UC NightRide

Why walk?

A live route planning algorithm for UC's NightRide service

Almudena Chapa
Daniel Lázaro
Jon Ander Martin

Definition of the problem:

Objectives:

- Coordinate the routes of the vehicles in service.
- Optimize the routes, minimizing the waiting time of the customers.

Nature of the problem:

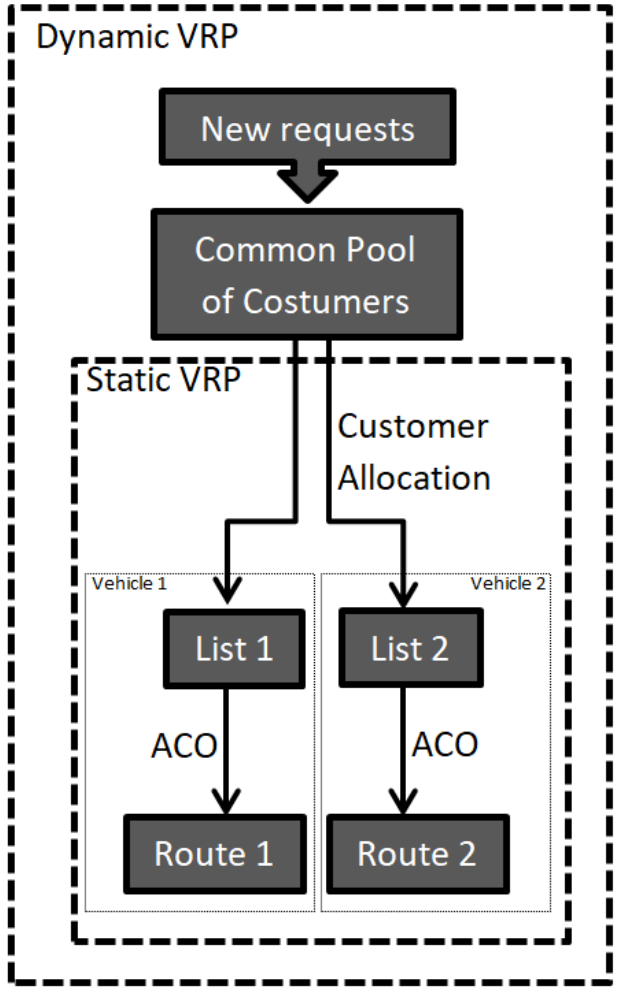
- DVRP combined with DARP:
  - The set of requests is not fixed, requests are spammed during the simulation.
  - Users request point to point trips.
- The vehicles share a common pool of customers to which the incoming requests are added.

Simplifications:

- The service has two vehicles → $N = 2$.
- Each request will have a single person riding.

Constraints:

- The capacity of each vehicle → $k = 5$.
- Pick-up locations must be visited before drop-off locations.



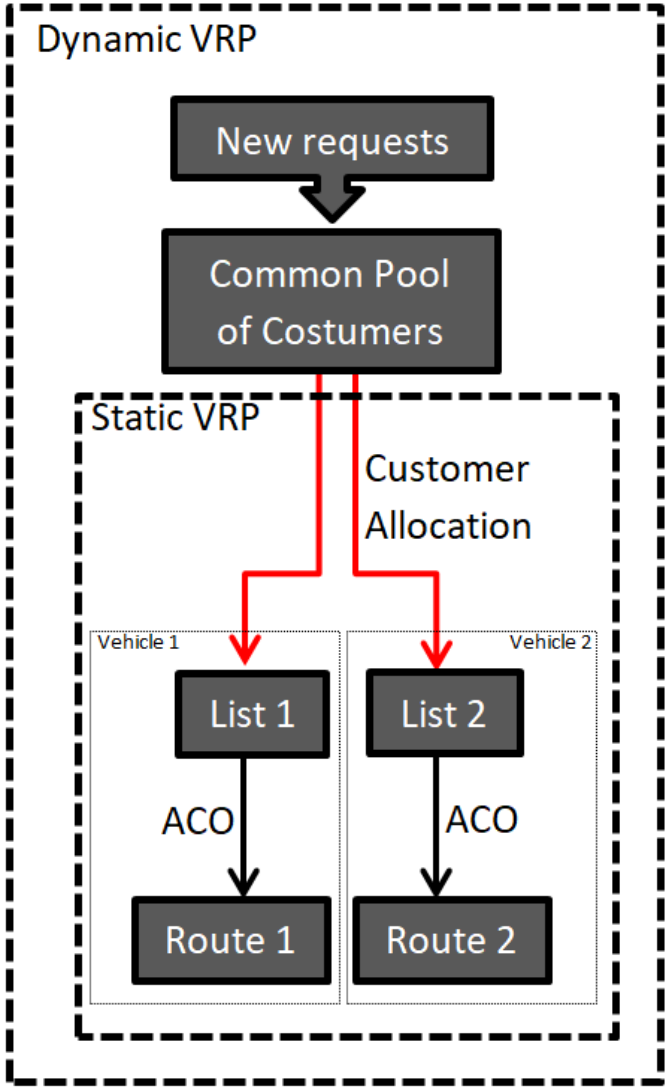
Methodology (1): Customer allocation

Allocation Clustering algorithm:

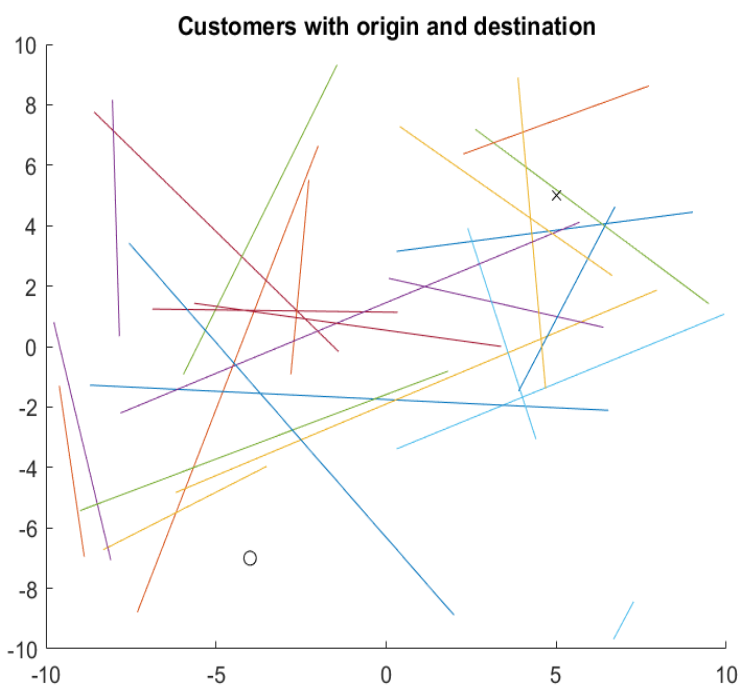
- Aim: Optimally distribute customers among the vehicles. It allocates the same number *n* of customers in both cars → $n \leq k$, thus the capacity condition is always fulfilled.

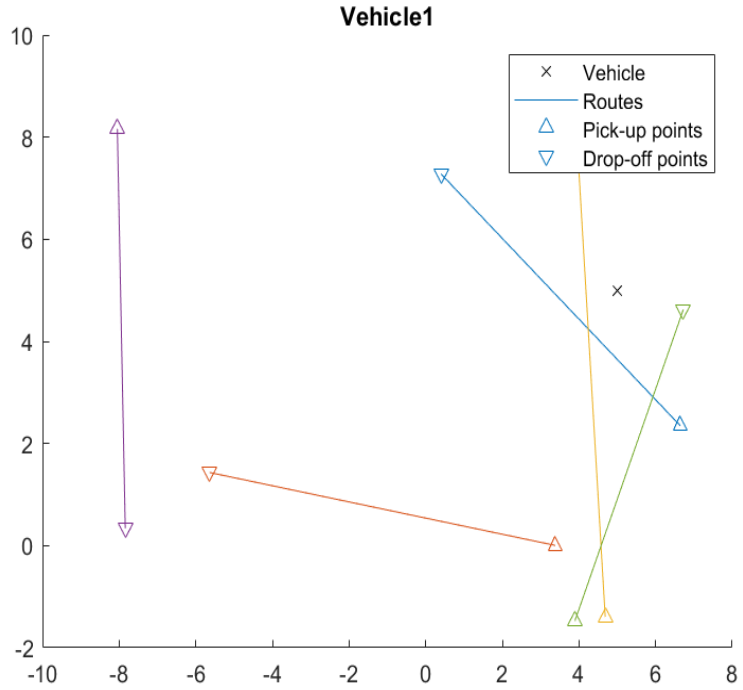
- Input information: Position in space of the vehicles and customers and the waiting time. The vehicles are the centroids of the clusters, assigning them the longest wait time promotes the selection of the customers that have been waiting the most.

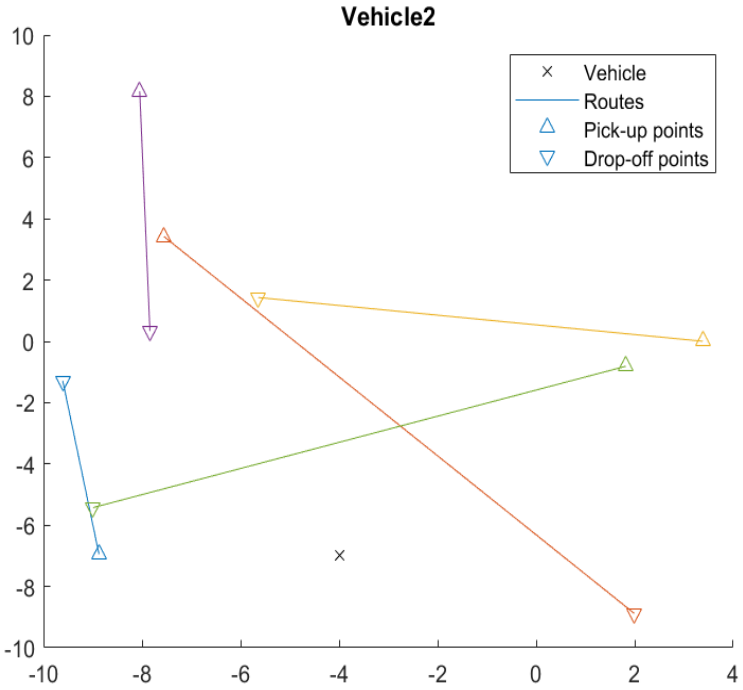
  - $x_{customer} = [x_{\text{pick}-up}, y_{\text{pick}-up}, x_{drop-off}, y_{\text{drop}-off}, t_{wait}]$
  - $x_{vehicle} = [x_v, y_v, x_v, y_v, t_{wait\ (longest)}]$



Methodology (1): Customer allocation





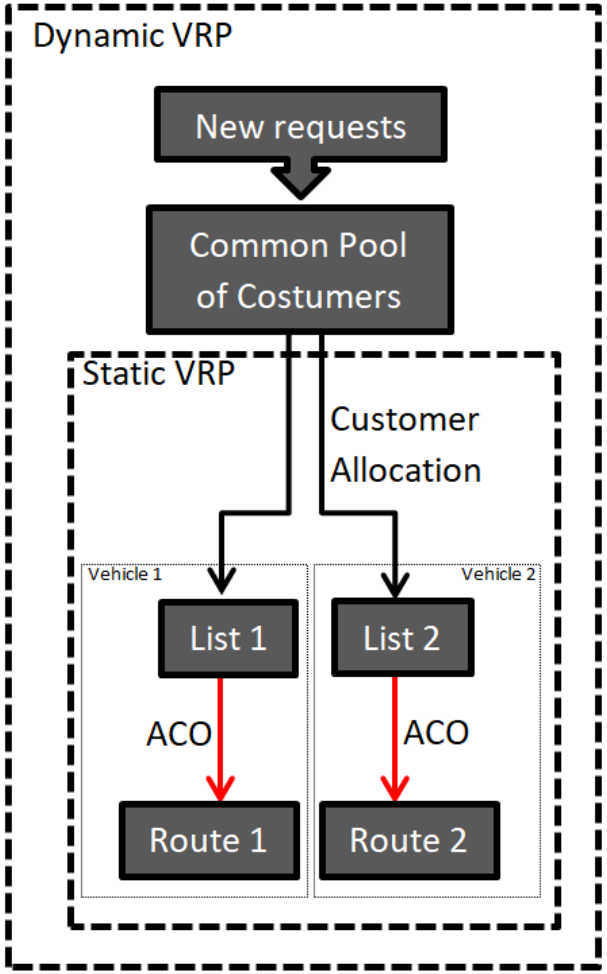


Methodology (2): Optimization of the routes

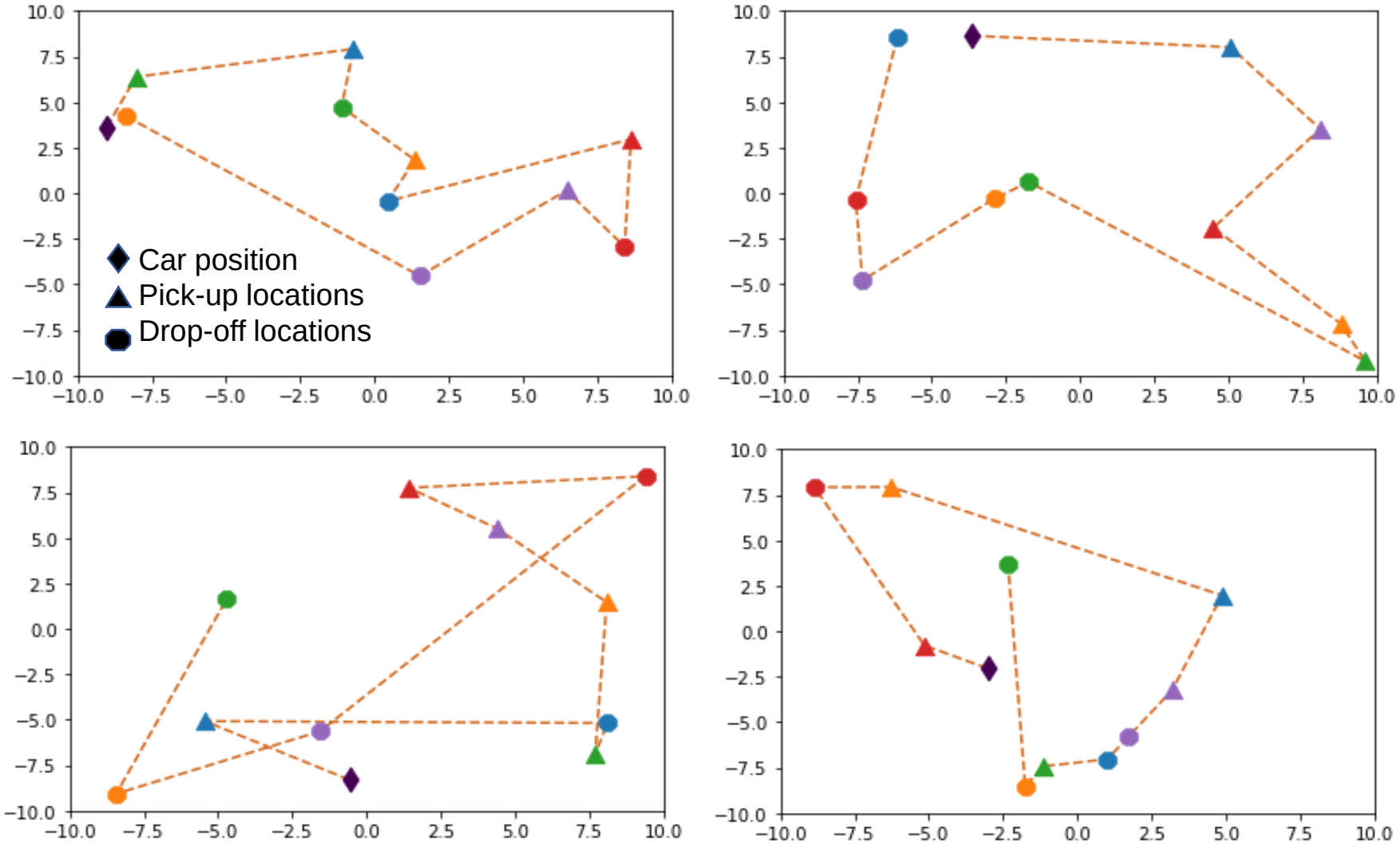
Ant Colony Optimization algorithm:

- Aim: find a near optimal route using *m* ants.
- Every ant starts at the position of the vehicle and constructs a 2n+1 way-point route.
- Before an ant chooses its next waypoint, it is provided with a list of illegals. Only viable routes constructed: The ants never visit first a drop-off node if they haven't visited the corresponding pick-up node.
- Parameters used:

$$n_{iterations} = 10,\ m = 20,\ q_0 = 0.2,\ \rho = 0.2,\ \beta = 6\ and\ \tau_0 = 1/65$$



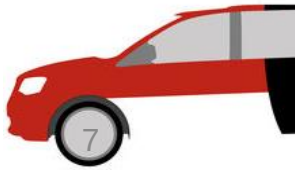
Methodology (2): Optimization of the routes



Results (1): Allocation clustering vs FIFO

- Human Allocating Criterion: FIFO. Serving the 5 oldest customers in the pool.
  - FIFO promotes a minimization of the waiting time, but the routes become more inefficient, ultimately increasing the average waiting time.

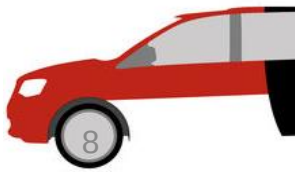
Method	t_{mean}	t_{std}	L_{mean}	L_{std}
Clustering	59.80	2.21	55.84	1.31
FIFO	76.86	1.77	61.03	1.35



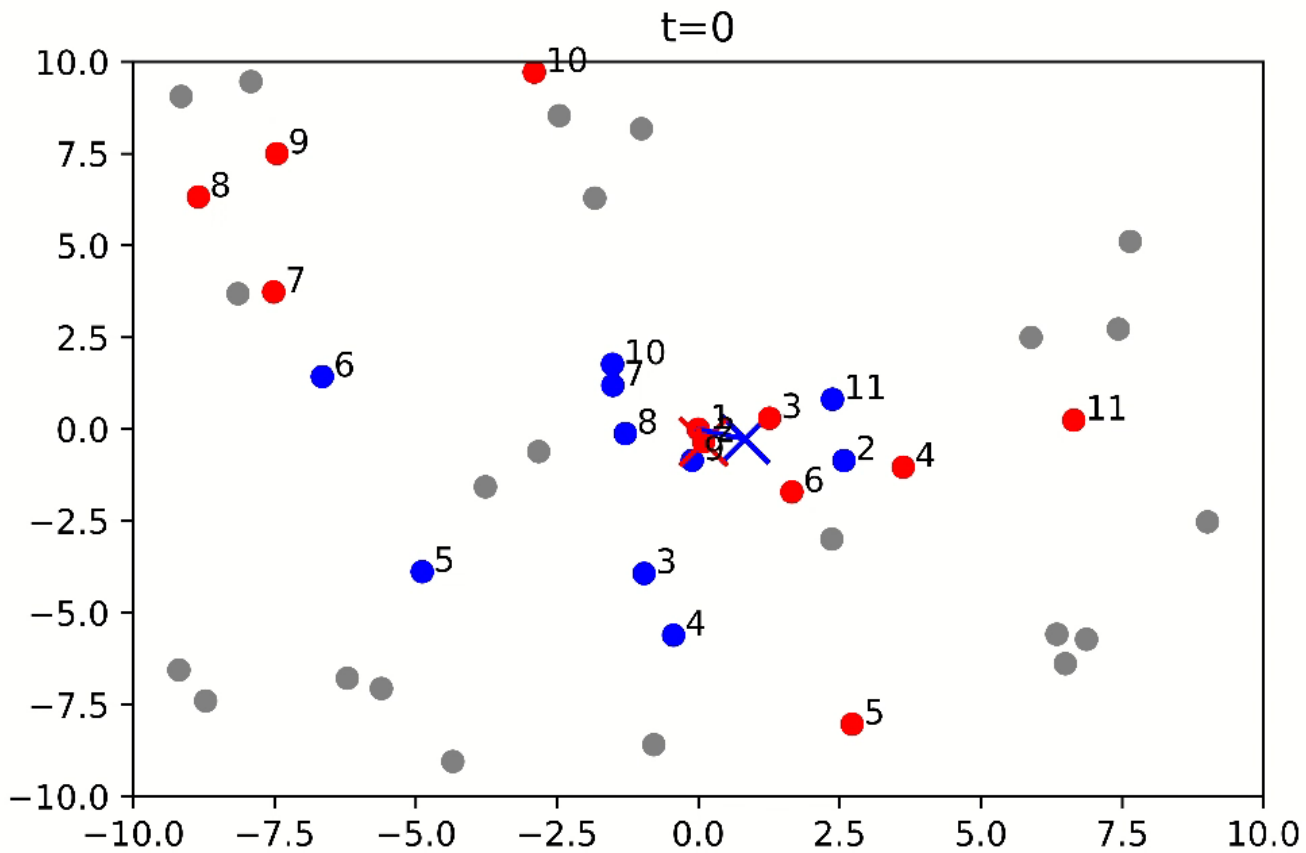
Results (2): ACO vs Manual approach

- 11 way-point routes.
- The algorithm outperforms the manual planning in 8 out of 10 simulation runs.
- Improvements in mean waiting times do not generally allow to serve more customers.
- No significant differences in the total distance covered by the vehicles.

Method	t_{mean}	D_1	D_2	n_{total}
Algorithm	84.73	348.8	327.6	55
Manual	87.50	352.8	368.0	60
Algorithm	75.58	334.3	366.8	60
Manual	81.67	361.2	399.5	60
Algorithm	65.67	361.1	343.0	60
Manual	85.67	352.9	402.1	60
Algorithm	66.31	351.7	365.9	65
Manual	84.50	356.0	365.9	60
Algorithm	79.17	371.2	366.3	60
Manual	76.08	352.2	364.9	60
Algorithm	73.83	369.8	355.7	60
Manual	77.75	360.2	399.4	60
Algorithm	60.00	385.0	365.3	65
Manual	70.08	364.8	376.3	60
Algorithm	62.92	333.1	352.7	60
Manual	68.92	337.3	354.5	60
Algorithm	81.17	368.5	378.6	60
Manual	84.64	337.2	345.4	55
Algorithm	74.58	352.6	373.9	60
Manual	71.25	375.0	365.6	60



Simulation of vehicles in service:



Conclusions:

- Results have shown that the algorithm outperforms a human by hand’s planning.
- The main difficulty of the problem is the allocation of the customers.
- It is “easy” for an individual to find a near optimal route with only 11 way-points.
- If higher capacity vehicles were considered, the difficulty of the task would increase exponentially for a human. ACO would make bigger differences.
- The simplifications made for this first approach are far from reality. Future development of the project should consider road network, non-individual requests, and traffic conditions.