Shortest Path and Scheduling with Driving Hours and Parking Availability Constraints

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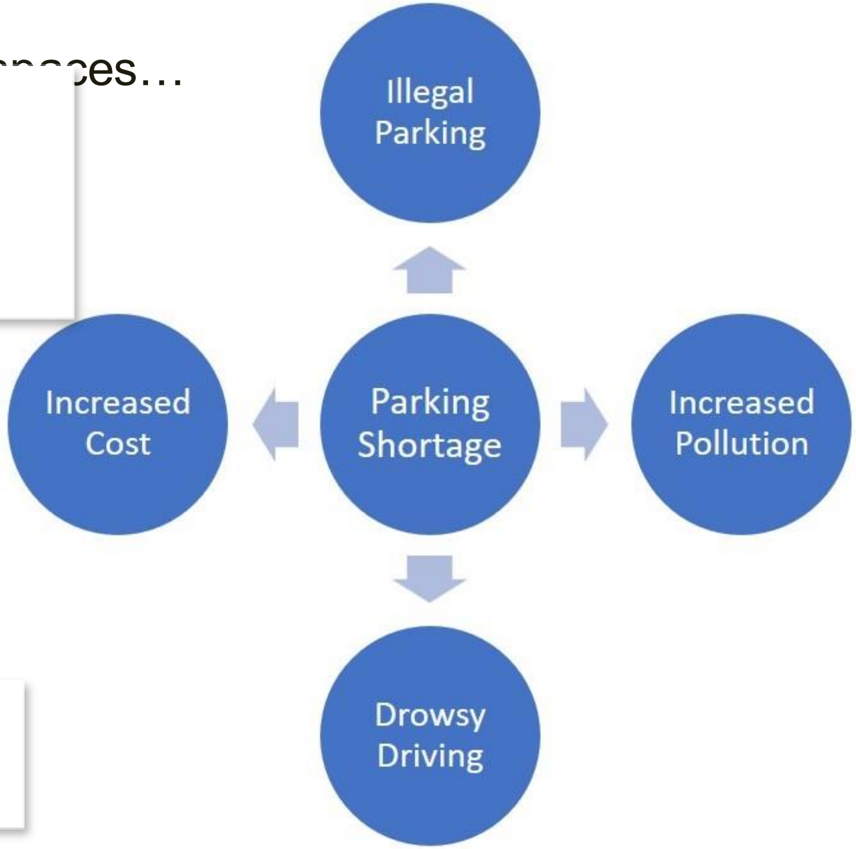
Motivation

Too many trucks, not enough parking spaces…

- Many drivers report issues to find truck parking at night.
- Less than 50% of truck stops report operating overcapacity at night.

Too many trucks going for the same rest areas at the same time!!!



Previous Work

- Working hours regulations
- Parking restricted to certain locations
- Scheduling (fixed path) → + Parking availability
- Routing (choose order of clients)

Truck Driver Scheduling

- Route and path are given

Vehicle Routing Problem

- Paths between any 2 locations are given

Our Objective

- Include parking availability
- Optimize path between clients

Problem

Objective

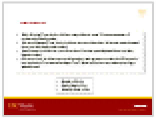
Minimize Trip Duration

- Send a single truck from A to B;
- Location B has 1 or more delivery time-windows;
- Can stop only at rest areas;
- Schedule must comply with the regulation;
- Rest areas with a scheduled stop must be available at the time of arrival.

Constraints

Structural
- Network Topology
- Departure time

Regulation
- Elapsed time
- Accumulated driving time
- Minimum rest duration



Client Time-windows
- Restrict arrival time

Parking Availability Time-windows
- If stopping, restrict arrival time
- If stopping, must rest

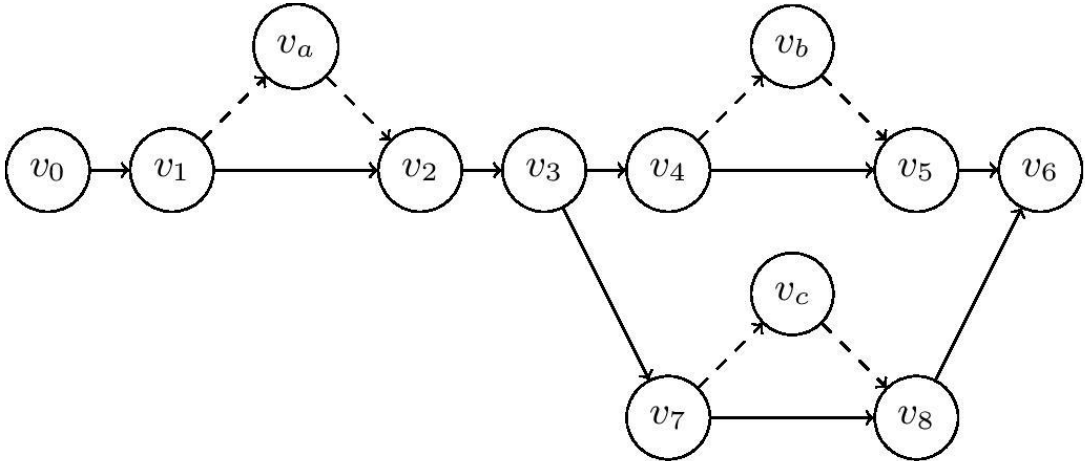
Required Visit/Stop ↑ (Client Time-windows)

Optional Visit/Stop ↗ (Parking Availability Time-windows)

Parking Availability

Time-windows

- start when the parking lot is expected to become available
- end when the parking lot is expected to become full
- **matter only when the driver needs to stop**
- **early arrival is not allowed.**



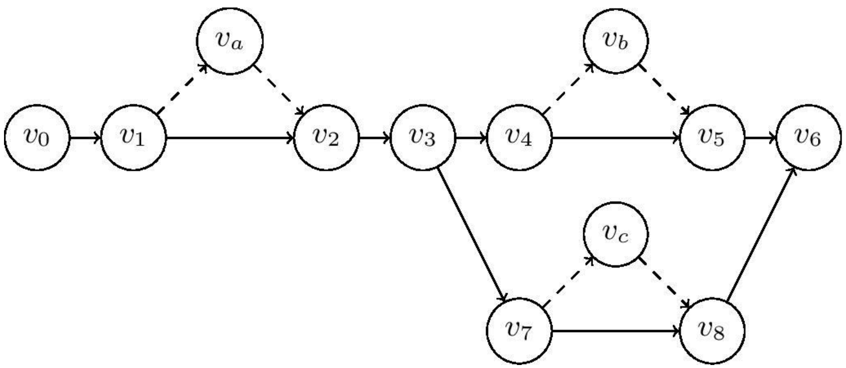
Shortest Path with Resource Constraints

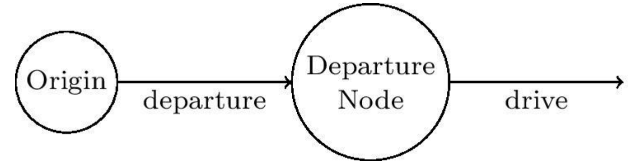
Resources

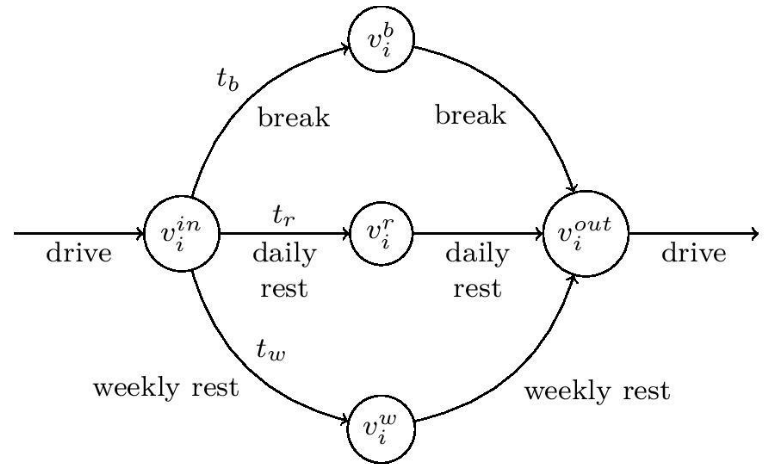
- current time (η^0)
- elapsed time since trip start (η^s)
- elapsed time since last *break* (η^b)
- elapsed time since last *daily rest* (η^r)
- accumulated driving time since last *daily rest* (ψ^r)
- accumulated on-duty time since last *weekly rest* (ψ^w)

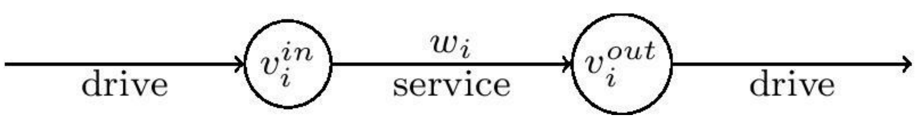
} Label

Road Network







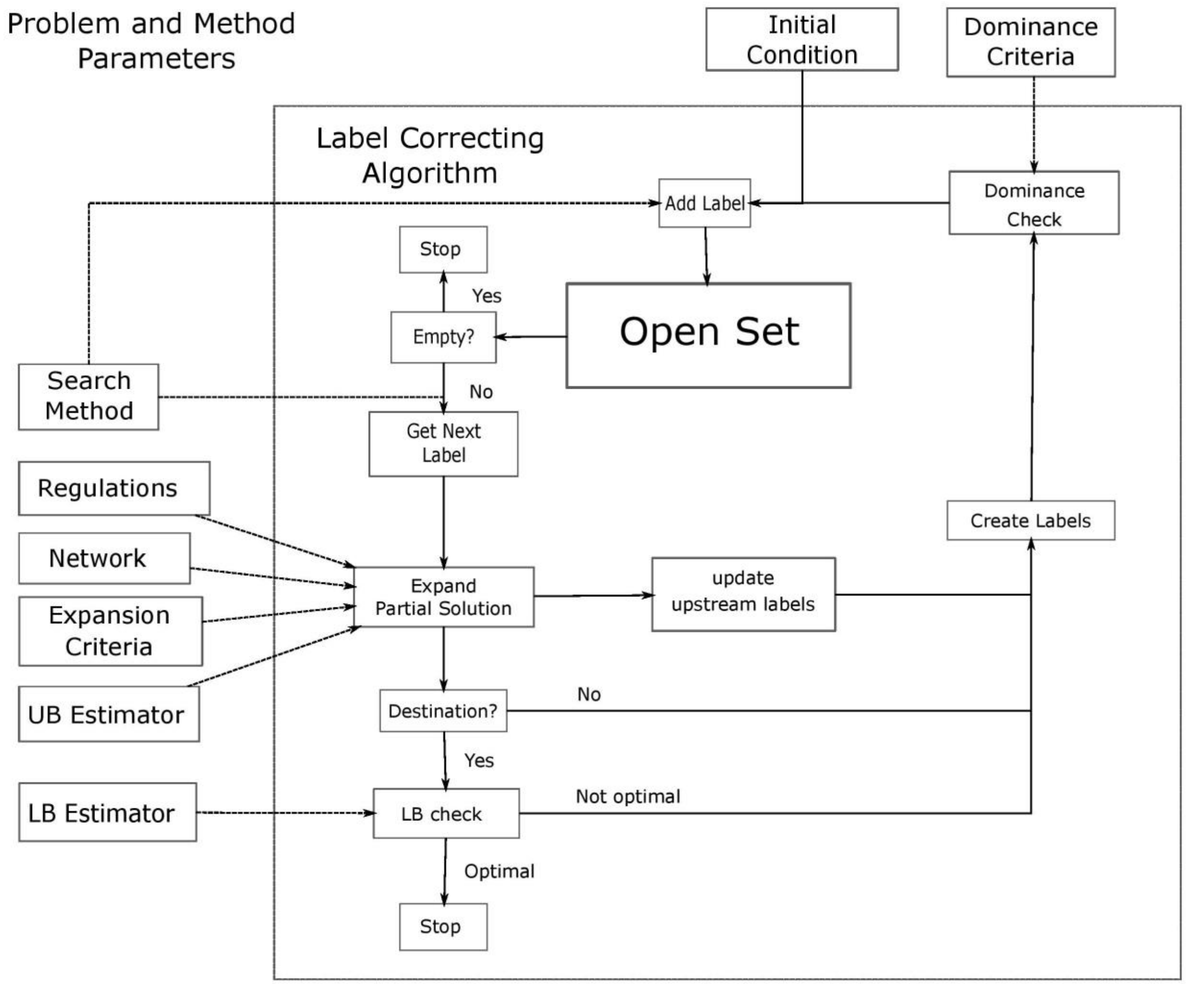


Resource Extension Functions

	f^d	f^s	f^b	f^r	f^w	f^0
$\hat{\eta}^0_{k+1} =$						
$\hat{\eta}^s_{k+1} =$						
$\hat{\eta}^b_{k+1} =$						
$\hat{\eta}^r_{k+1} =$						
$\hat{\psi}^r_{k+1} =$						
$\hat{\psi}^w_{k+1} =$						

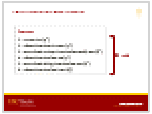
d: Driving, s: Service, b: Break,
r: Daily rest, w: Weekly rest, 0: Departure

Label Correcting Algorithm



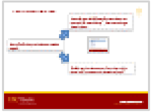
Label Correcting Algorithm

- Label Treatment Order

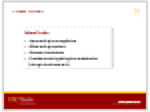


- Decisions to Test

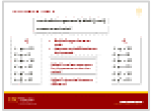
- Label Improvement



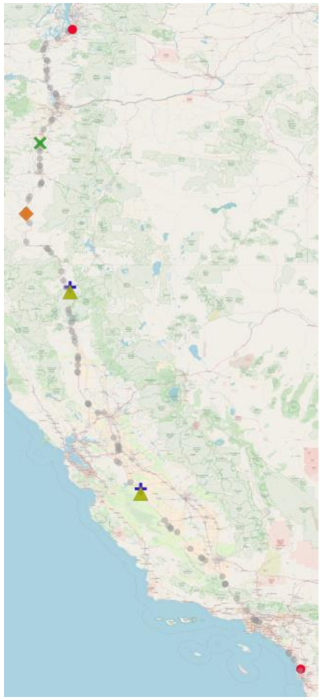
- A*



- Dominance Check



Experiment

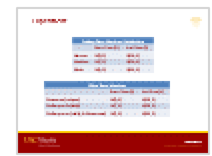


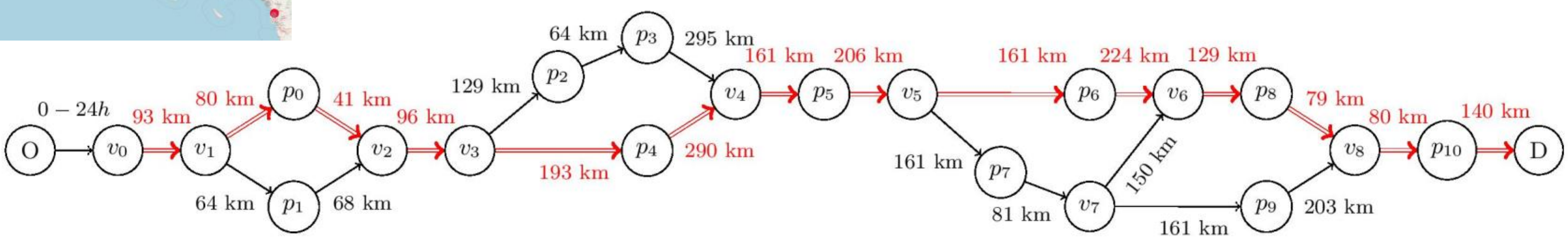
Measurements

- Alternative route usage
- Average driving times
- Average trip duration

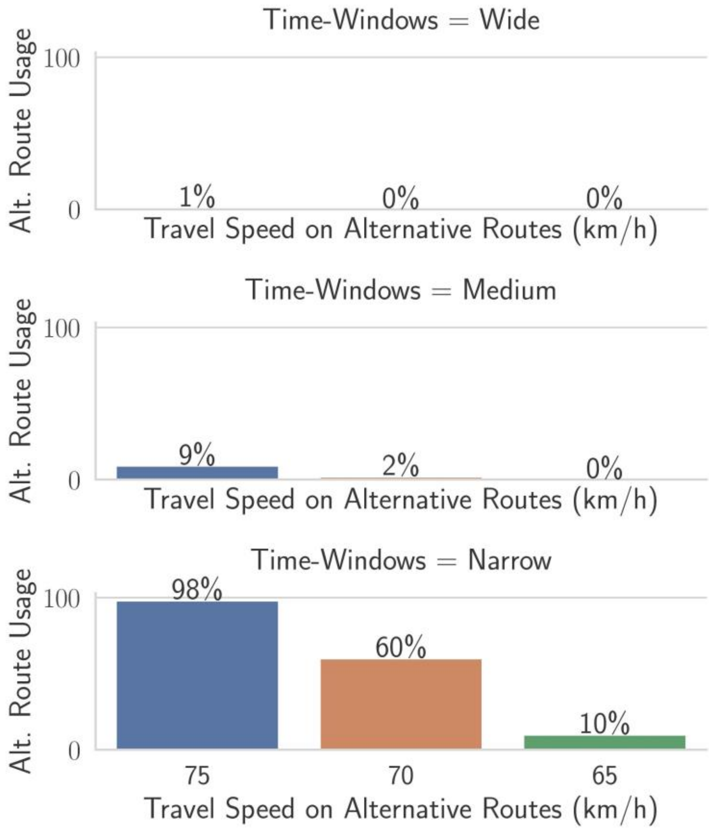
Main route

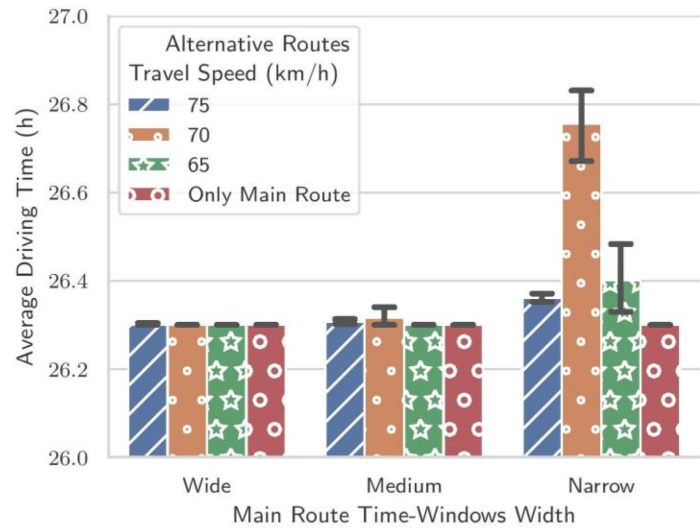
Alternative route

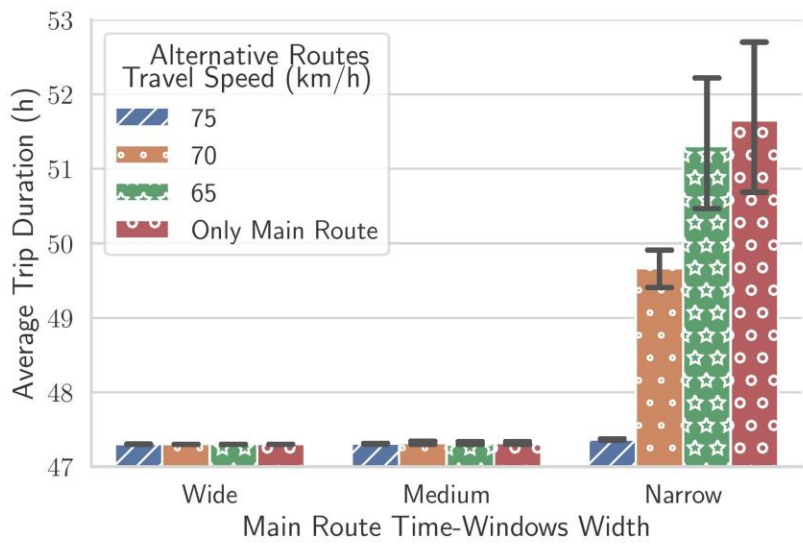




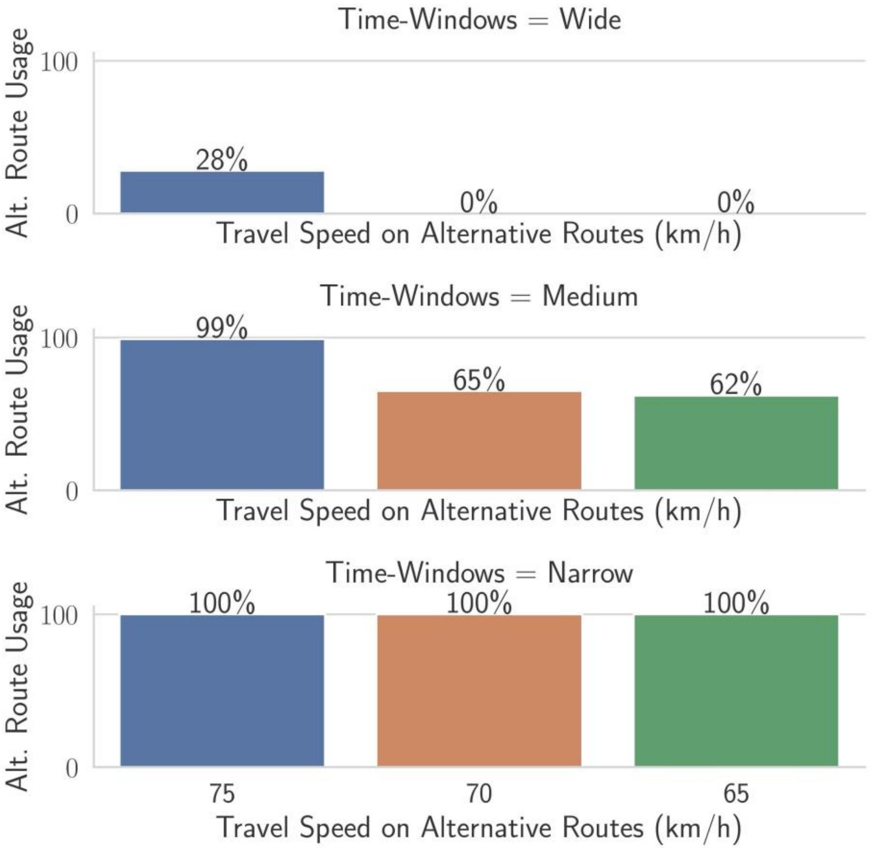
Results – Single Client

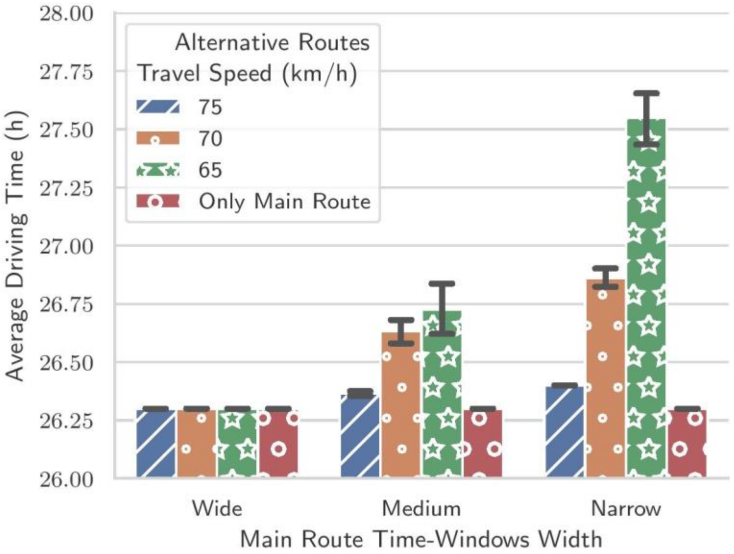


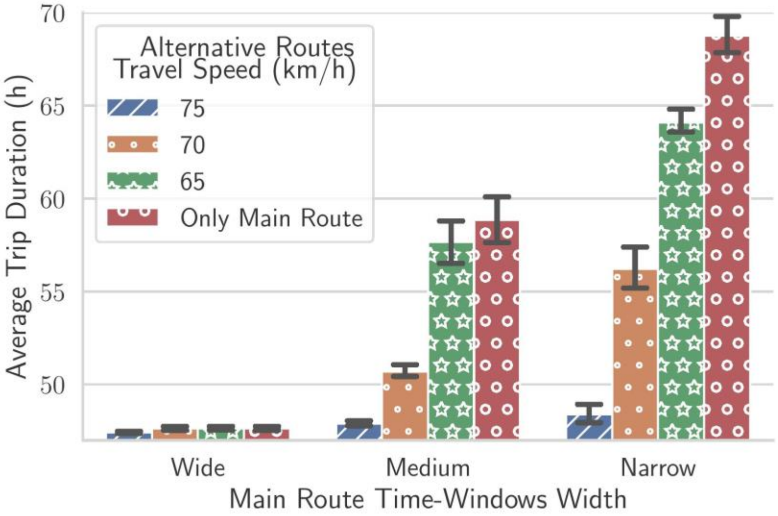




Results – Two Clients







Conclusion

- **Parking restrictions** greatly affect the minimum cost **path** and schedule between two locations;
- Under limited parking availability, it is cost-effective to consider **alternative paths**;
- The label correcting method presented generates paths and schedules that are **feasible in practice**;
- It can be used as a **post-processing** step to refine the path for a given route or directly integrated in a **vehicle routing algorithm**.

Future Work

Thank You!

- Stochastic Parking Availability
- Extend to Battery Electric Trucks (energy consumption, charging stations)
- Include speed optimization
- Include time-dependent travel times
- Multiple vehicles routing
- Vehicle platooning