Including Individual's Coordination in a Multi-Agent Transport Simulation

Thibaut Dubernet

Institute for Transport Planning and Systems (IVT)
ETH Zurich

STRC 2013

Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Introduction

- most travel simulation tools simulate behavior of *isolated* individuals
  - individuals make decisions independently, given traffic conditions influenced by others
- actual 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

Introduction

Agent's Coordination in MATSim

Performance

Conclusions

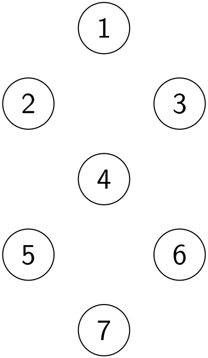
The MATSim View of (Individual) Decision Making

- 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)
- ⇒ individual plans needing coordination are grouped in "joint plans": sets of individual plans to be selected together.
- ⇒ "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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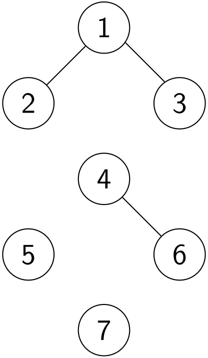

- some agents have joint plans

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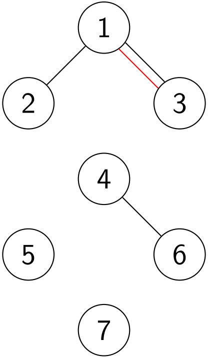

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- or use common resources

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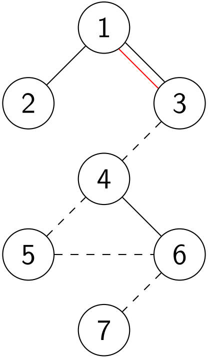

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- "social ties" along which coordination behavior can be created

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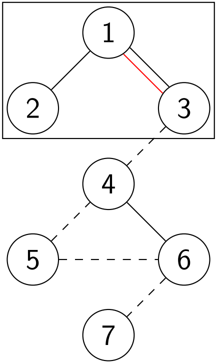

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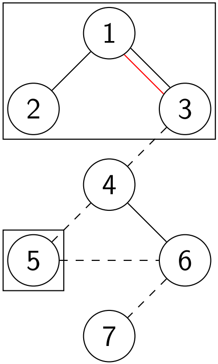

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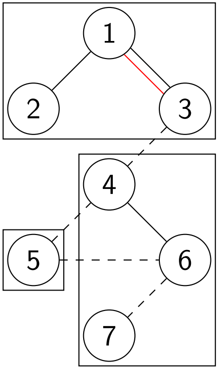

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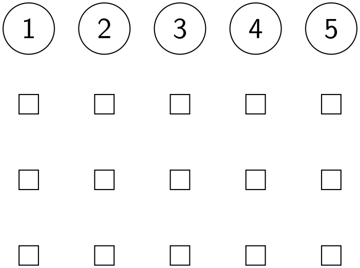

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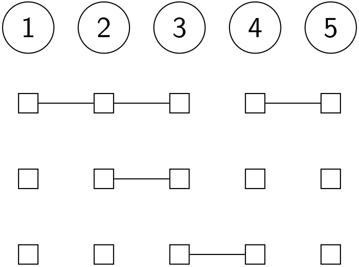

- agents have plans
- joint plans constraints

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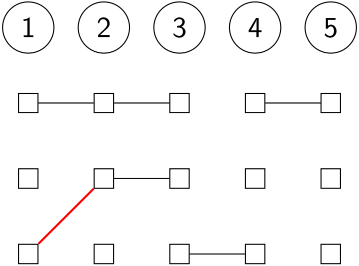

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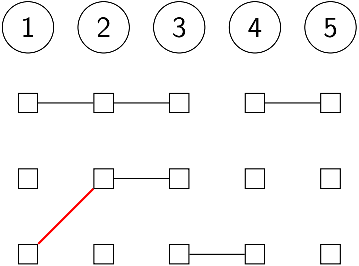

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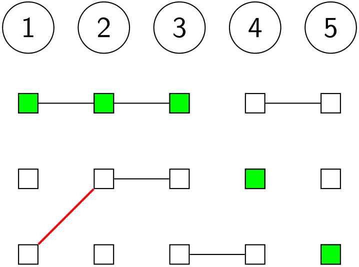

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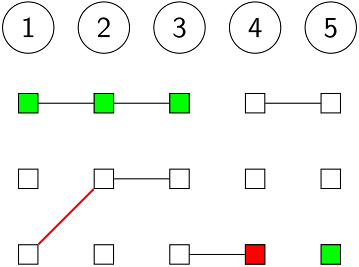

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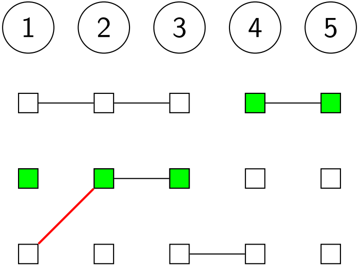

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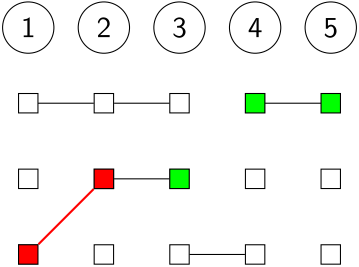

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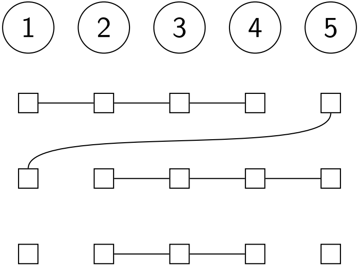
Plan Selection for Removal



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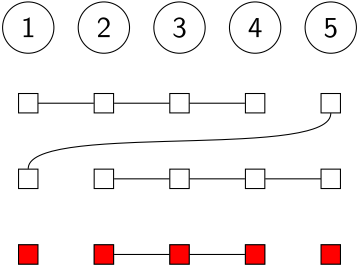

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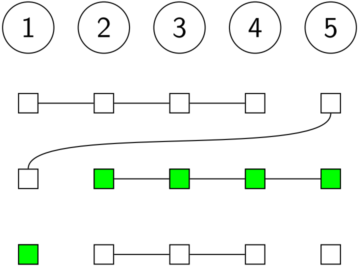

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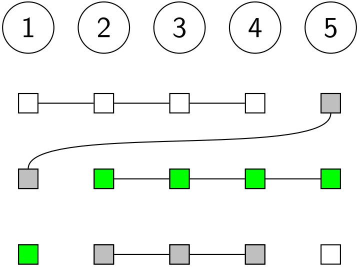

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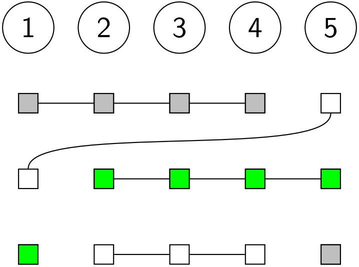

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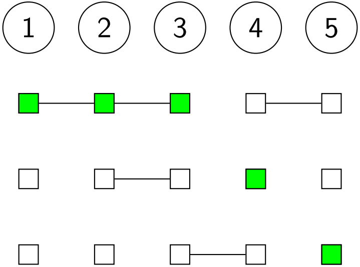
Plan Selection

- 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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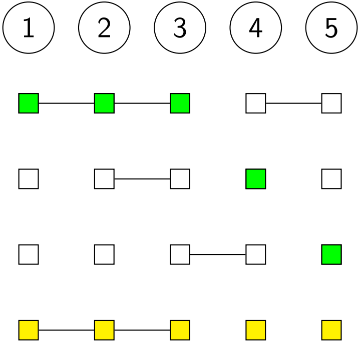

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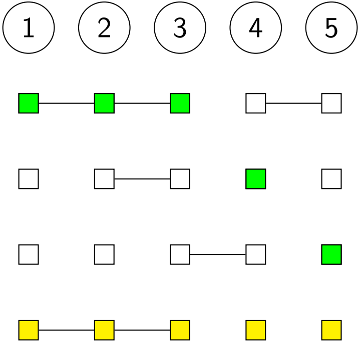

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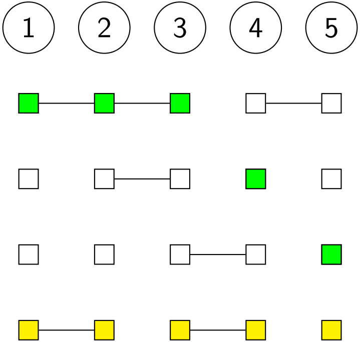

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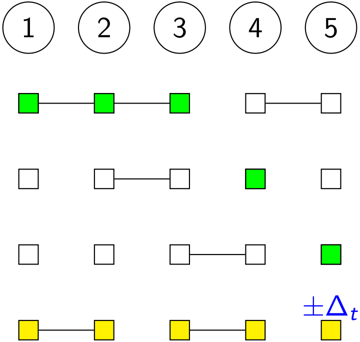

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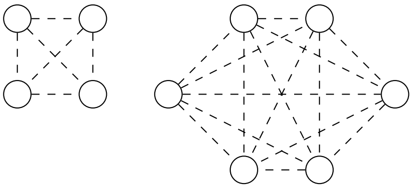
- modify:
  - agents interations
  - other dimensions

Test Scenario: Shared Vehicles in Households

- "corridor" network, with large capacity (no congestion)
- H-W travel time by car: 6min
- 10010 agents with H-W-H plans
- "desired" work duration 4h, always open
- even-sized fixed cliques, from 2 to 20 members



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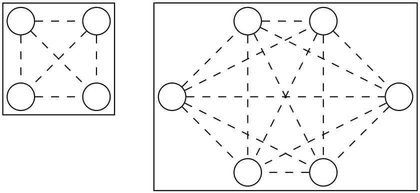

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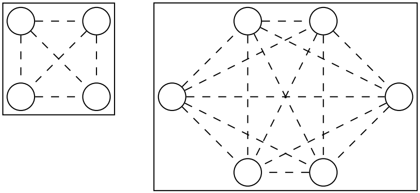

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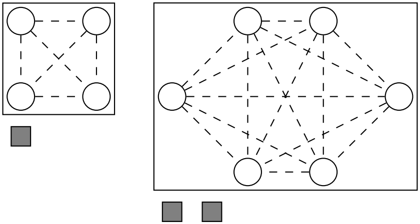
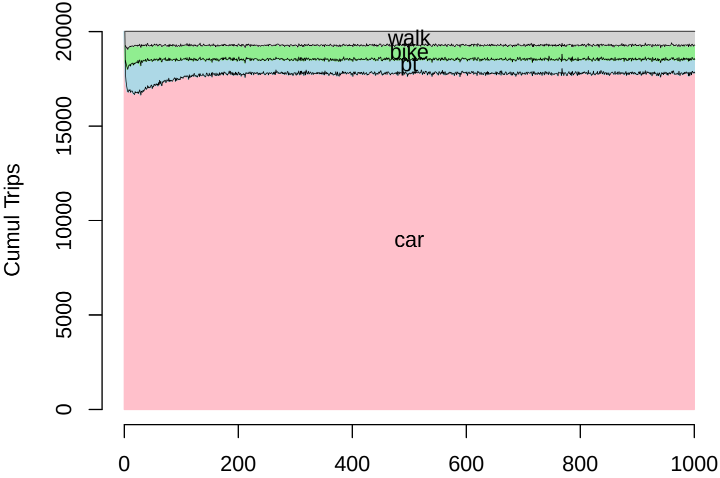
- one vehicle for 4 agents in the clique.



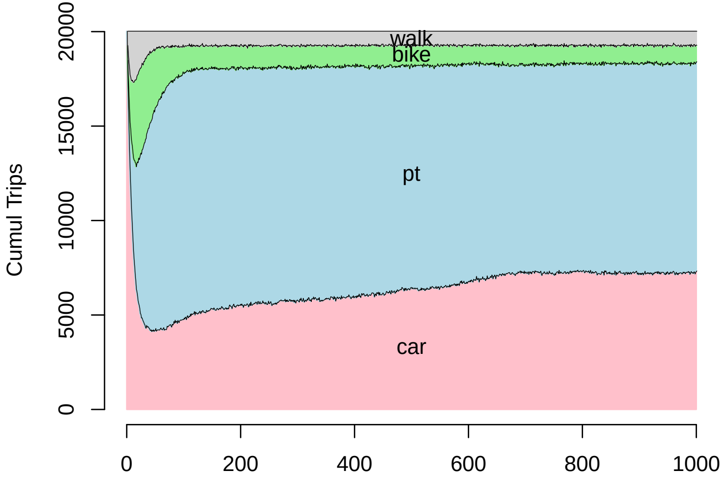
Replanning Strategies

Strategy	Probability
Logit-like choice	0.6
Mode mutation	0.1
Random vehicle reallocation	0.05
Joint plans recomposition	0.05
Time mutation	0.2

Mode Evolution, Own Car



Mode Evolution, Limited Car, No Coordination



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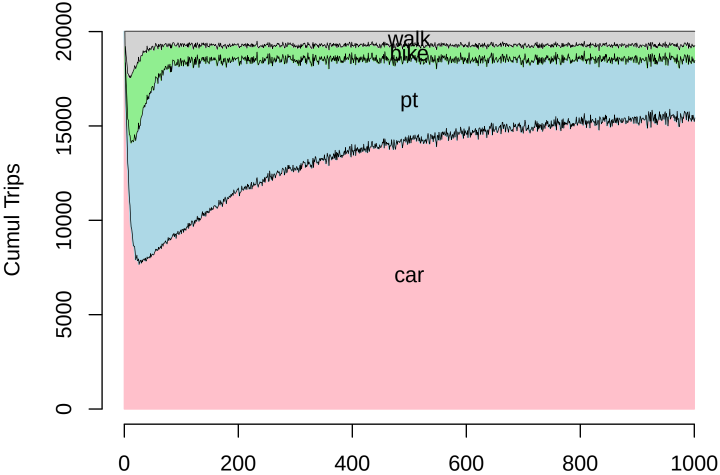
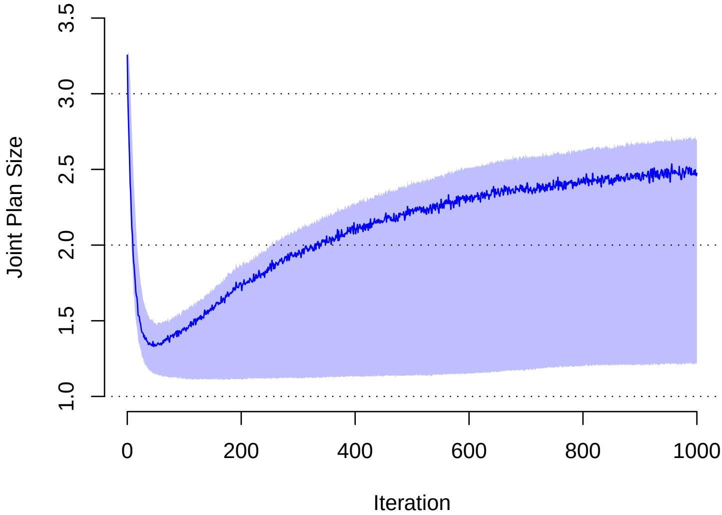


Conclusions

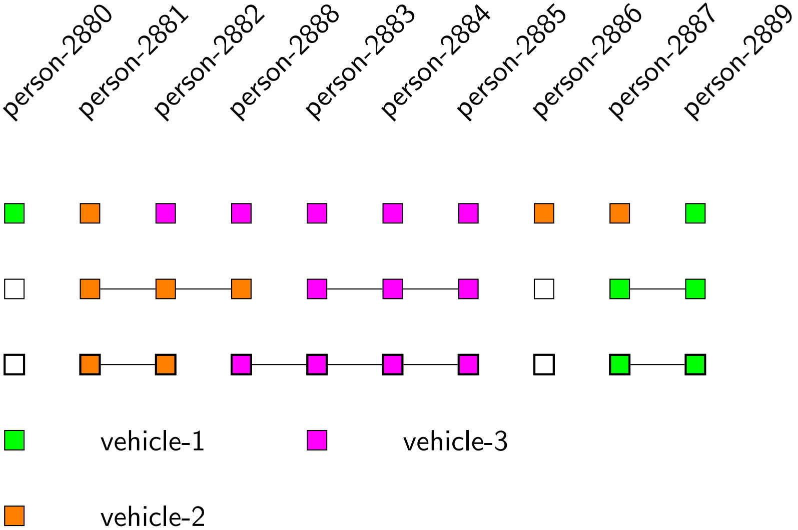
- motivations:
  - coordination of individuals is an important behavior
  - most travel forecasting models/simulation tools are individual based
- performance of the approach:
  - behaves *quite* well for joint trips (*c.f.* paper)
  - behaves *reasonably* well for shared vehicles
  - group level plan selection can be very slow!
- demonstrated here on cliques, but more complex network structures are possible
- next steps:
  - validation for intra-household ride-sharing (requires calibrated scenario!)
  - joint trips *and* limited vehicle resources
  - joint activities

Questions?

Evolution of Joint Plans Size



Example of Final Joint Plan Structure



Running Times

Run	Total Dur. (min.)	Avg. Repl. Dur. (ms)
Own Car	23	2
Lim. Car, No Coord.	20	1
Lim. Car, Coord.	42	799

Final Mode Shares

	Mode Share (%)		
Mode	Own Car	No Coord.	Coord
Walk	3.71	3.74	3.80
Bike	3.85	4.37	3.92
Public Transport	3.51	55.27	15.21
Car	88.94	36.62	77.07