AMoDSim: An Efficient and Modular Simulation Framework for Autonomous Mobility on Demand

A. Di Maria, A. Araldo, G. Morana and A. Di Stefano

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Outline

AMoDSim

A Simulator for future generation ride sharing systems

- Motivation
- AMoDSim: Model and Architecture
- A case study

Introduction

A new era of Urban Transportation driven by ICT

- Connectivity (3G and 4G), smartphone apps
- Emergence of *Ride Sharing* services
- Autonomous Mobility on Demand services (**AMoD**)

Need Of ...

- Efficient and Scalable algorithms to match requests to the available vehicles
- NP hard [1]

- **Simulation tools**

[1] J. Alonso-Mora, S. Samaranayake, et al. “On-demand high-capacity ride-sharing via dynamic trip-vehicle assignment”. PNAS, 114(3):462-467, 2017.

Mobility on Demand in other simulators

Yet another simulator… Why?

Case-Specific

- Built from scratch every time
- Not reusable
- Results not reproducible

Commercial

Open source

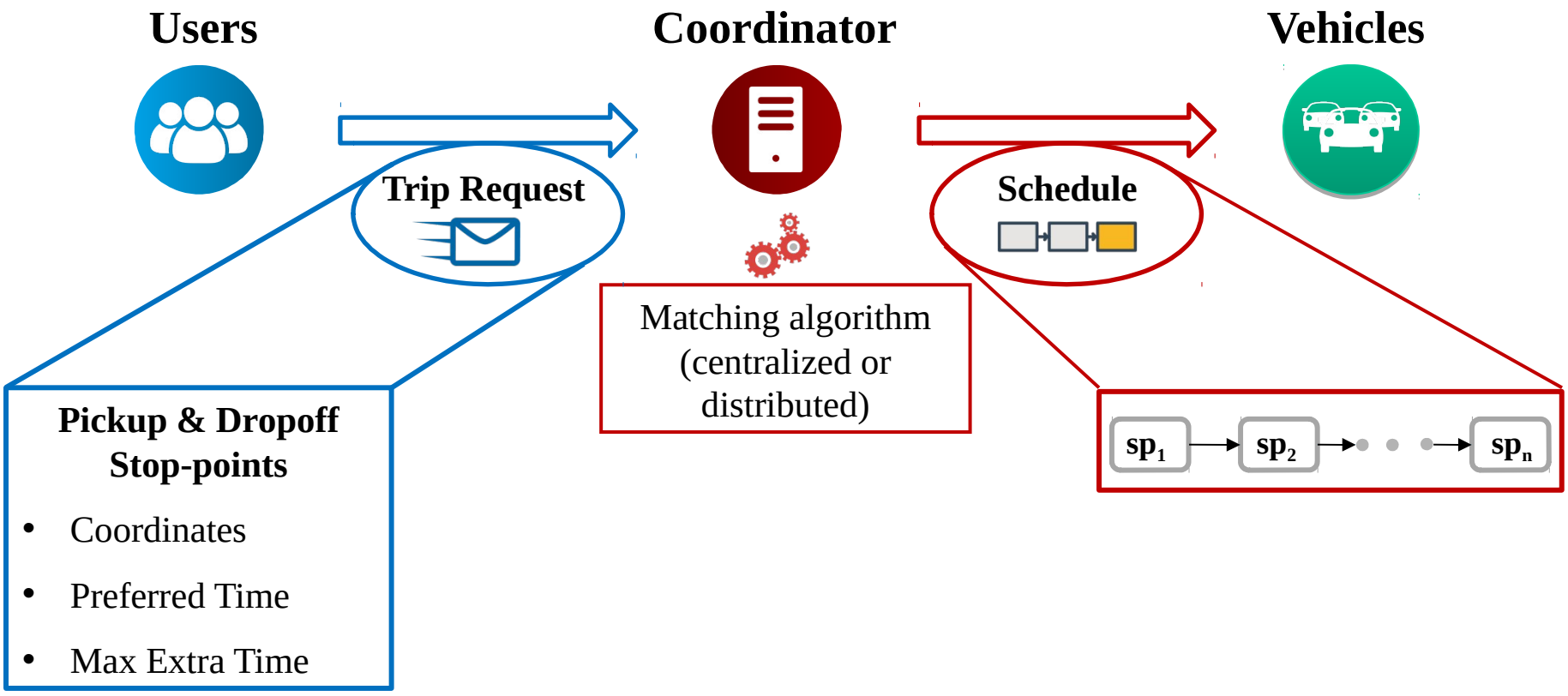
- Difficult to setup
- Economic indicators? Detailed topology
- Detailed movement → **Overhead**

AMoDSim

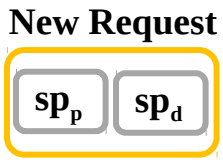
- Not *better* but different goals
- Algorithm-oriented
- Open source
- Easy to use
- Massive simulation campaigns
- Ready-to-use algorithm performance results

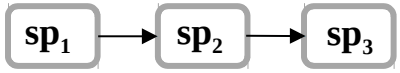
MATSim
Multi-Agent Transport Simulation

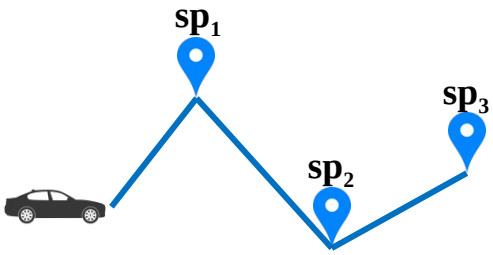
AMoDSim: the model

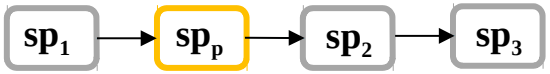


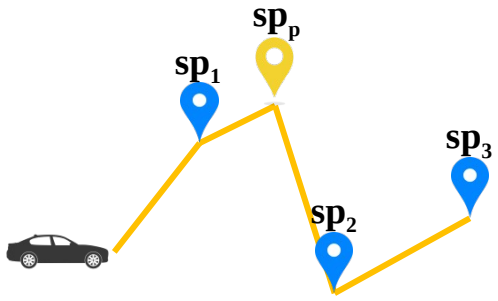
AMoDSim: time constraints





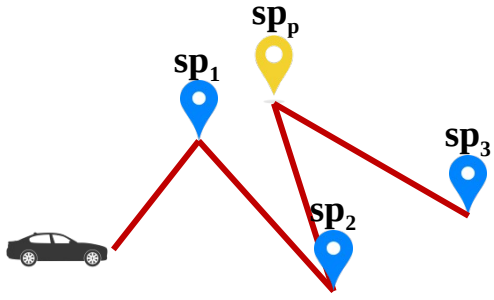






Is feasible?
(max extra-time)

Additional Cost: C1

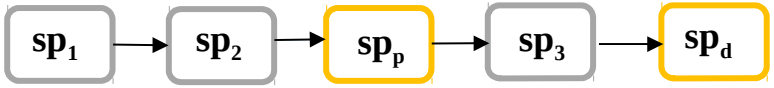


Is feasible?
(max extra-time)

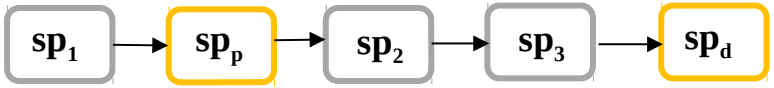
Additional Cost: C2

AMoDSim: time constraints

Additional Cost:
C1



Additional Cost:
C2

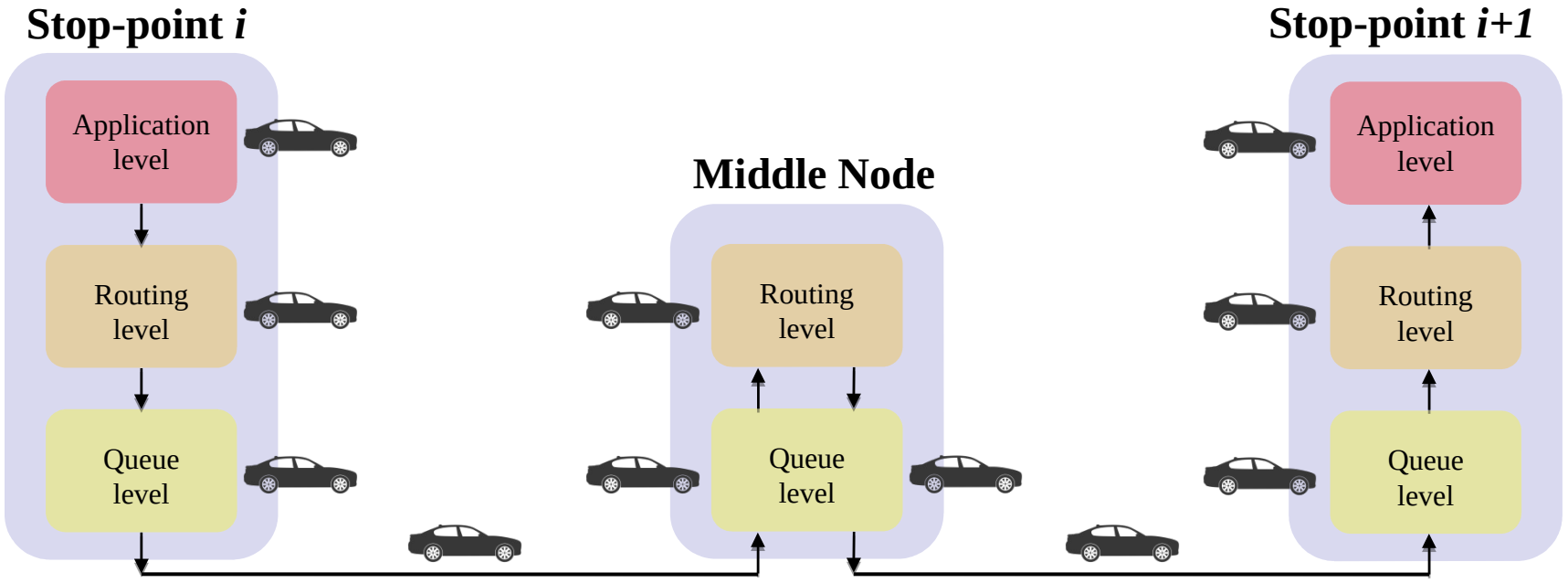


Additional Cost:
C2

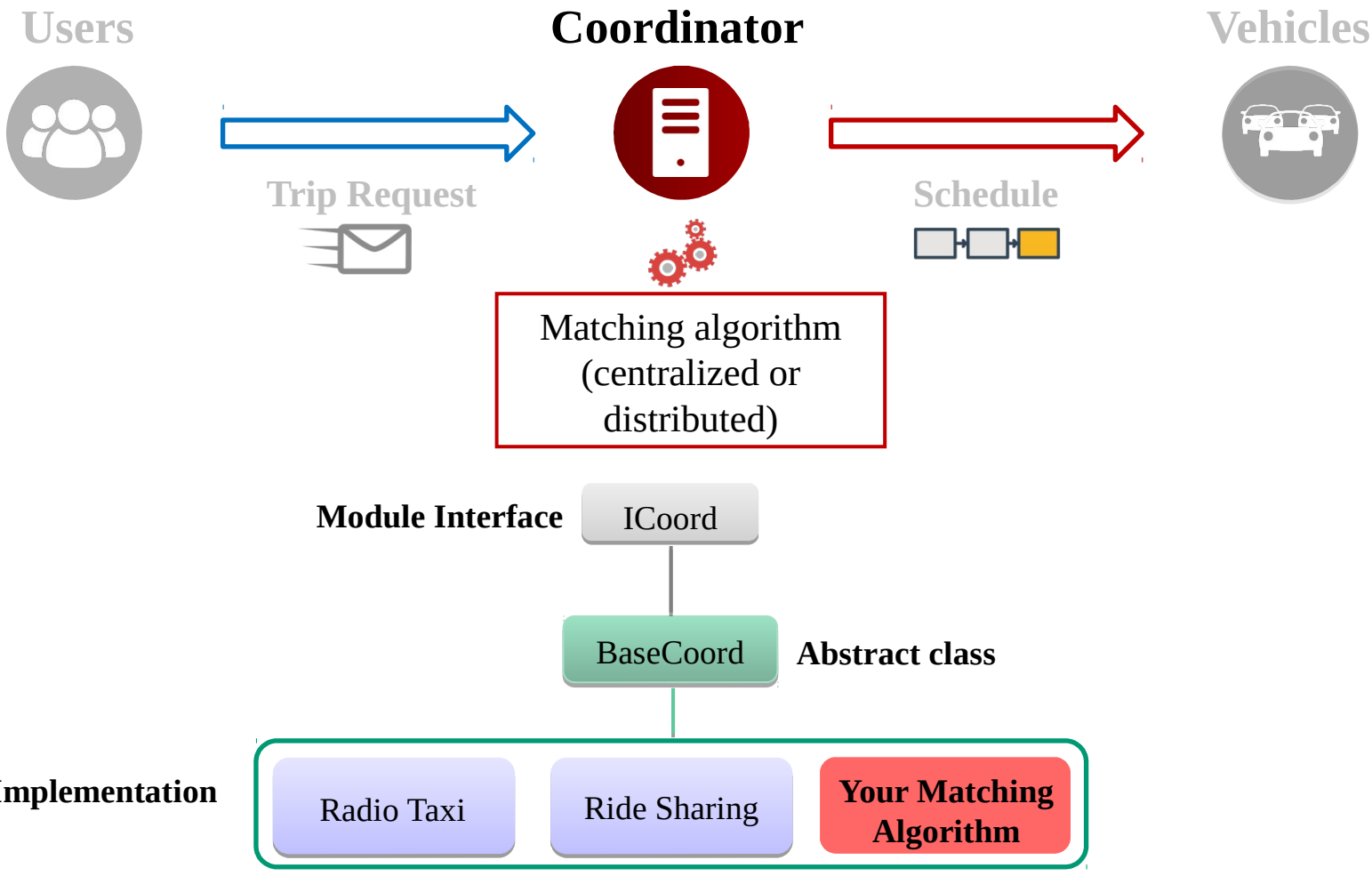
AMoDSim: sw architecture

Network Packet

Graph



AMoDSim: sw architecture



Case Study: scenario

Network
Manhattan Grid that cover an area of 60 km^2

Fleet
500 up to 9000 vehicles

Seat
Single-seater up to 10-seater minibus

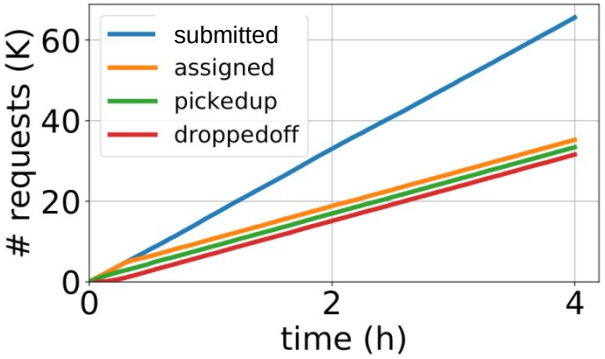
Requests
20 up to 640 per hour per km^2 with Poissonian arrivals

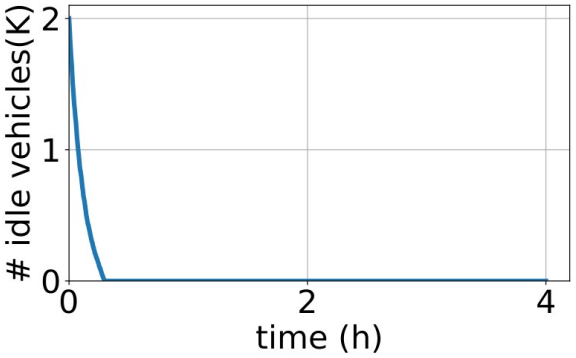
Matching algorithms
Radio-Taxi and Insertion-Heuristic

Runs
1800 simulations of 4h

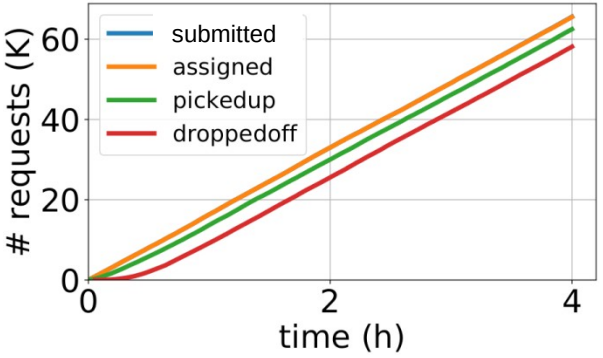
Results and Analysis

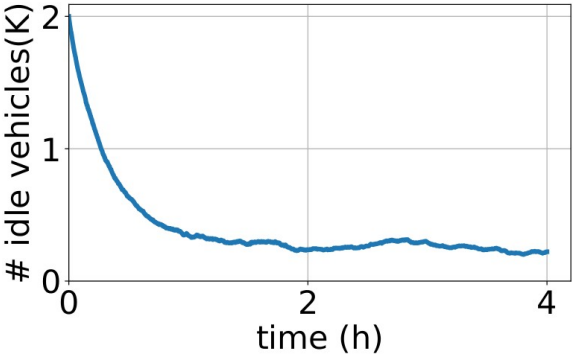
Radio Taxi



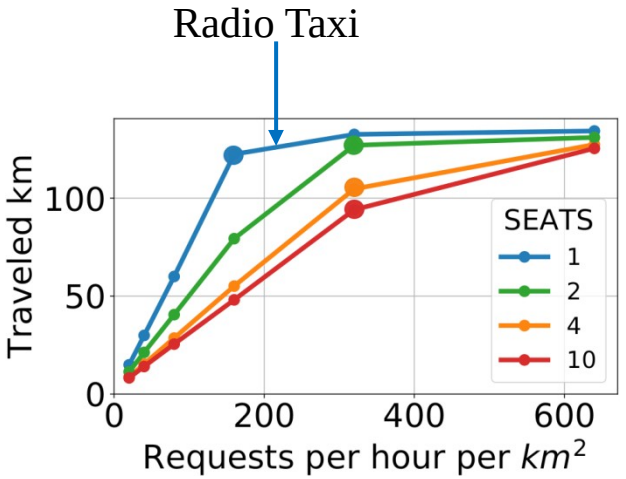


Ride Sharing





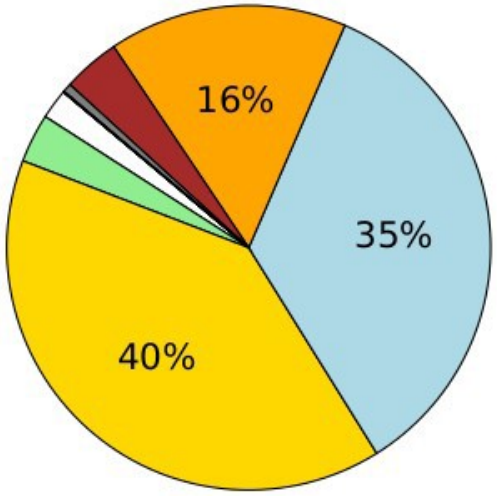
- 320 requests per h per km^2 [1, 2]
- 2 K, 4-Seater vehicles



[2] J. Jaeyoung et al. Design and Modeling of Real-time Shared-Taxi Dispatch Algorithms. TRB 92nd Annual Meeting, 2013

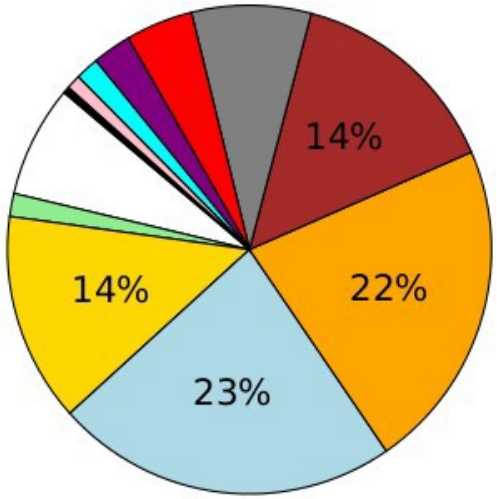
Results and Analysis

Vehicle Occupancy (Ride sharing)



$\Delta t = 5\text{min}$

Demanding users

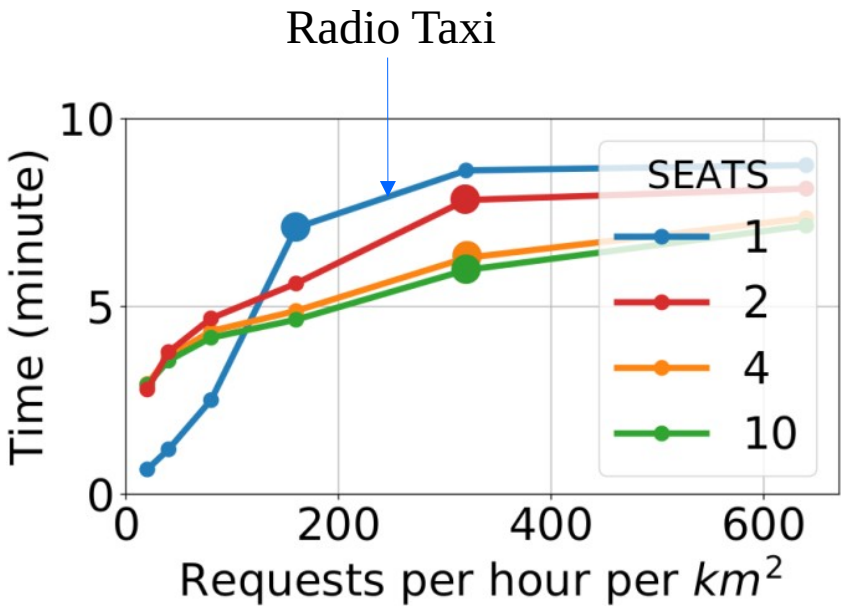


$\Delta t = 30\text{min}$

Less-demanding users

Results and Analysis

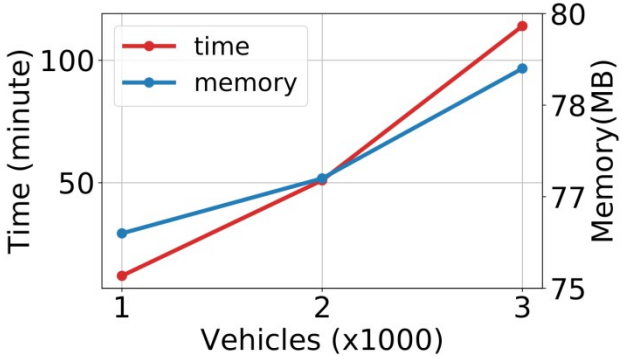
Per-person Waiting Time



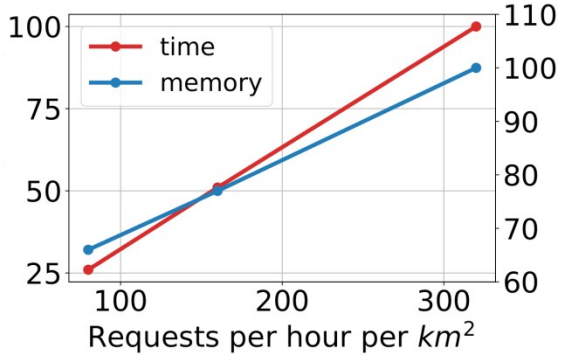
2 K Vehicles

Results and Analysis

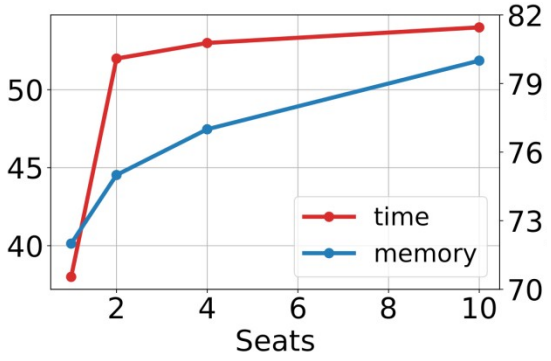
Computation Time & Memory Consumption



- 320 requests per h per km^2
- 4-Seater vehicles



- 2 K, 4-Seater vehicles



- 320 requests per h per km^2
- 2 K vehicles

Conclusions

Aim ...

- Accelerate research in future ride sharing systems
- Enable researchers to assess their solutions, verify and reproduce their results, comparing them on a common base

Hopes ...

- Researches will exploit the simulator and contribute to its evolution with proper code extensions as new requirements arise

Future works …

- Compare AMoDSim with other simulators

References

Get AMoDSim

https://github.com/admaria/AMoDSim

Contact us

- Andrea Di Maria adimaria@auctacognitio.net
- Andrea Araldo andrea.araldo@telecom-sudparis.eu
- Giovanni Morana gmorana@auctacognitio.net
- Antonella Di Stefano ad@dieei.unict.it

Q and A?

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External References

Scenario related References:

[1] J. Alonso-Mora, S. Samaranayake, et al. On-demand high-capacity ride-sharing via dynamic trip-vehicle assignment. PNAS, 114(3):462–467, 2017.

[2] J. Jaeyoung, R. Jayakrishnan, et al. Design and Modeling of Real-time Shared-Taxi Dispatch Algorithms. TRB 92nd Annual Meeting, 2013.

[3] M. Hyland and H. Mahmassani. Dynamic Autonomous Vehicle Fleet Operations: Optimization-Based Strategies to Assign AVs to Immediate Traveler Demand Requests. Transport Res. C-Emer, 92:278–297, 2018 (Grid with static link travel time)

[4] S. Robinson. Measuring bus stop dwell time and time lost serving stop with London ibus automatic vehicle location data. Transport Res Rec, 2352(1):68–75, 2013. (Acceleration/Deceleration)

[5] J. Jung, R. Jayakrishnan, et al. Design and Modeling of Real-time Shared-Taxi Dispatch Algorithms. In TRB Annual Meeting, volume 8, 2013. (Poissonian Arrivals)

[6] J. Elpern-Waxman. Transportation Terms: Dwell Time, 2017. (Boarding/Alighting)