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Time Dependent Pollution Routing Problem (TDPRP)

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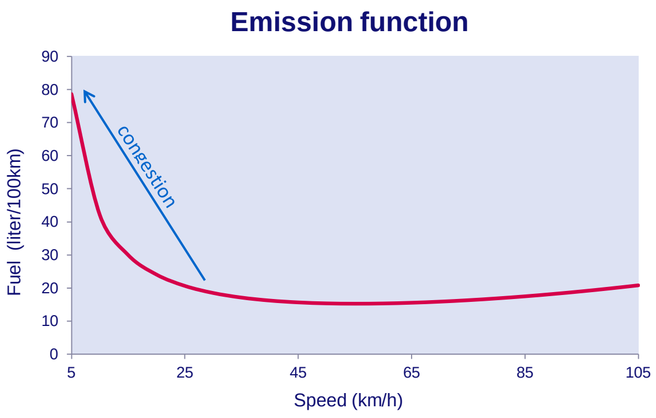
Problem description

Inputs
- homogeneous fleet of vehicles
- set of customers with known demand
- hard service time windows
-time-dependent speeds in cases where there is traffic congestion

Decision variables
- route
- departure time
- free flow speed



Objective
minimize a cost function that accounts for greenhouse gas emissions, fuel consumption, and driver costs.

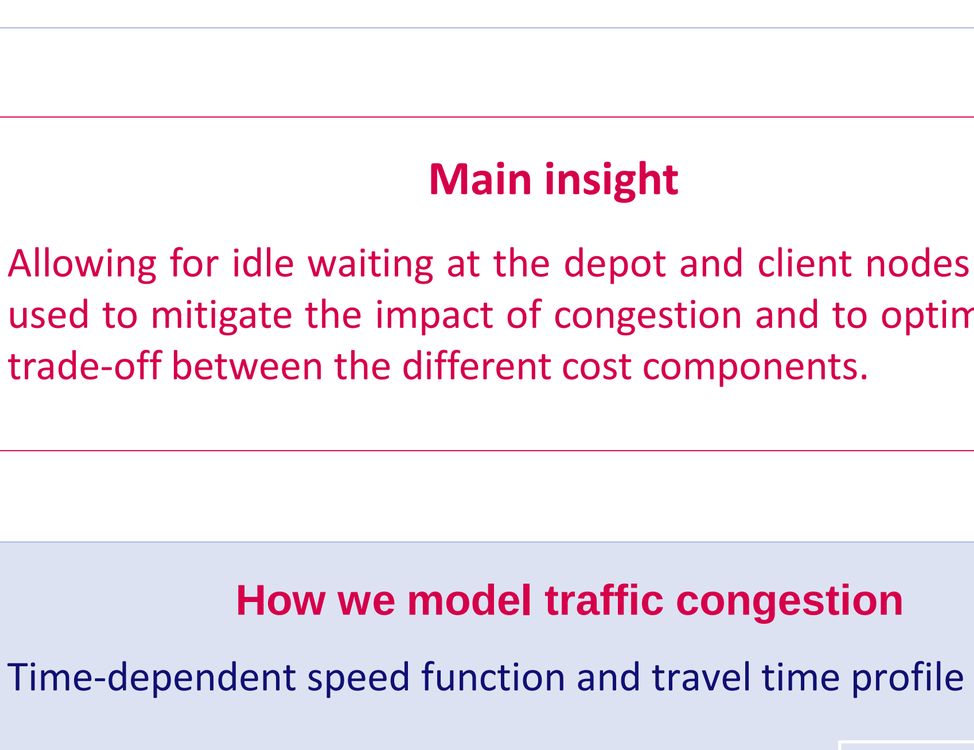
Main insight

Allowing for idle waiting at the depot and client nodes can be used to mitigate the impact of congestion and to optimize the trade-off between the different cost components.

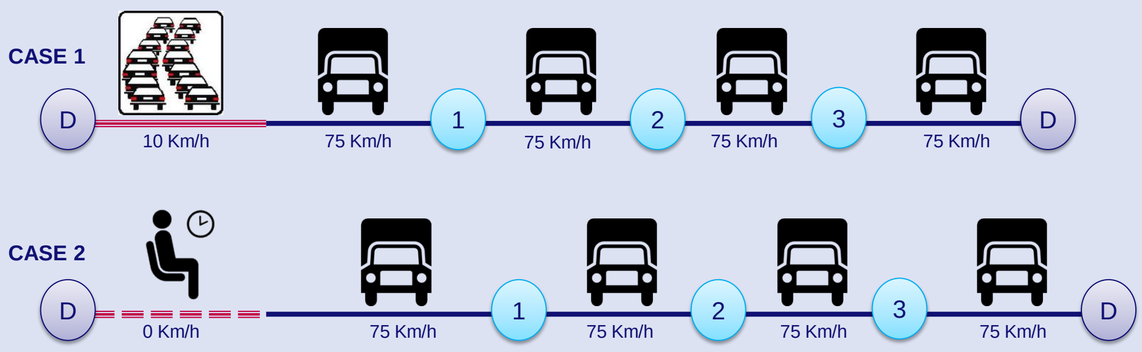
How we model traffic congestion

Time-dependent speed function and travel time profile

a congestion length
v_c congestion speed
v_f free flow speed
d distance



Illustrative example



Data	Value
Total distance	160 Km
Congestion length	6 h
Congestion speed	20 Km/h

Solution	CASE 1	CASE 2
Departure time (h)	0	6
Fuel cost (1.916 €/l)	69.67	43.875
Driving cost (9.483 €/h)	69.48	77
Total cost (€)	139.15	120.875

Analytical results

1) Given a single-link TDPRP instance, if there are no time windows one of the following two solutions is optimal:

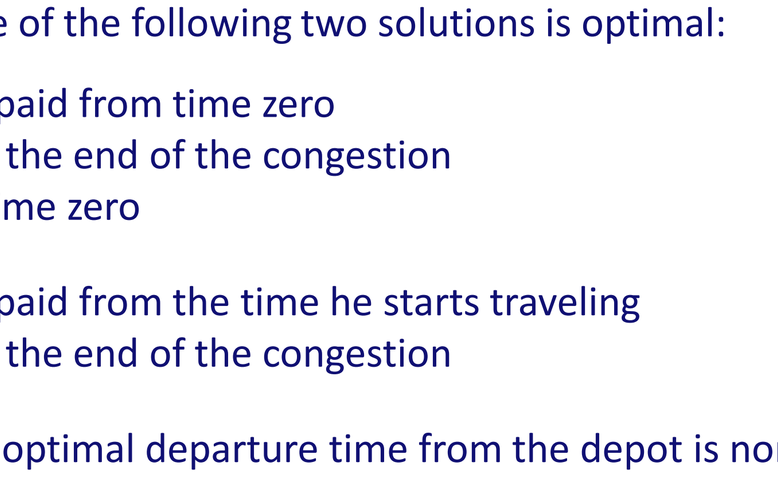
- the driver is paid from time zero
  - wait until the end of the congestion
  - leave at time zero

- the driver is paid from the time he starts traveling
  - wait until the end of the congestion

2) The (lowest) optimal departure time from the depot is non decreasing with respect to the time windows.

Illustrative example

Congestion speed: 30 Km/h
length: 2.5 h



DATA	NO TW		LOWER TW		
Departure time (h):	**0 ***	2.5	0	**1.6 ***	2.5
Fuel cost (1.916 €/l)	**35.62**	32.88	34.75	**32.4**	33.75
Driving cost (9.5 €/h)	**29.61**	39.12	38.25	**38.25**	38.25
Total cost (€)	**65.23**	72	73	**70.65**	72