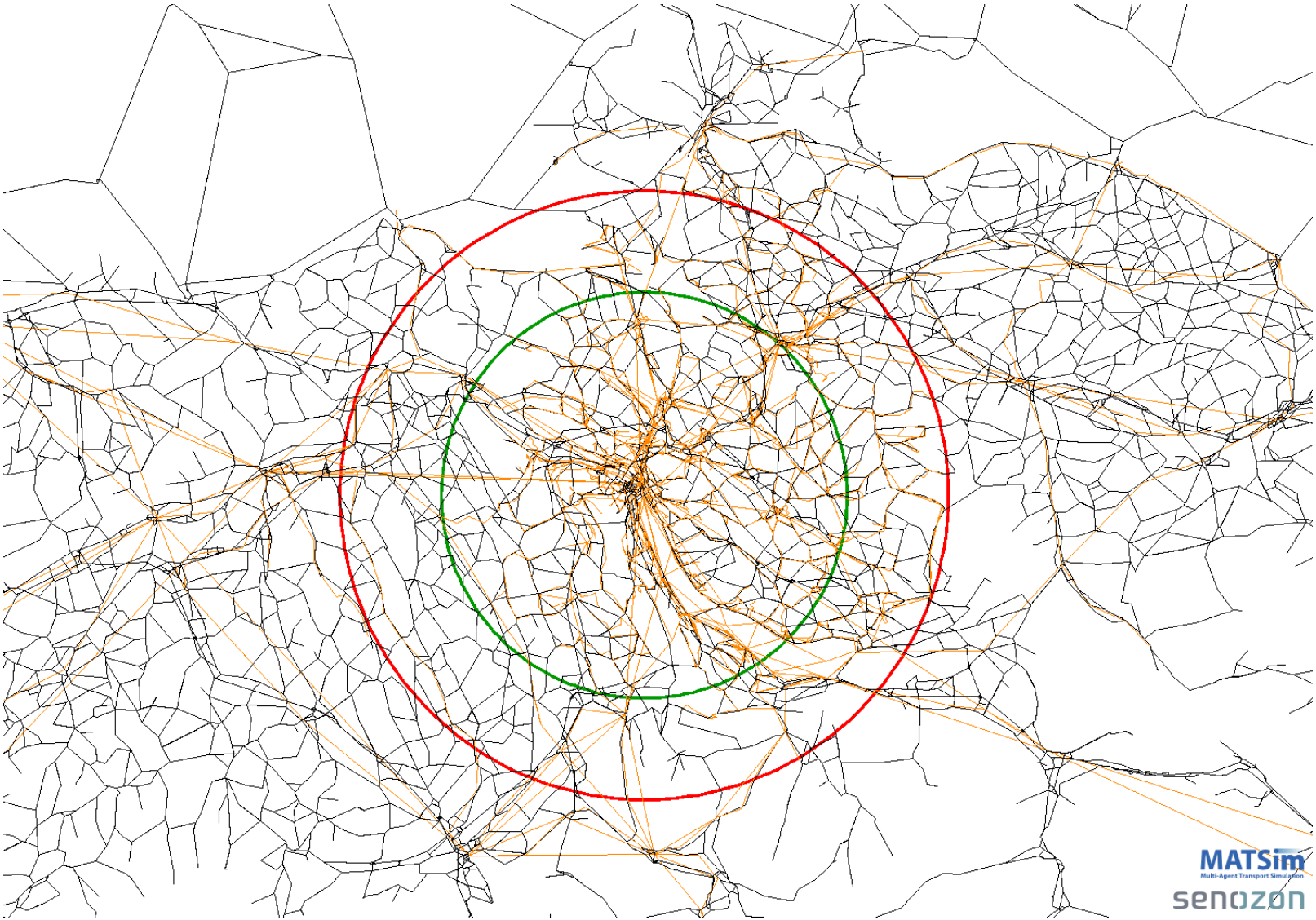
Aims

- use the approach for the case of *intra-household ride sharing*, using a pre-existing scenario for the Zurich area
- see how the approach performs when "plugging" it in a pre-existing scenario, with a minimal amount of adaptation
  - Hope: structural constraints can explain important aspects of joint travel patterns
- identify limitations of scenario/approach

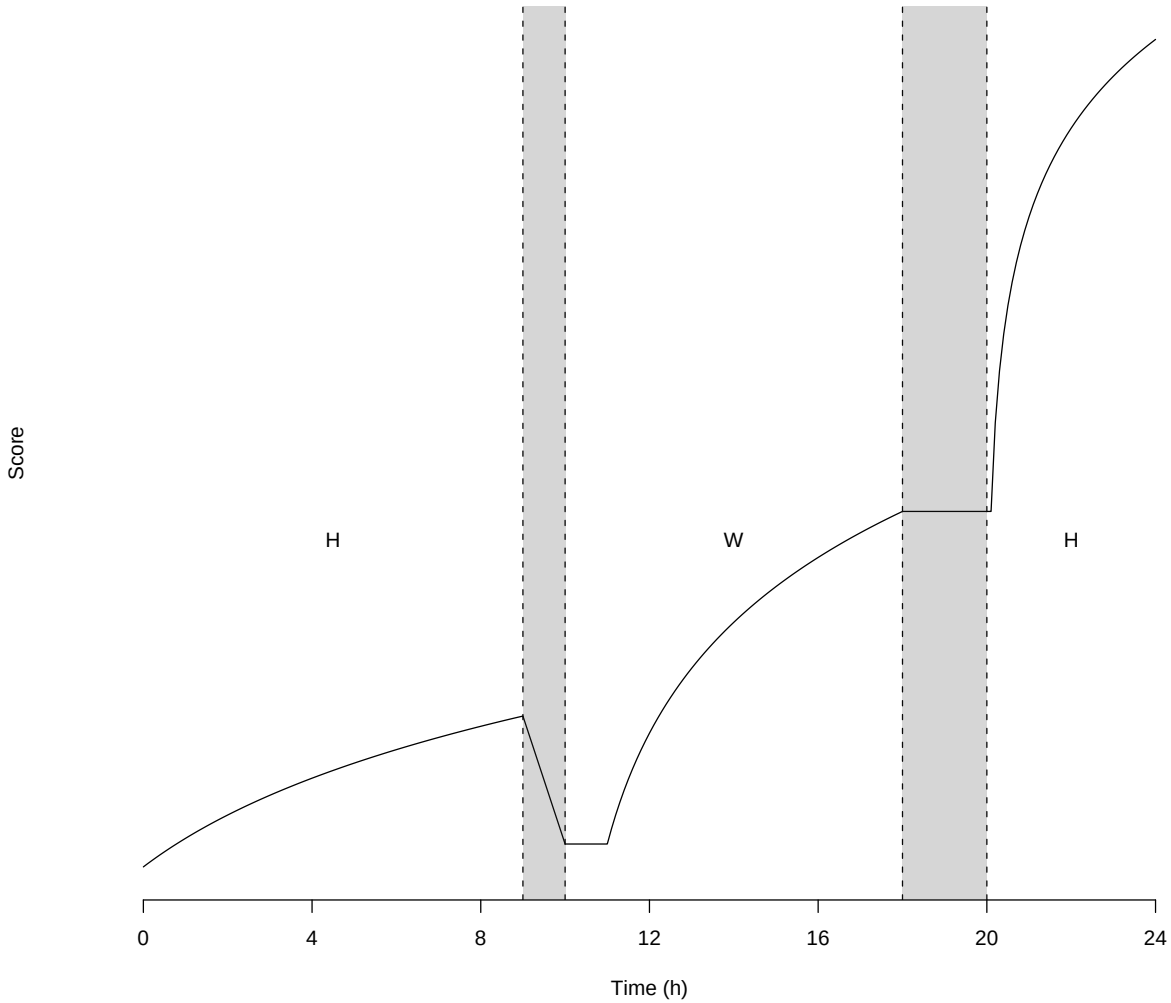
Scenario

- Zurich scenario:
  - planning network
  - schedule-based public transport
  - individuals grouped in households (Census 2000)
  - *working day* activity chains from National Travel Survey 2005
  - only households for which at least one member passes at least once closer than 30km to *Bellevue* Place are retained
  - 10% sample
- validation data:
  - National Travel Survey 2005
  - consider only trips with origin and destination closer than 20km to *Bellevue*

Network



Utility Function



Utility Function Parameters

- re-calibrated from existing scenario
- no explicit marginal disutility of traveling by car (*opportunity cost* only)
- "desired durations" differ from agent to agent
- opening times defined at the *facility* level

Replanning Modules

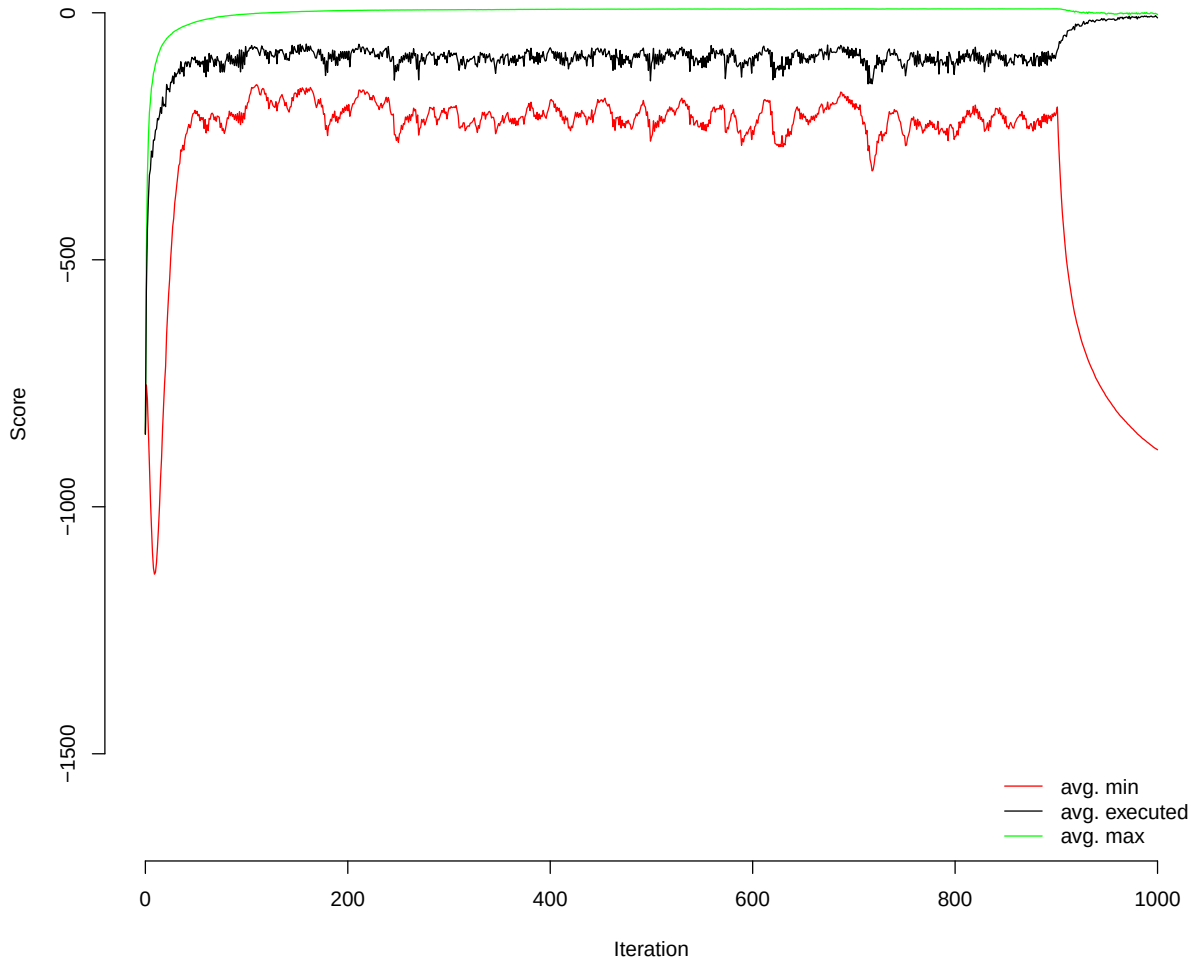
Module	Weight	Deactivated in Scenarios
Logit-like Selection	0.5	
Time Allocation Mutation	0.1	
Subtour Mode Mutation	0.1	
Re-routing	0.1	
Joint Trip Mutation	0.1	*base*
Joint Leisure Location Choice	0.1	*base*, *jt*

- full household always replanned together
- Joint Trip Mutation: *joins* a car and a public transport trip
- Joint Leisure Location Choice: allocates randomly a leisure location *from the set of leisure locations of the household*
- "innovations" deactivated after 900 iterations

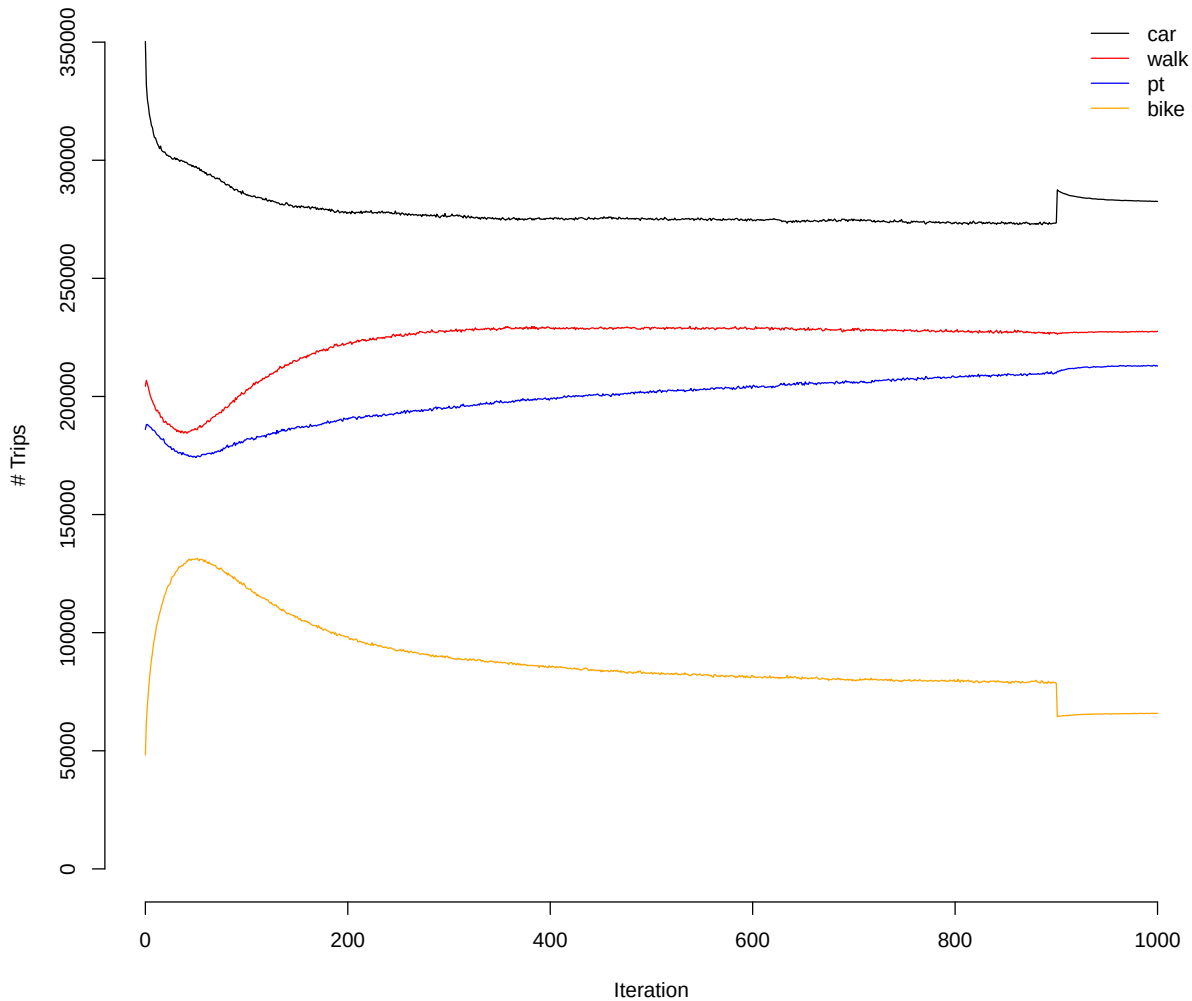
Variants of the Scenario

1. *base*: no joint travel
2. *jt*: joint trips are randomly included
3. *jt.l*: joint trips are randomly included, leisure location choice
4. *jt.l.s*: joint trips are randomly included, leisure location choice, score linearly time passed with household members
5. *jt.l.sl*: joint trips are randomly included, leisure location choice, score linearly time passed with household members *in leisure activities*
6. *jt.l.sll*: joint trips are randomly included, leisure location choice, score logarithmically time passed with household members *in leisure activities*, with the same parameters as for leisure

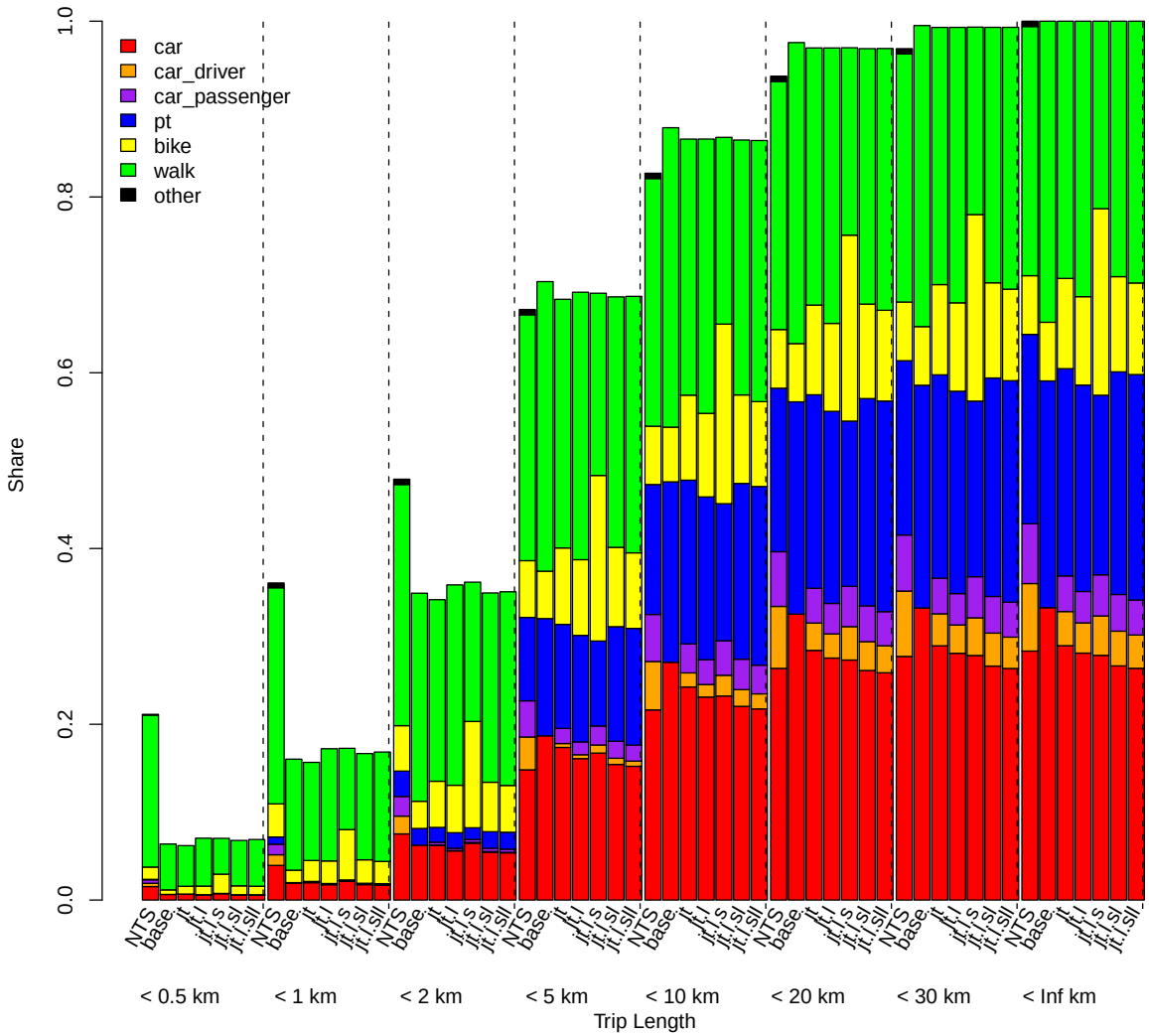
Score Evolution (Base Scenario)



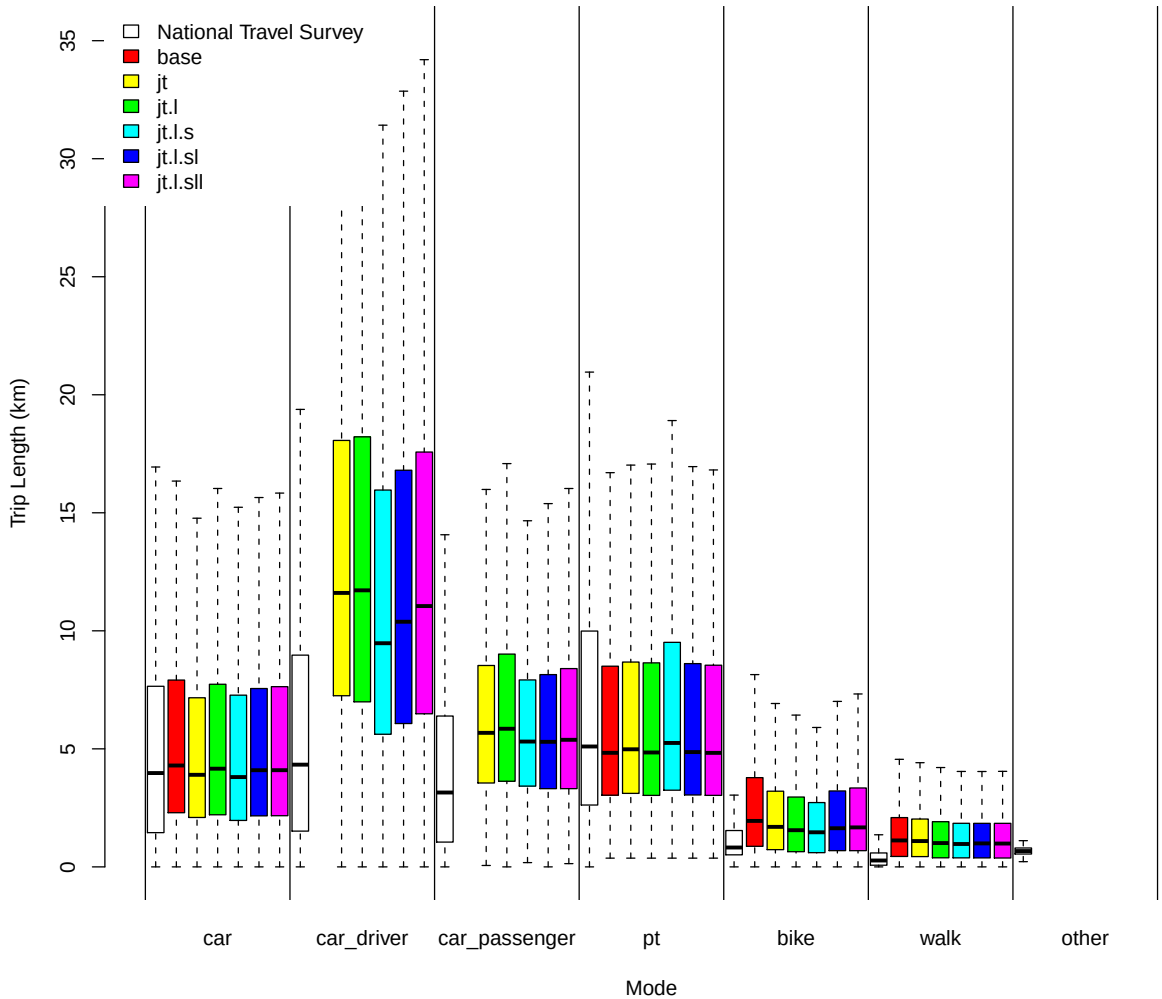
Mode Evolution (Base Scenario)



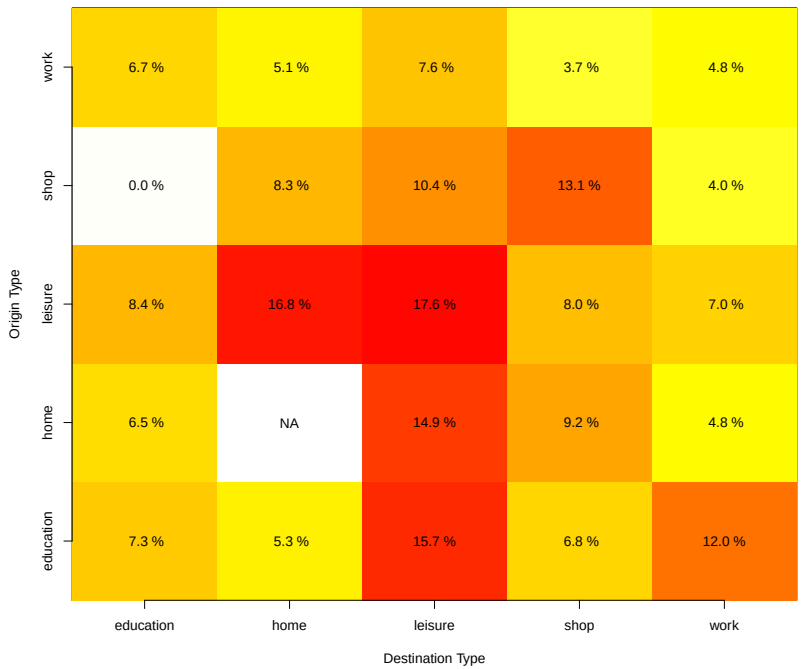
Mode Share Comparison

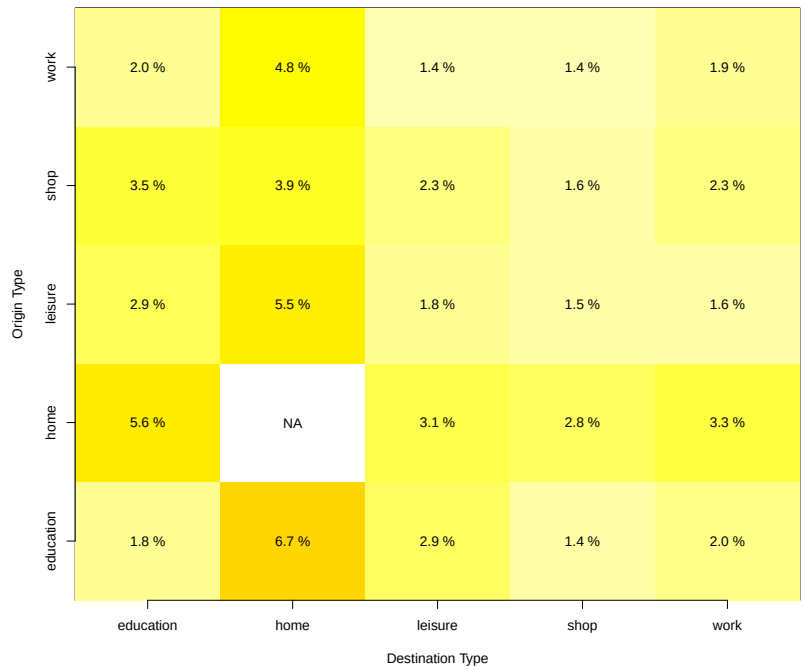


Distance Distribution per Mode

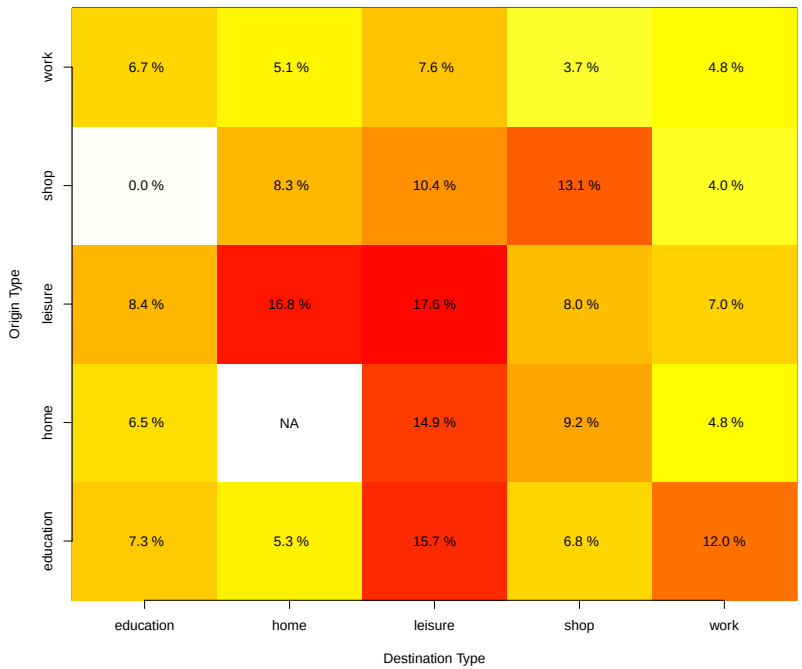


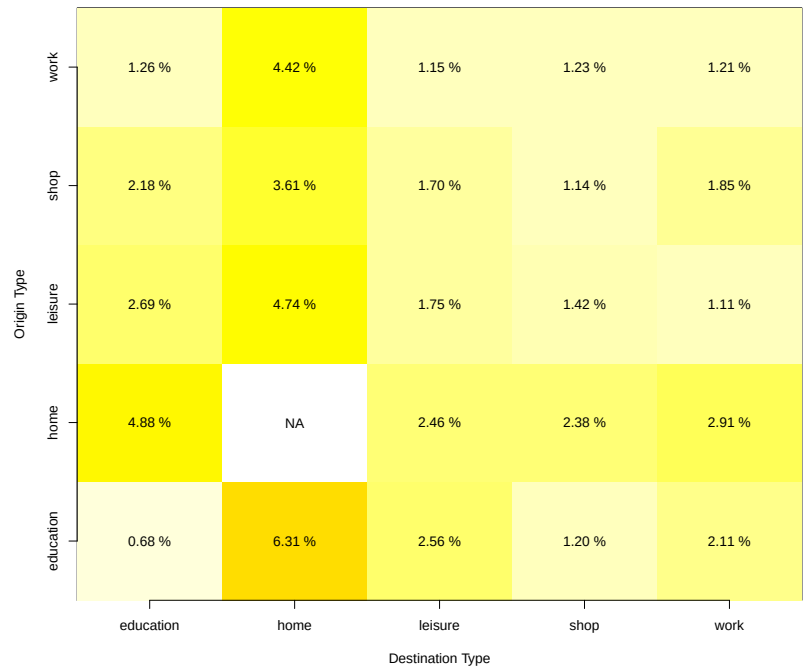
Passenger Share per Purpose: NTS vs jt





Passenger Share per Purpose: NTS vs jt.l





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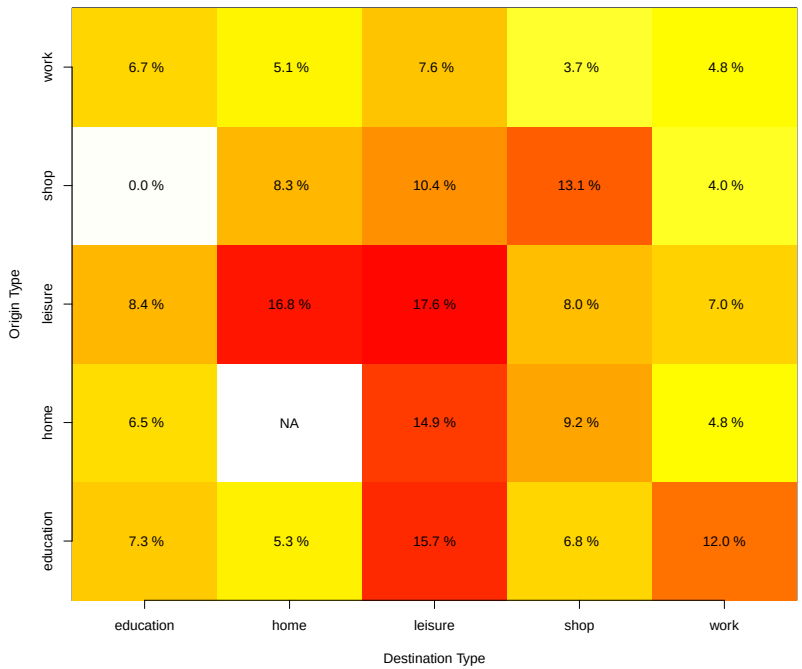

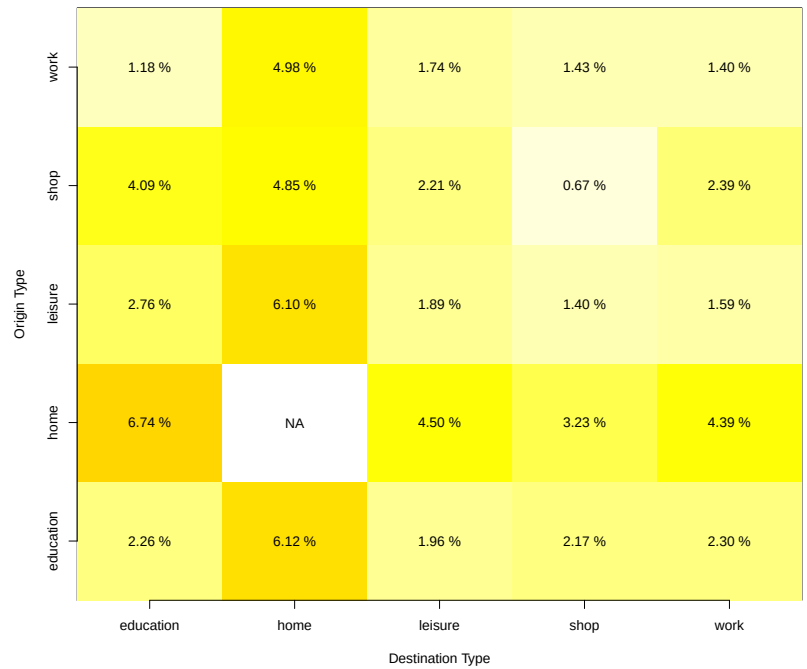

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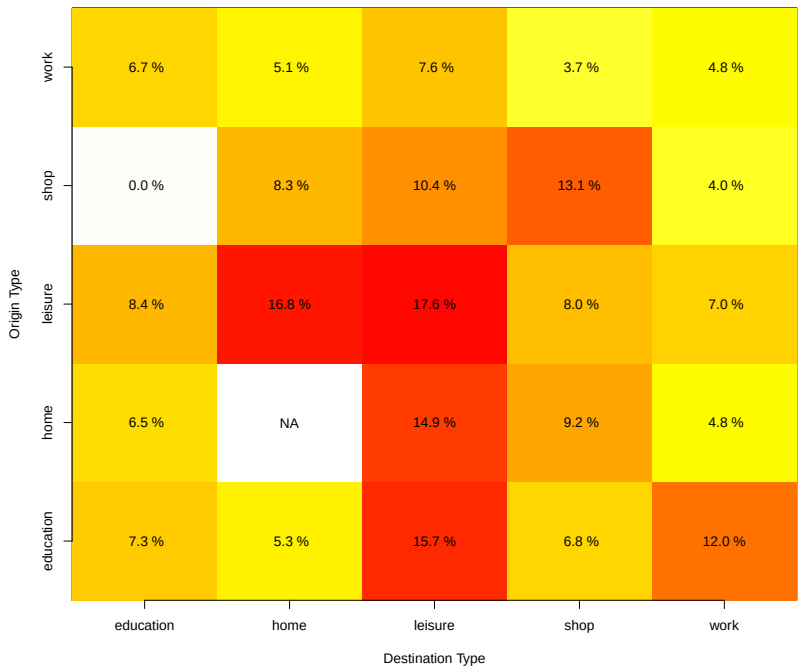

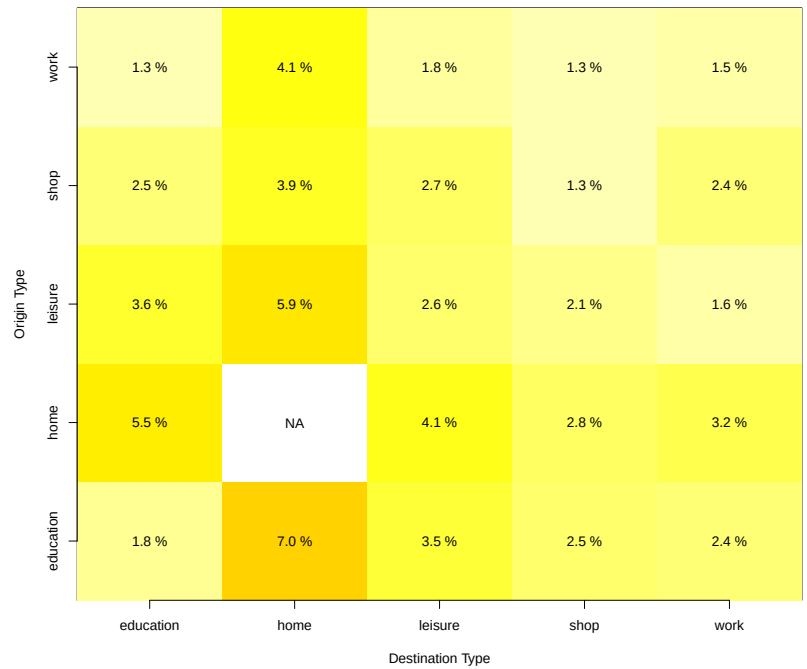

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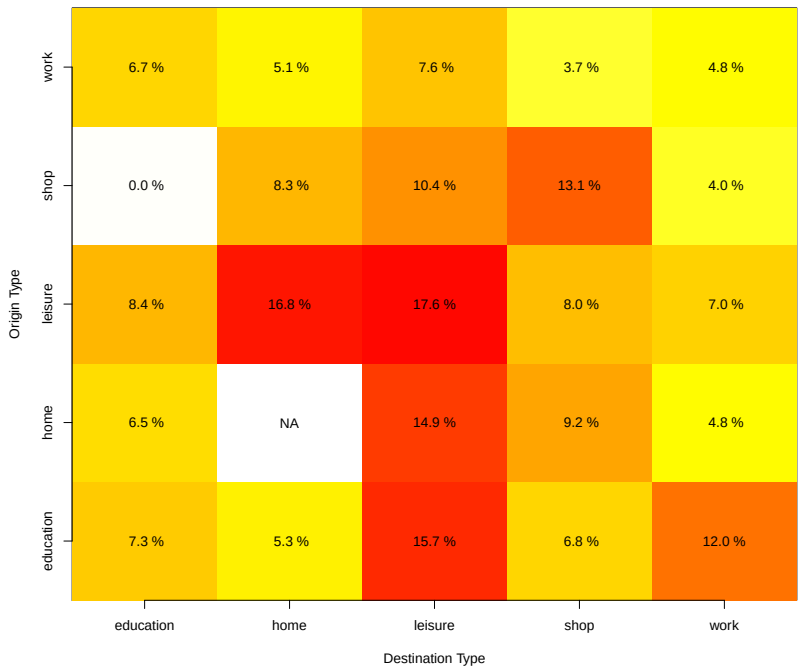

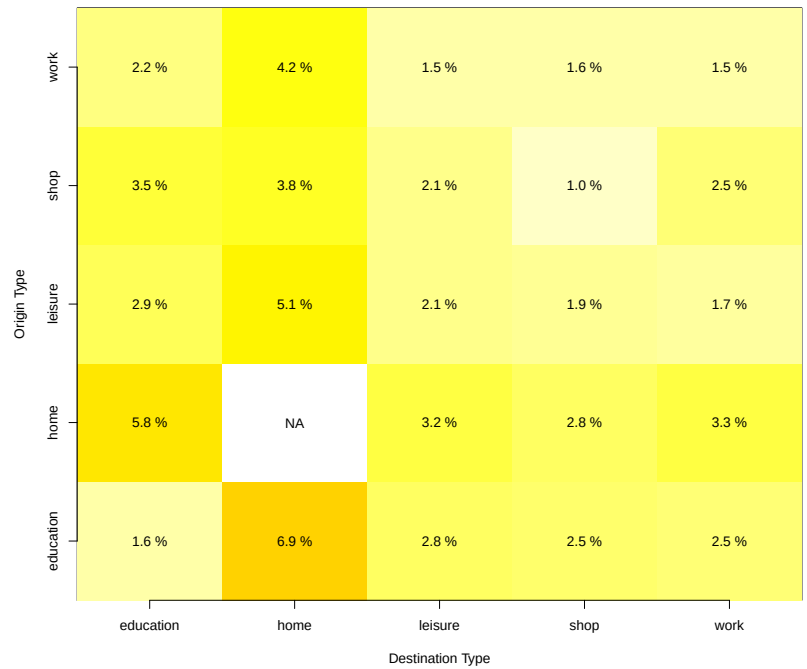

Summary

- though "utility transfers" seems a strong hypothesis, joint travel share underestimated
  - no explicit cost of travel
  - no limited vehicle resources (no data)
- "drive to work/school" trips quite well predicted, the rest underestimated
- driver detours are overestimated, probably due to the absence of explicit disutility of travel
- associating a positive utility to joint presence at leisure activity *did not* improve the share of joint modes to leisure activities
  - no joint generation of schedules
  - no generation of pure serve passenger tours
  - only intra-household ride-sharing

Conclusion

- most travel simulation tools do not include joint travel
- an approach applicable with general social network topologies was implemented in MATSim
- comparison of the results with travel diary data allows to identify limitations of the approach and plan the next steps

Next Steps

- improve accuracy of driver detours
  - re-calibrate a scenario with cost of travel
  - joint activities w/ location choice?
    - not a significant impact for the approach used here
- improve overall passenger share
  - household-level correlation of plan construction / co-adaptation of plan structures
  - consider limited vehicle resources
  - generate pure *serve-passenger* tours?
    - purpose "service" represents only 10% of the driver trips in the National Travel Survey
  - include friendship relationships?
- improve specificity of leisure purpose
  - consider friendship relationships?
  - co-adaptation of plan structure