Optimal fleet management for real-time ride-sharing service considering network congestion

Negin Alisoltani

Directors of Research:

Ludovic Leclercq & Mahdi Zargayouna

GRETTIA and LICIT

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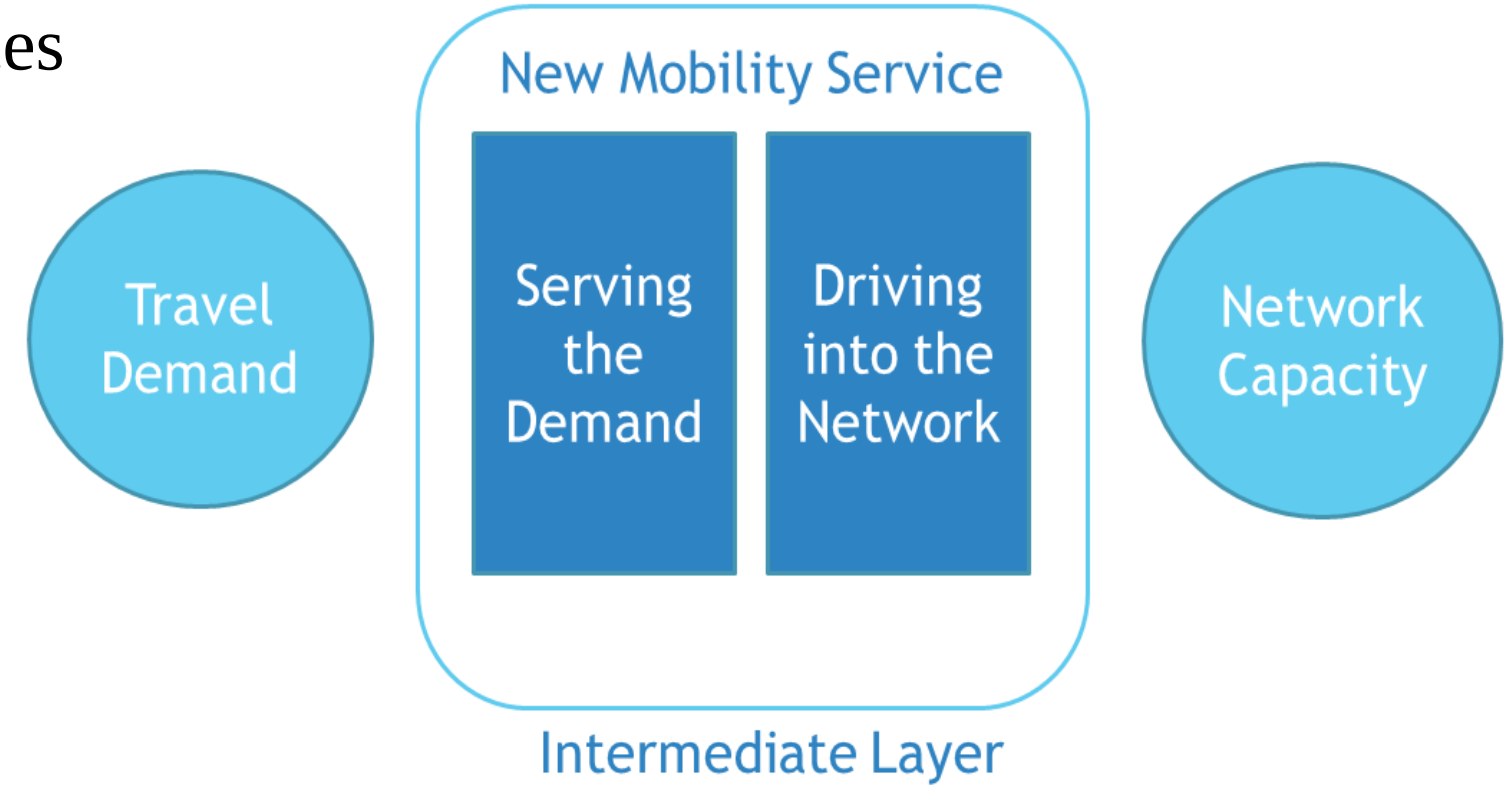
Transportation system integrated by new mobility services

- New mobility services
- Future vision
- Main objectives



Real-time Ridesharing

- Ridesharing definition
- Dynamic ridesharing
  - Independent
  - Cost-sharing
  - Non-recurring trips (<> traditional carpooling or vanpooling)
  - Prearranged (<>casual ridesharing, hitch-hiking and hailing a taxi)
  - Automated matching

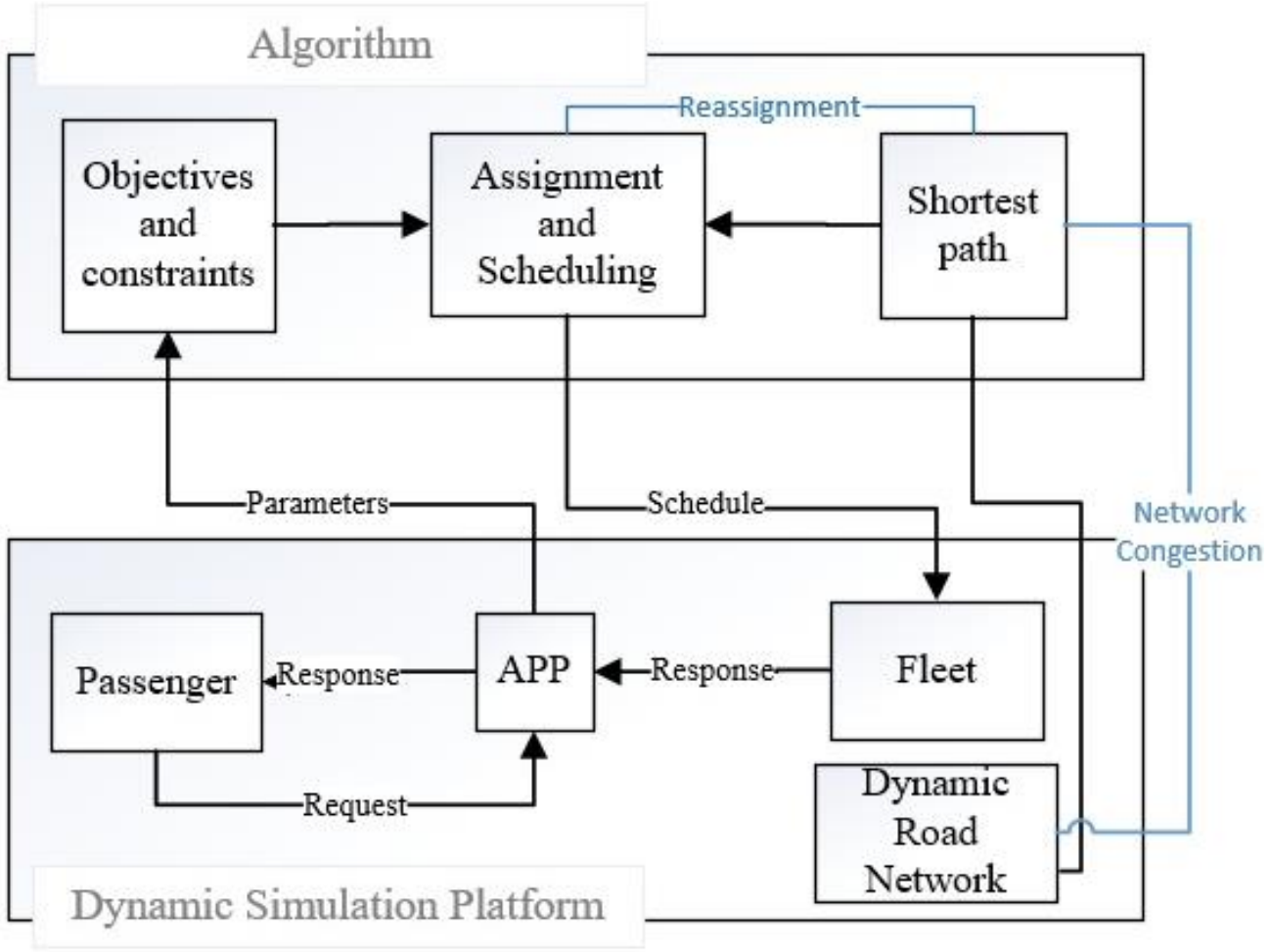
Research questions

- Designing a fleet management system for a ride-sharing service
- Considering traffic congestion in ride-sharing

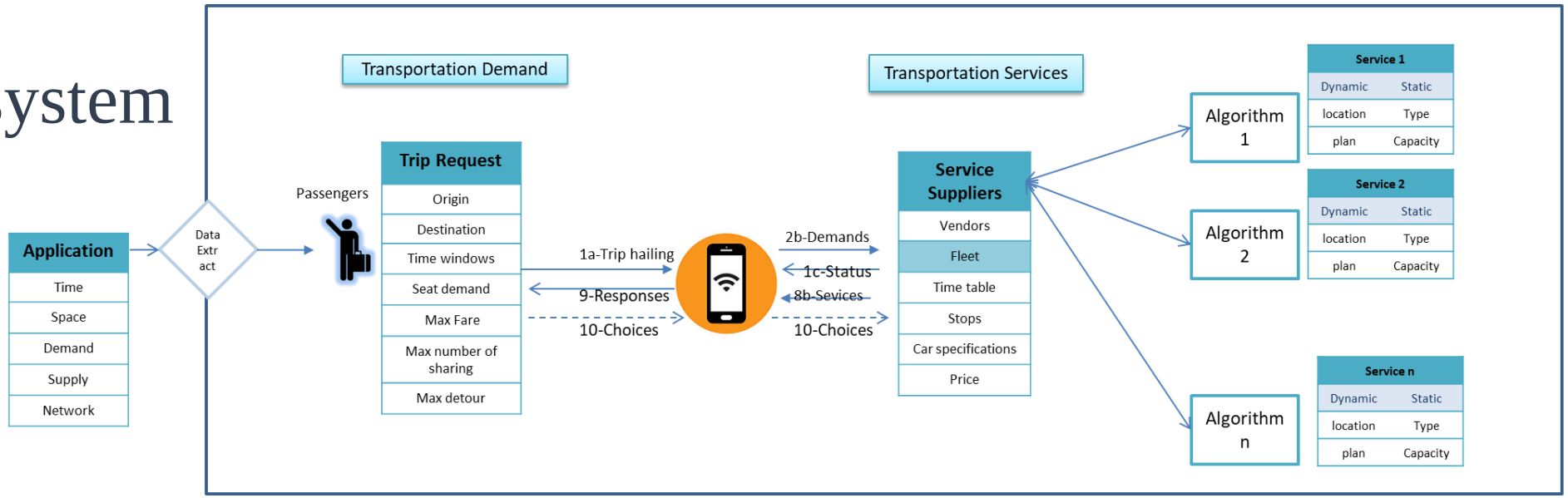
- Finding the optimal matching between participants in a very short time for large-scale problems
- Modeling the ride-sharing problem
- Managing both ride providers and passengers satisfaction
- Validating the optimization method

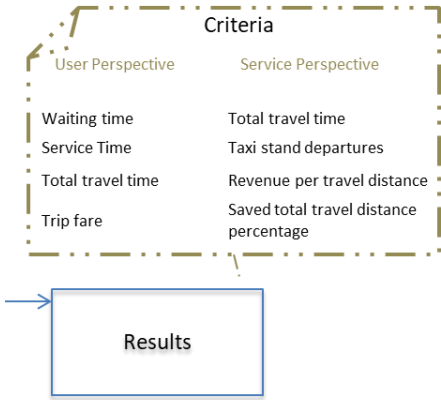
System main parts

- Simulation platform
- Optimization algorithm

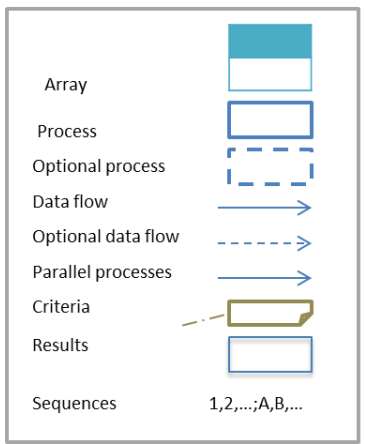


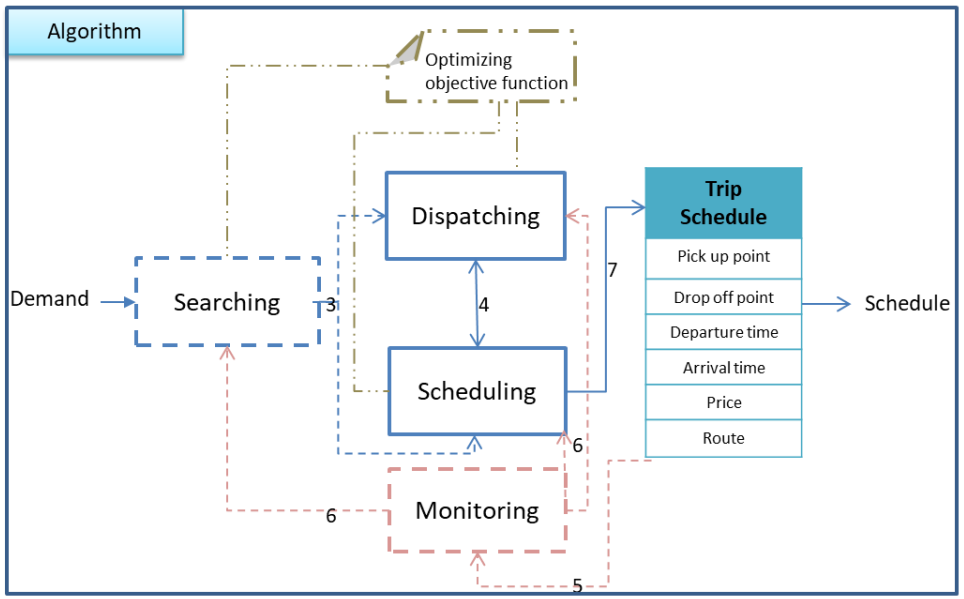
The system


Transportation Demand
Transportation Services
Application
Time
Space
Demand
Supply
Network
Data Extr act
Passengers
Trip Request
Origin
Destination
Time windows
Seat demand
Max Fare
Max number of sharing
Max detour
1a-Trip hailing
9-Responses
10-Choices
2b-Demands
1c-Status
8b-Sevices
10-Choices
Service Suppliers
Vendors
Fleet
Time table
Stops
Car specifications
Price
Algorithm 1
Algorithm 2
Algorithm n
Service 1
Dynamic Static
location Type
plan Capacity
Service 2
Dynamic Static
location Type
plan Capacity
Service n
Dynamic Static
location Type
plan Capacity


Criteria
User Perspective
Service Perspective
Waiting time
Service Time
Total travel time
Trip fare
Total travel time
Taxi stand departures
Revenue per travel distance
Saved total travel distance percentage

Results


Array
Process
Optional process
Data flow
Optional data flow
Parallel processes
Criteria
Results
Sequences
1,2,...;A,B,...


Algorithm
Optimizing objective function
Dispatching
Searching
Scheduling
Monitoring
Demand
Schedule
Trip Schedule
Pick up point
Drop off point
Departure time
Arrival time
Price
Route
3
4
5
6
6
7

Mathematical model

❑Objectives

- Passengers waiting time
- Passengers travel time
- Vehicles travel time
- Vehicles travel distance

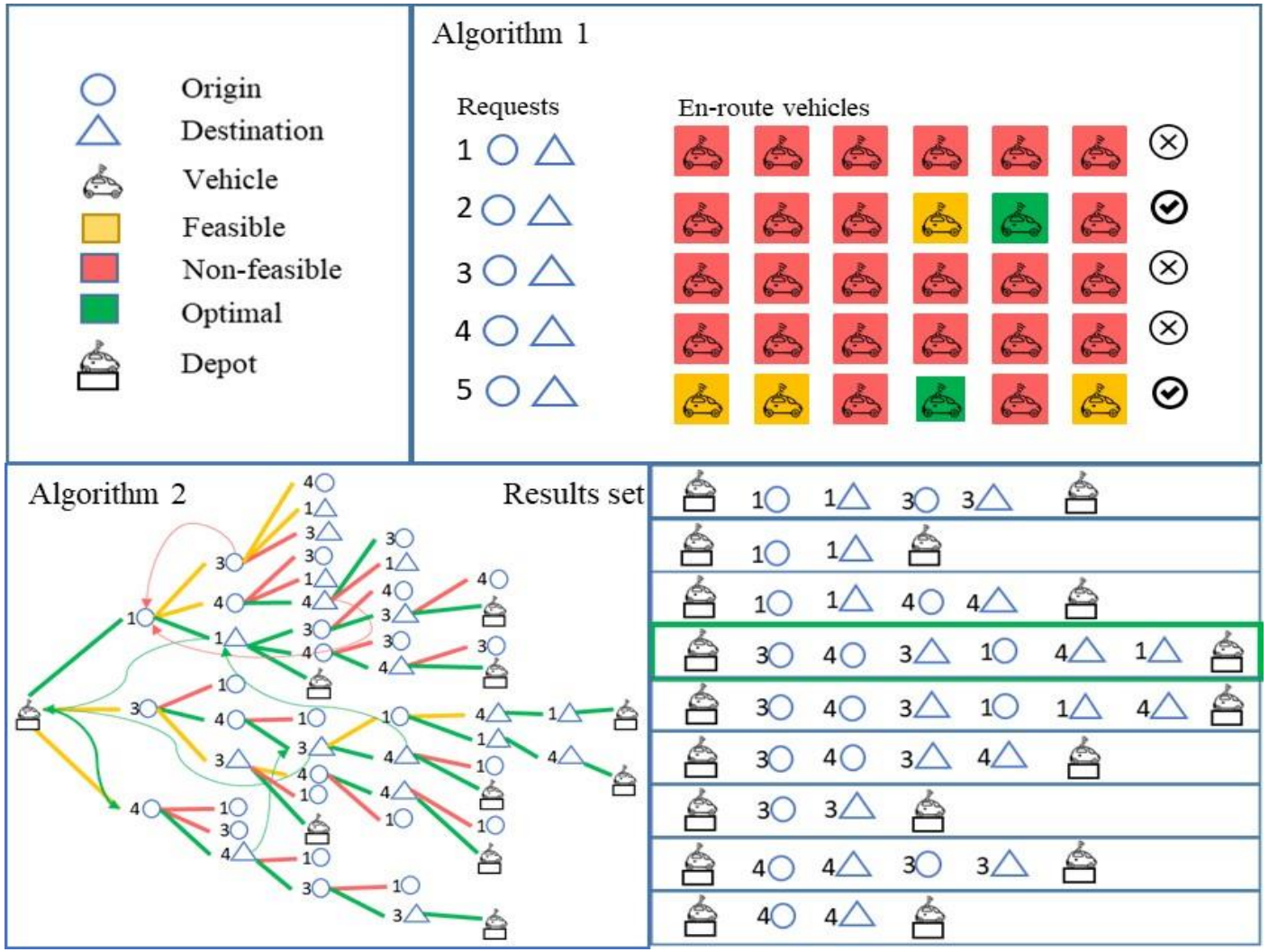
❑Constraints

- Capacity of the cars
- Time window
- Number of sharing
- Quality of service

❑Features

- Door-to-door sharing
- Serving all requests
- Number of seats
- NP-hard problem
- Branch-and-cut concept

Routing algorithm

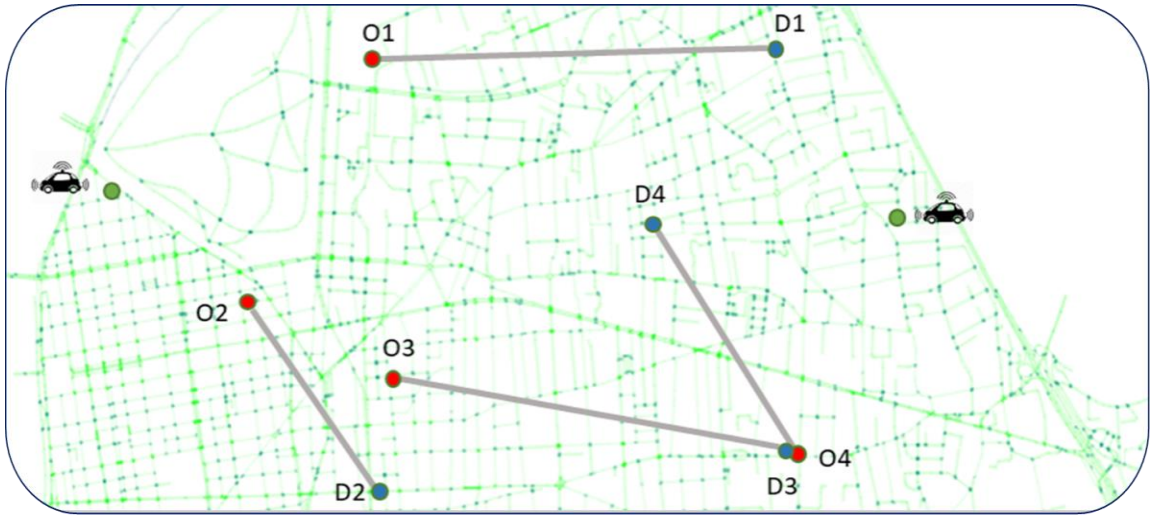


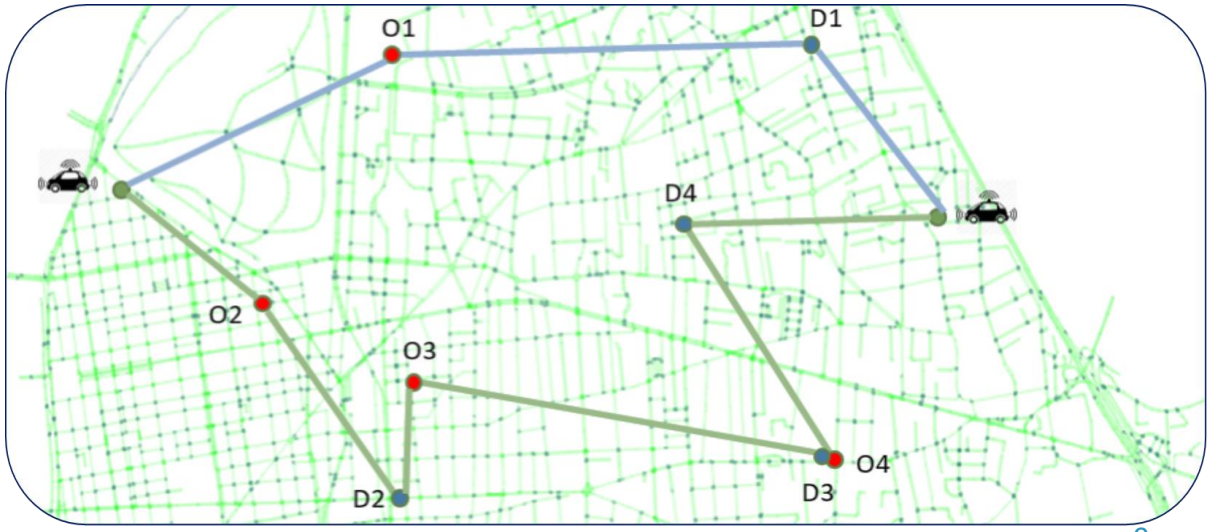
Assignment algorithm

- Exact algorithm
- Based on branch-and-cut method
- Validating algorithm
- Example

Passengers	Demanded seat	Number of sharing	Earliest pick up time	Latest arrival time
1	1	3	8:00	8:45
2	2	2	8:00	8:25
3	2	1	8:15	9:00
4	2	3	8:30	9:20

Answer	Cars routes	Obj.
A	O1 > D1 ||| O2 > D2 ||| O3 > D3 ||| O4 > D4	517
B	O1 > D1 > O4 > D4 ||| O2 > D2 > O3 > D3	418
C	O1 > D1 ||| O2 > D2 > O3 > D3 > O4 > D4	390
D	O3 > D3 > O4 > D4 ||| O1 > D1 ||| O2 > D2	416





Network congestion impact

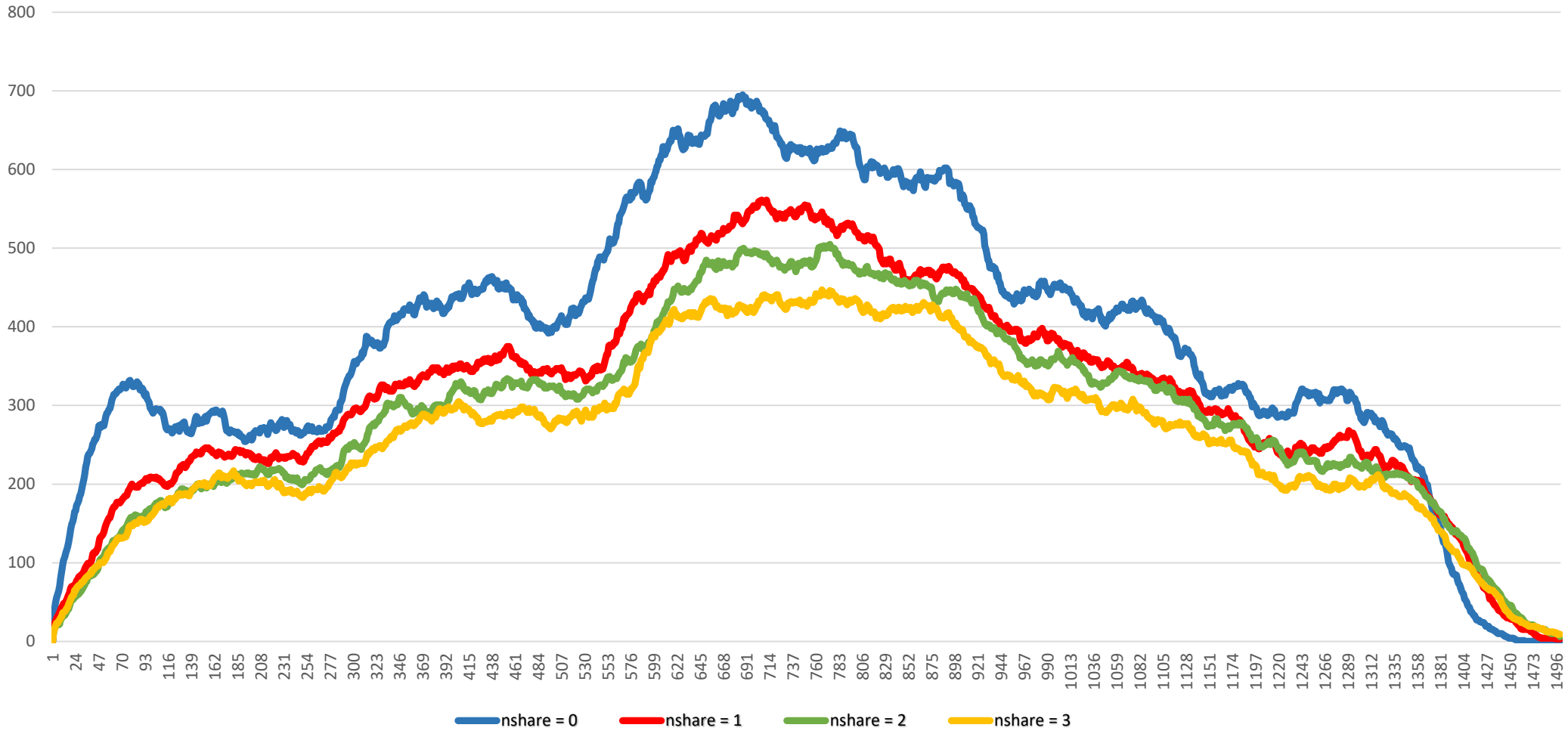
Dynamic traffic conditions:

- Plant model: that represents the traffic dynamics reality.
- Prediction model: that is used during the assignment process.

Results:

Number of sharing	0	1	2	3
Total travel time	11037: 53: 00	10716: 38: 40	10647: 47: 30	10501: 23: 35
Passenger waiting time	2 min	4 min	8 min	12 min
Total number of cars	61353	56648	55542	55290
Computation time	33 sec	10 min	23 min	5 h

Results: Congestion



Conclusion

- More sharing can improve the providers objectives
- Number of sharing 1 and 2 make small increase in passengers objectives
- Computation time is acceptable for number of sharing 1 and 2
- The exact algorithm works well with up to 400 requests at each iteration

Challenges and Future researches

- Making the algorithm scalable for large-scale problems (proposing clustering-based heuristics)
- Switching the plant model to a more refine one
- Solving assignment problem for over 1 million requests
- Real-time and dynamic simulation of the problem
- Ride-sharing re-assignment in case of any disturbance

Thank you for your attention