Expanding the First Mile Access to Transit: Assessing the Capabilities of Demand Responsive Transport to Feed Rail Transit Stations in the San Francisco Bay Area

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Contents

- Motivation
- Methodology
  - MATSim as simulation framework for dynamic modes
  - Simulation of shared taxi services
  - How to evaluate the performance of a shared taxi fleet
- Application: BART feeder services
- Conclusion

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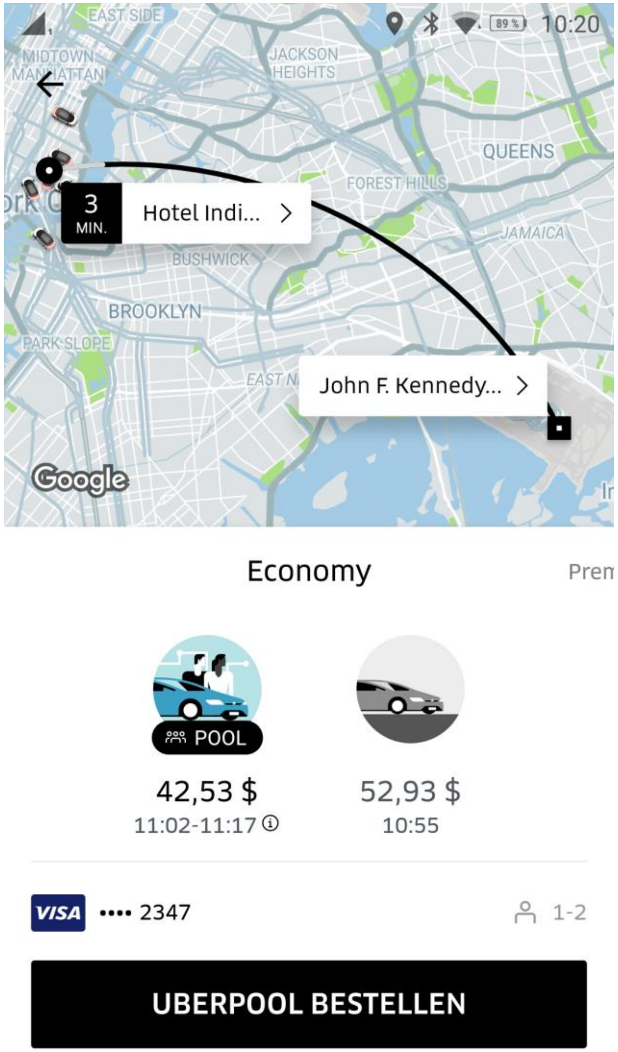
Motivation

- TNCs (Uber, Lyft, taxify) have started to offer pooled passenger services
- Multiple passengers are matched, offering a lower price with a small increase in travel time
- Guaranteed arrival window at a fixed rate
- Risk of sharing is on the operator‘s side



Motivation

- Agent based simulation models allow a direct assessment of fleet paramters without too much real-world data to answer:

- Sustainability questions
    - Comparison of e.g. TNC vs. public transport (vs. private car)

- Future fleets of Autonomous vehicles
  - Shared Autonomous vehicles

- Answer of both supply and demand related questions
  - Effect of prices, service areas, …

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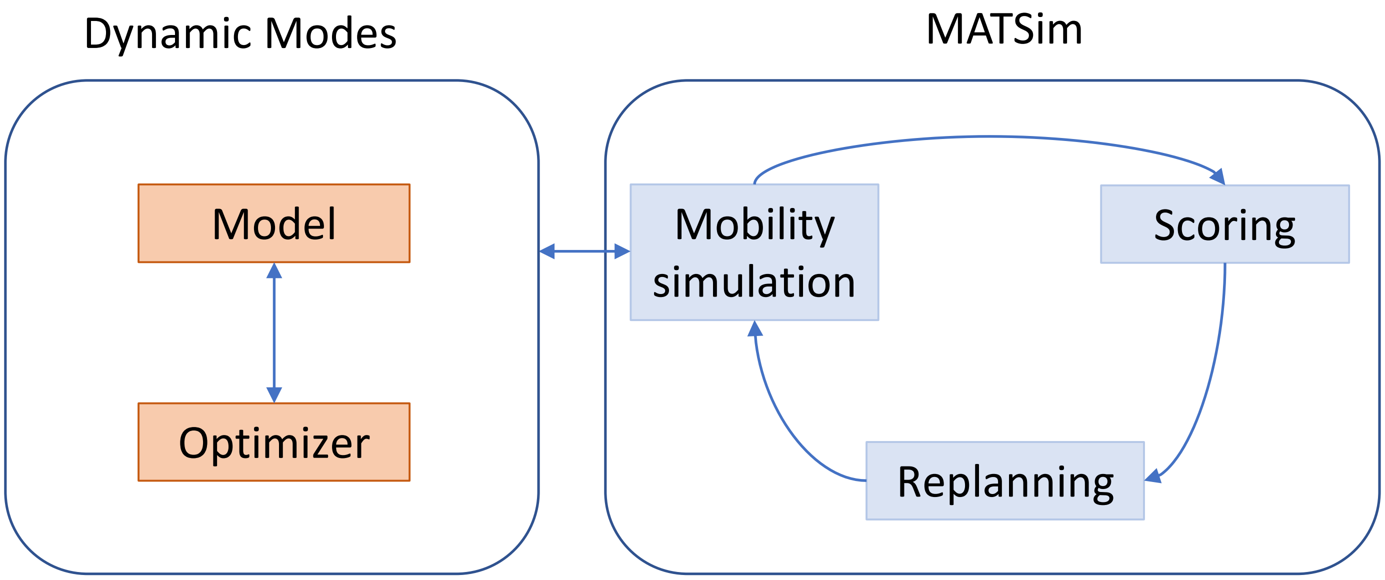
Methodology: MATSim

- MATSim allows the simulation of agents along their daily activity chains
- Open source, written in JAVA and well-documented
- Multiple iterations with behavioral changes in between allow agents to maximize their utility
- Dynamic modes, such as taxis or DRT directly operate within the traffic simulation runtime



Simulation of dynamic transport services in MATSim

DVRP module

- **DVRP** = Dynamic Vehicle Routing Problem

- Real-time fleet management
- Fleet included into traffic
- Interaction between the dispatcher, drivers and passengers

Available modules

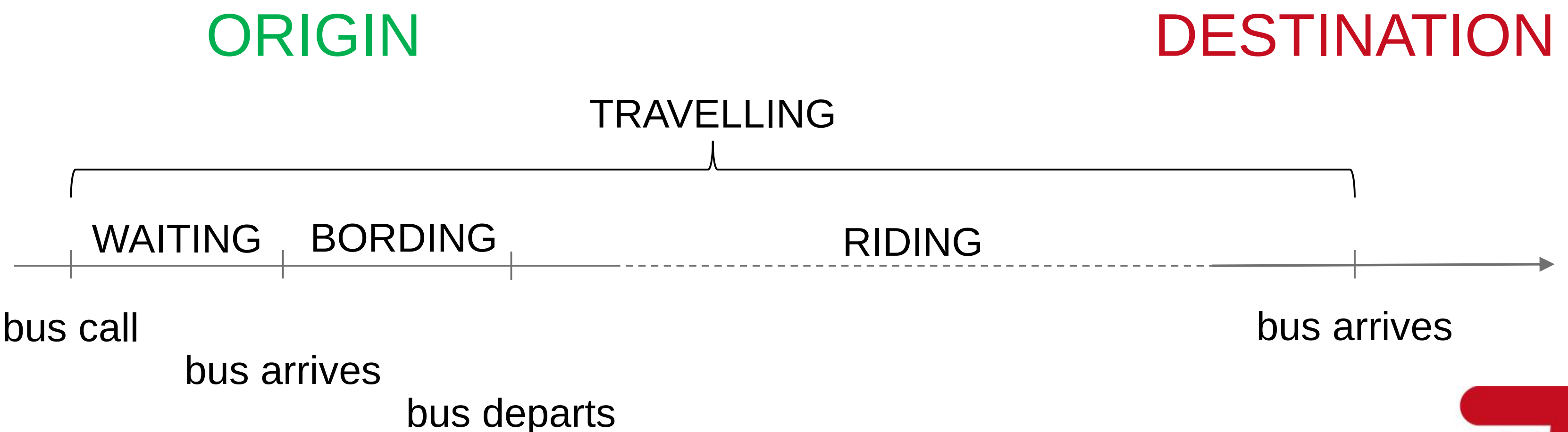
- Taxi
- SAVs
- DRT (demand responsive transport) → <u>used here</u>

DRT Model

Requests

- immediate requests
- destinations known in advance

- passenger time windows:
  - fixed max wait time t^{wait}
  - max travel time $t_r = \alpha t_r^{direct} + \beta$, where
    t_r^{direct} – direct ride time origin → destination



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Insertion algorithm

Objectives

- Directly (main): minimize bus operation time
- Indirectly: minimize fleet size and passenger ride time (not wait!), maximize request acceptance rate

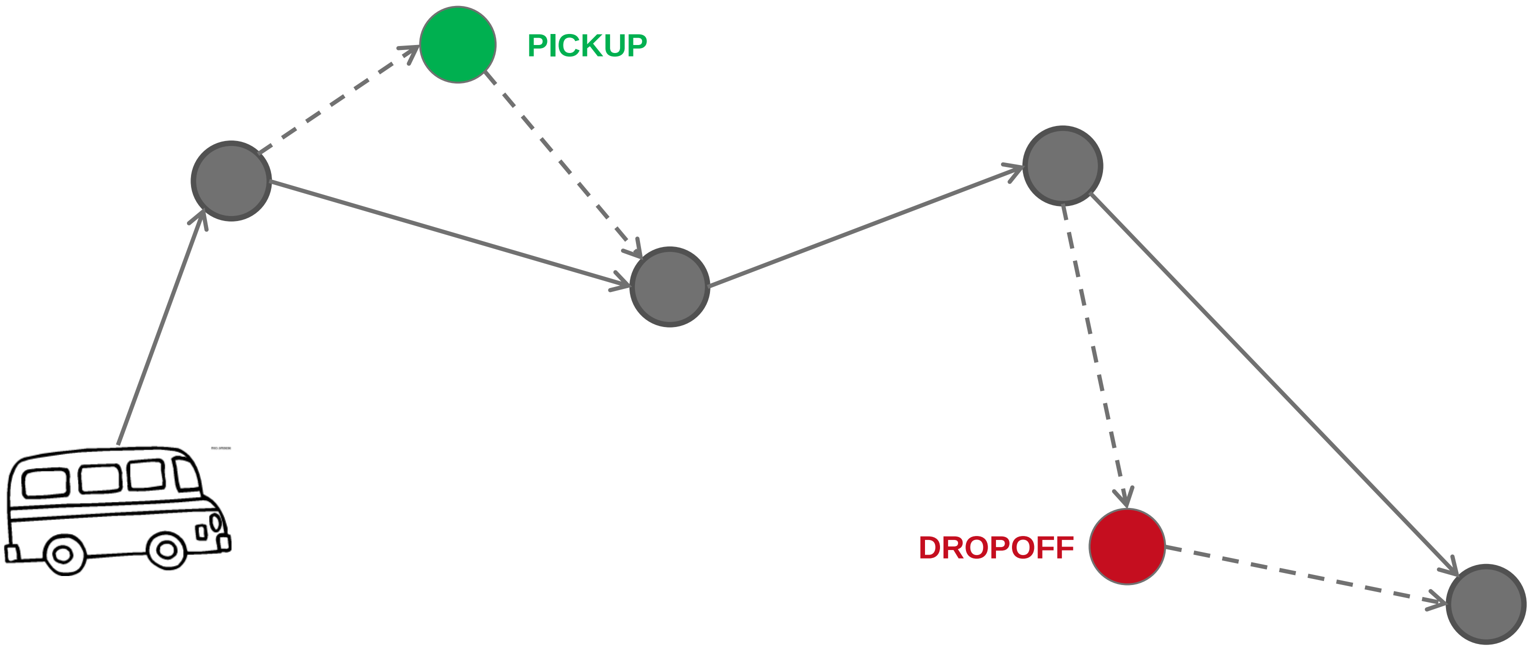
Reacts to a DRT call

- For each bus:
  - Try to insert the passenger pickup and dropoff into the bus route at different points
  - Validate each insertion

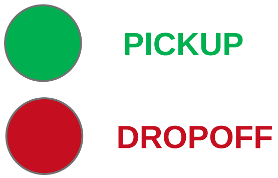
    (time and capacity constraints cannot be violated)
  - Evaluate each insertion

    (measure: bus operation time extension)
- The request is inserted into the schedule according to the least-cost insertion found
- If none found, the request gets rejected

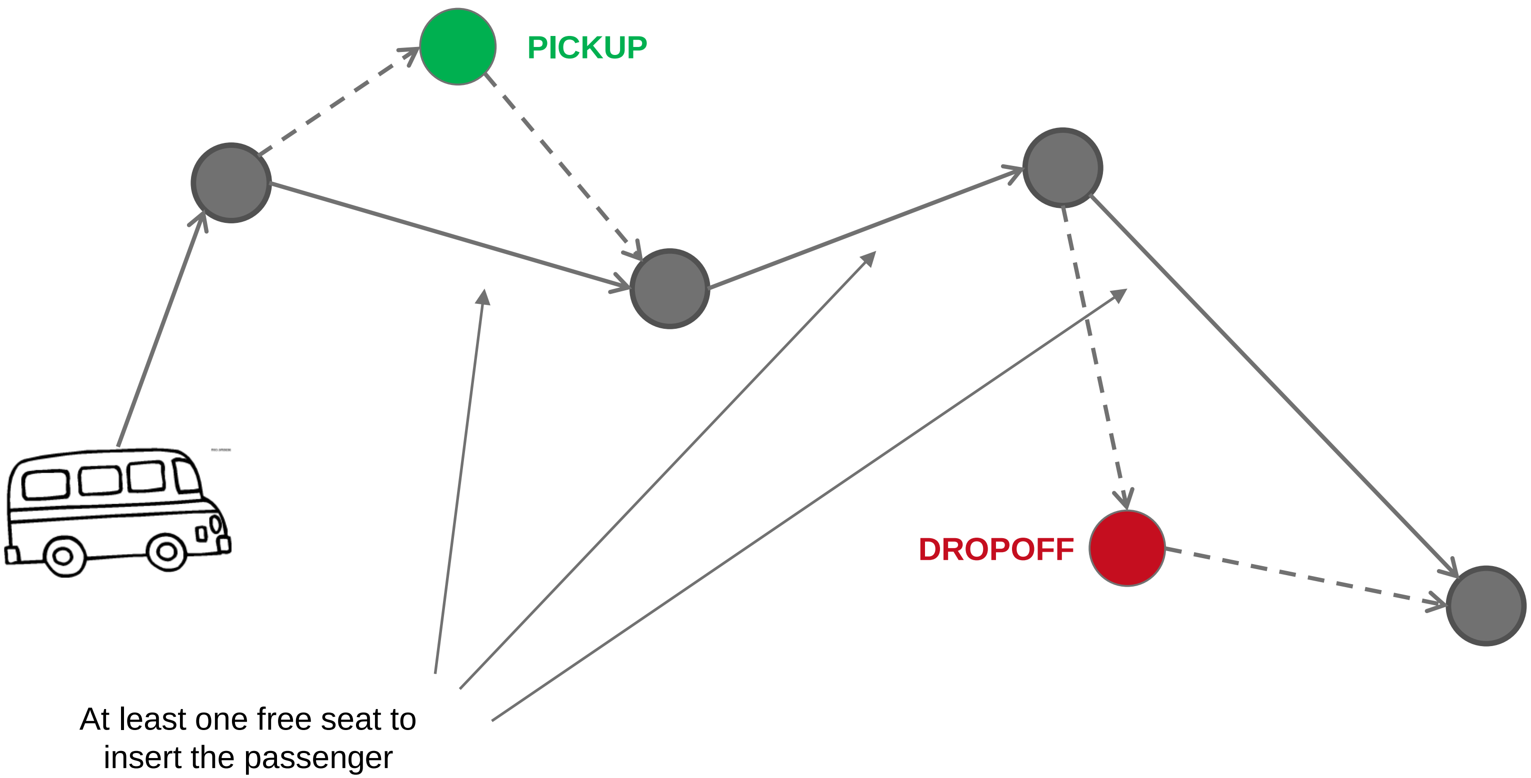
Checking a valid request insertion (for each vehicle / a subset of vehicles)



Pickup and dropoff locations of the inserted request



First condition: A free seat between all planned stops



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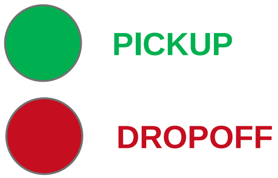
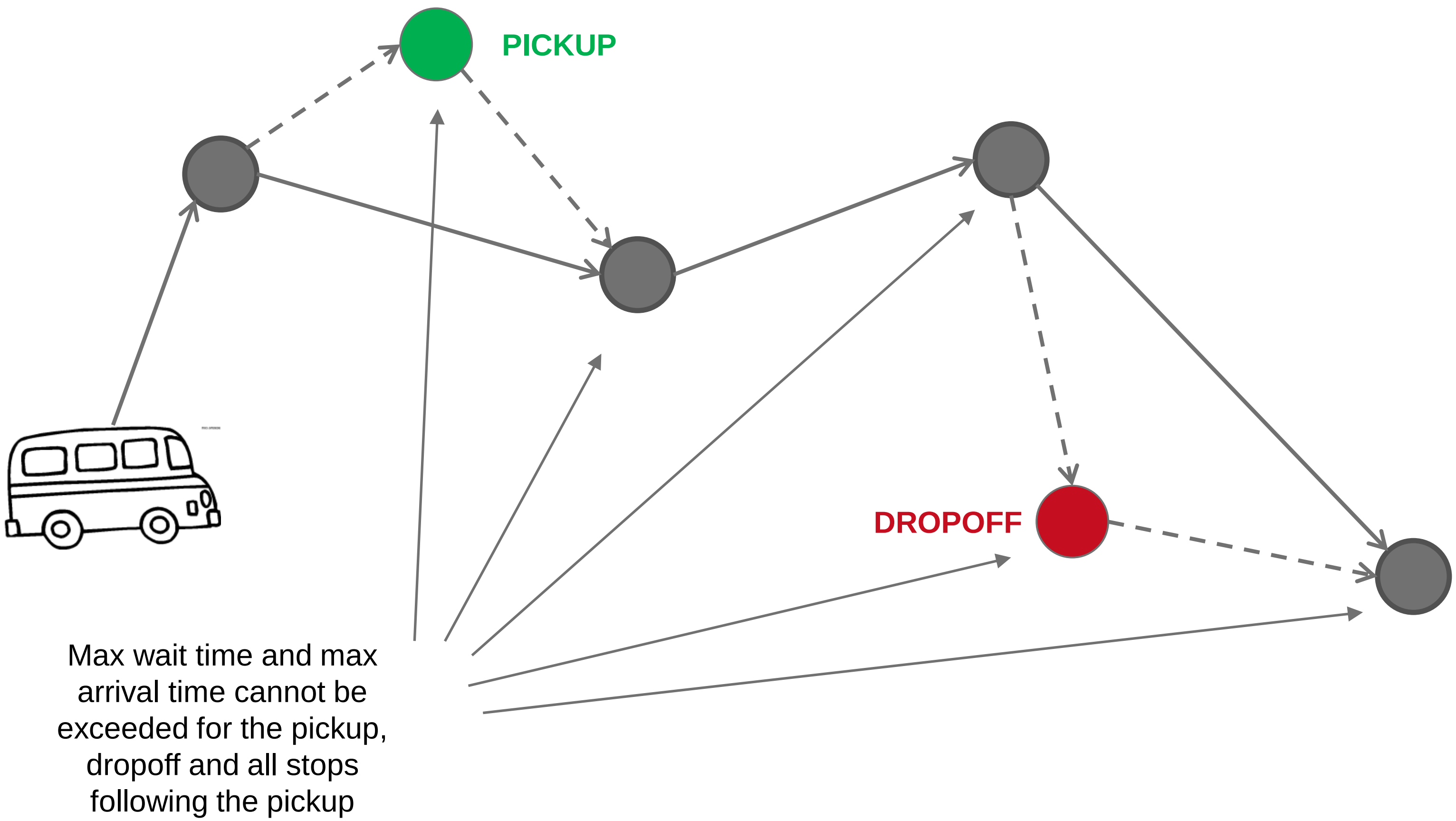


Second condition: No passenger‘s detour constraint is violated

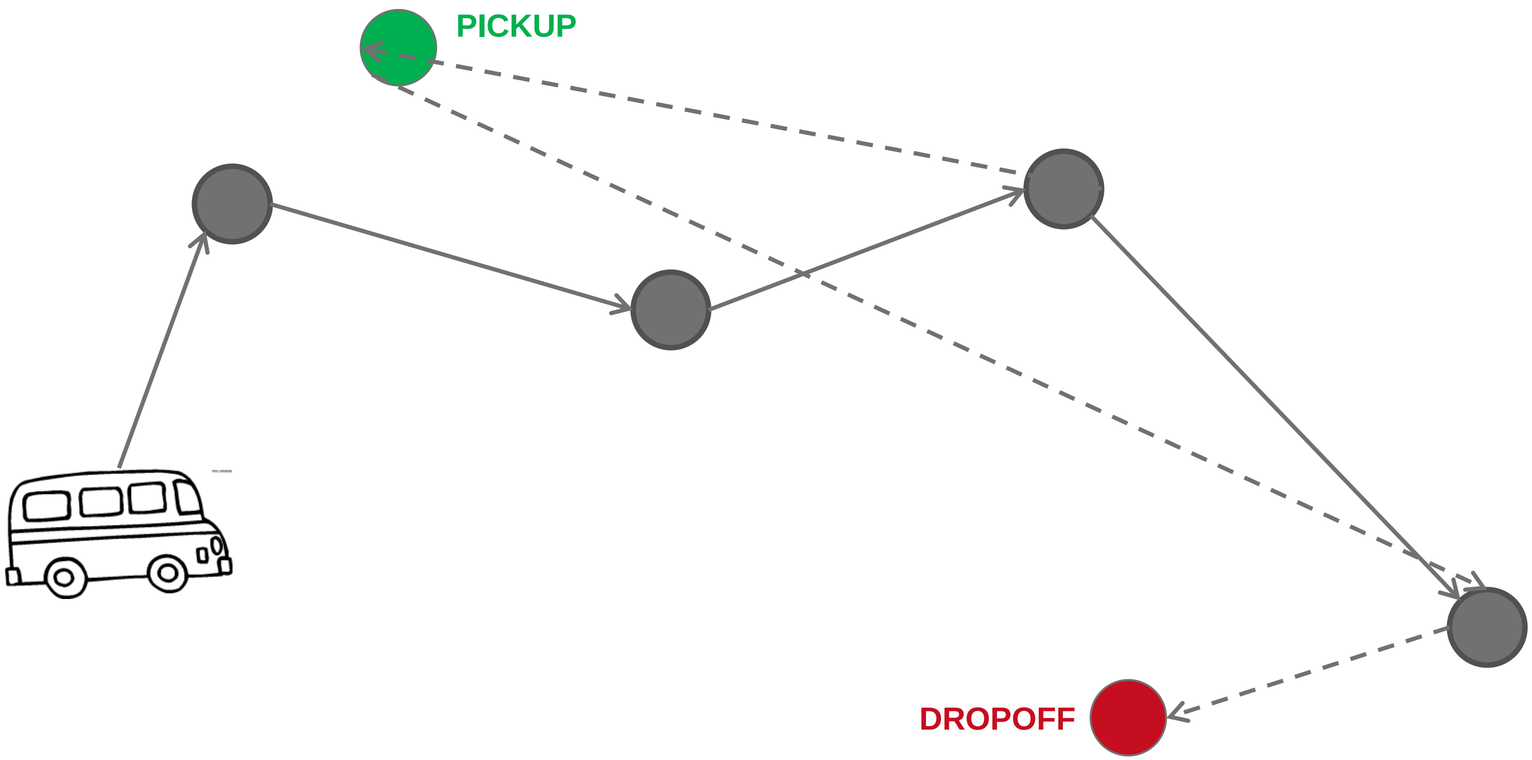


Pickup and dropoff locations of the inserted request

PICKUP

DROPOFF

Re-evaluation of pickup / drop-off order to find shortest overall route



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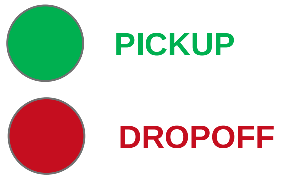

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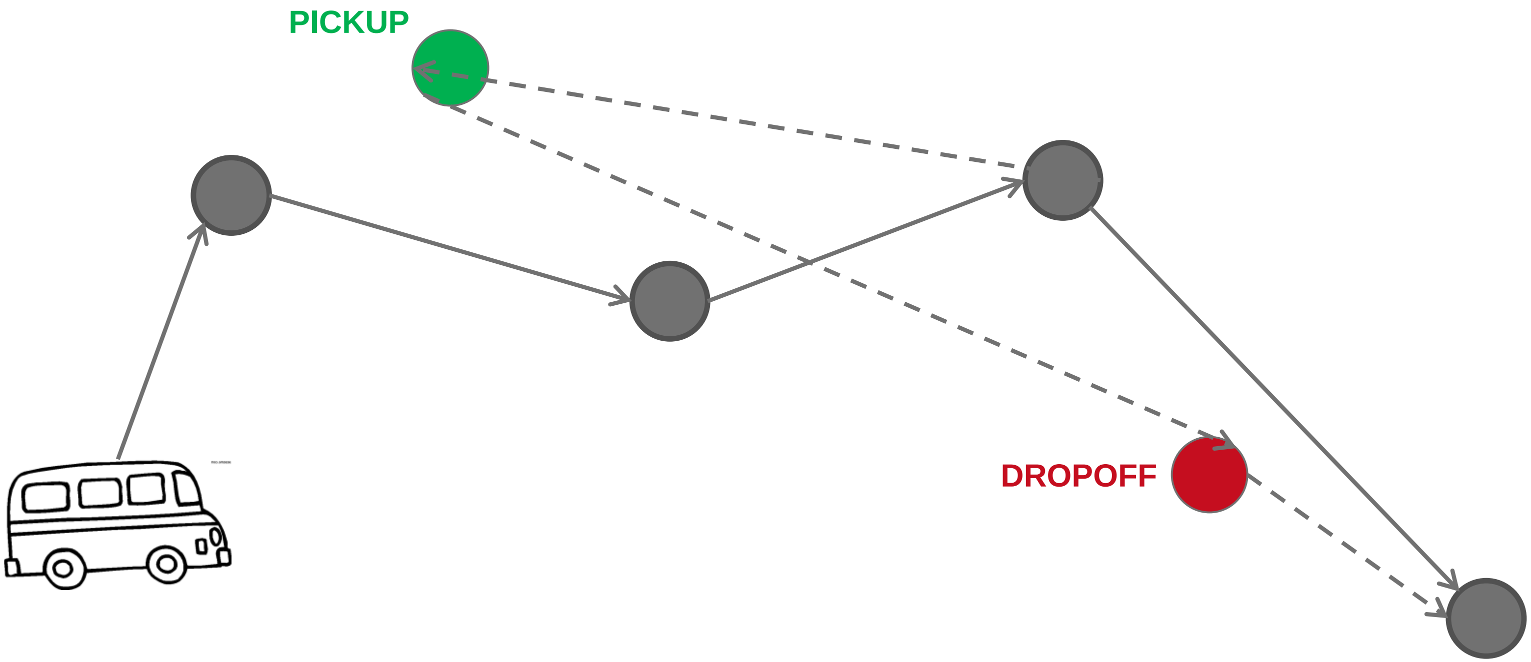

Pickup and dropoff locations of the inserted request

PICKUP

DROPOFF

How to evaluate the performance of a shared taxi fleet

- A high revenue ratio may not neccesarily be good, as it can also mean that passengers are transported for long detours

- Indicator that takes into account direct distance of a trip can compensate for this:

$$\lambda = \frac{d^T}{\sum_{r \in N} d_r^{direct}}$$

- $\lambda = 1.0$: a direct car trip with passenger without parking search

- $\lambda > 1$: a taxi trip with a single passenger and additional empty mileage

- $\lambda < 1$: Due to vehicle sharing, less vehicle miles are traveled than by car

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Case study: Access to BART stations in the Bay area

- Pooled, dynamically dispatched vehicles may be used to feed heavy-rail transit lines
- Pooling can greatly reduce pressure on Park & Ride facilities and provide a comfortable first-mile access

- Three simulation experiments:
  - Self-drive to BART
  - Use of single occupancy taxi
  - Use of DRT

With / without driver

https://www.bart.gov/schedules/bystation

BVG, 2018

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Demand generation & model building

- Synthetic population is based on San Francisco Bay Area MTC-ABM

- Originally, around 8 million synthetic persons, including all demographic values, such as gender and person specific value of time

- Selection of possible persons who are likely to use BART if first mile access was better by editing parameters in the mode choice model of the MTC-ABM

- Synthetic population turned into MATSim agents and their acces to the closest useful BART station is simulated here

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Scenario overview

Scenario	Vehicle	Paying Occupants	Pick-Up Location	Vehicle fleet	Costs	
					Human Driven Vehicle	Automated Vehicle
Base Case	Personal	Single	Home	83,000	**$0.18**	**NA**
Scenario 1	Shared Ride	Multiple	Home	5,000	**$0.75 per mile**	**$0.26**
Scenario 2	Shared	Single	Home	15,000	**$1.50 per mile**	**$0.48**

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Example for a shared taxi trip

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Results

- Trips by taxi & DRT tend to take somewhat longer and have a higher per mile cost

- Save on parking costs at BART stations

- Generalized cost analysis, taking into account travel time, VOT of agent, parking costs:

	Base case: Self-drive
	Driver
Average IVTT (min)	9:38
Average waiting time (min)	n/a
Average Generalized Cost (US$)	5.68
λ	1.00

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Conclusion

- MATSim‘s DRT extension is a mighty toolkit to explore the effects of shared vehicles
- It allows a precise evaluation of fleets … and their customers
- The First Mile example shows:
  - Pooling is essential to bring a cost benefit over self driving
  - Pooling is essential to bring an ecological benefit or a relief to traffic
  - Travel time increases during AM peak are neglectable
  - From today‘s cost perspective, only automated vehicles will bring an actual benefit in generalized costs
- Results are preliminary, we expect to publish full results by the end of the year

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Thank you for your attention!

Questions?

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Find the code:
https://github.com/jfbischoff/matsim-davis