Solving the Vehicle Routing Problem for Heavy-Duty Electric Vehicles with Optimality Guarantees

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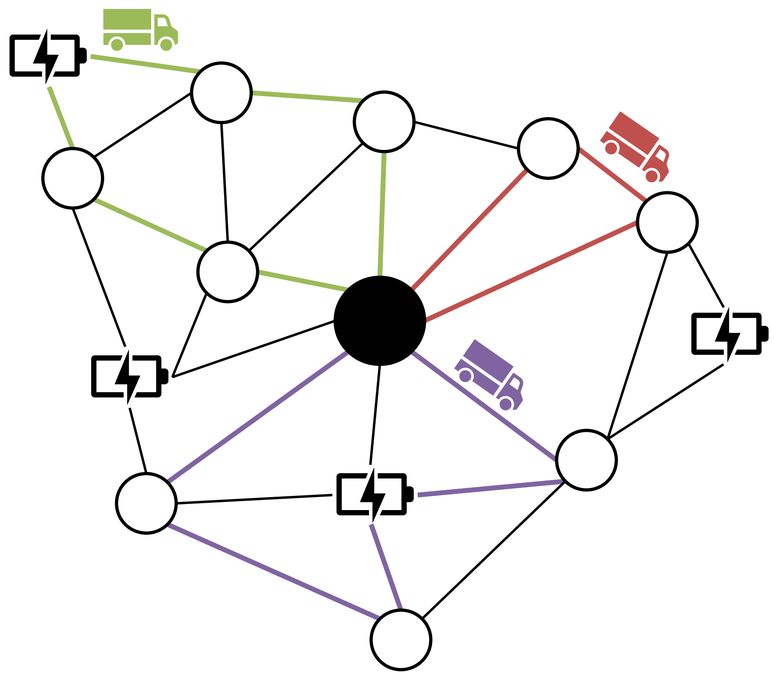
Motivation & Research Goals

The transportation sector is currently undergoing a significant transformation with the increasing **electrification** of heavy-duty vehicles. While this transition offers **substantial environmental benefits**, it also presents **new challenges in planning** and scheduling transportation assignments. Examples of such challenges are the weather-induced influence on the vehicles' range and the need to take charging into account. Addressing these complex challenges in an efficient and effective manner while still being able to give optimality guarantees necessitates advancements in the field of **vehicle routing problems** (VRP), both in adapting existing methods and developing new ones**.**

The Electrical Vehicle Routing Problem



Variables

λ_p^k Binary variable, 1 if vehicle *k* uses route *p,* else 0, $p \in N$ where *N* is all possible routes

Ongoing work:
How can congestion at chargers be modelled?

Model

$$\min \sum_{p \in N} \sum_{k \in K} c_p \lambda_p^k \ (Minimize\ total\ cost)$$

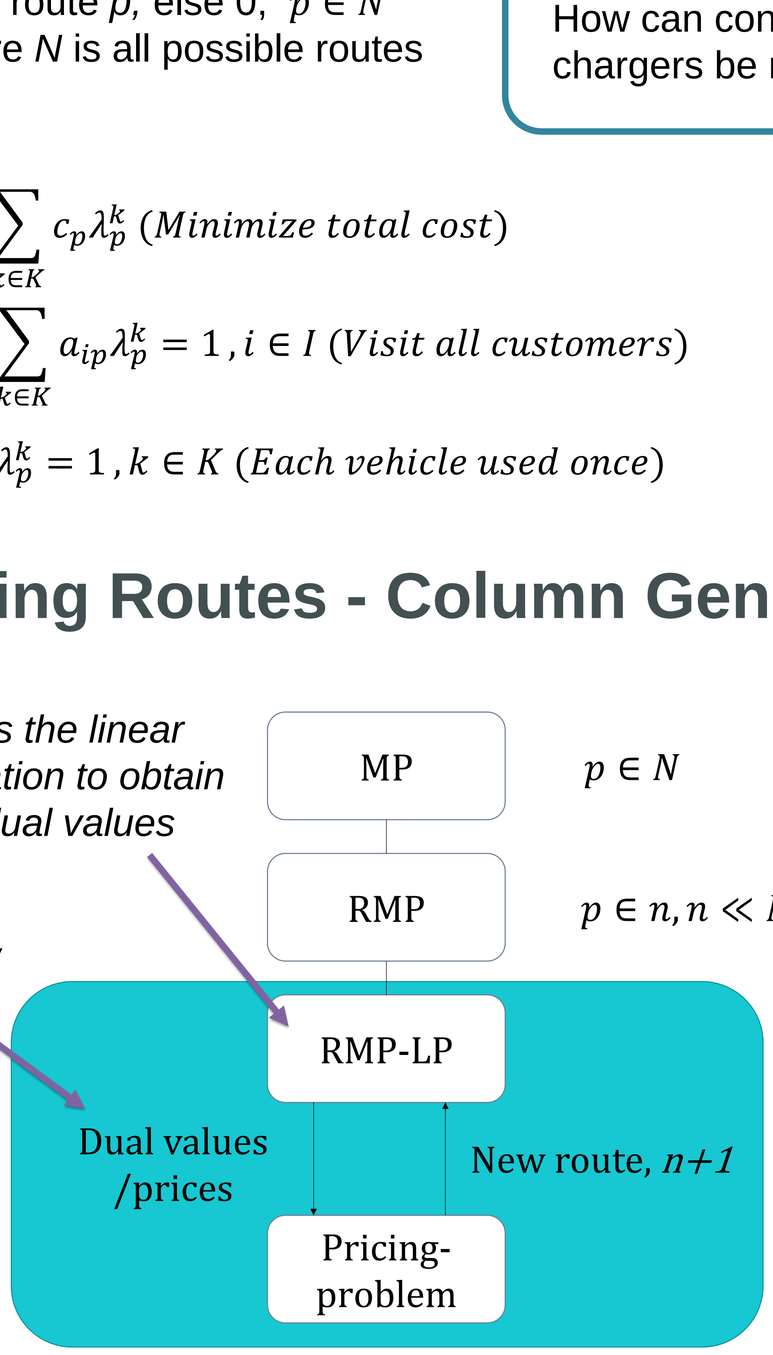
$$\sum_{p \in N} \sum_{k \in K} a_{ip} \lambda_p^k = 1, i \in I \ (Visit\ all\ customers)$$

$$\sum_{p \in N} \lambda_p^k = 1, k \in K \ (Each\ vehicle\ used\ once)$$

Generating Routes - Column Generation

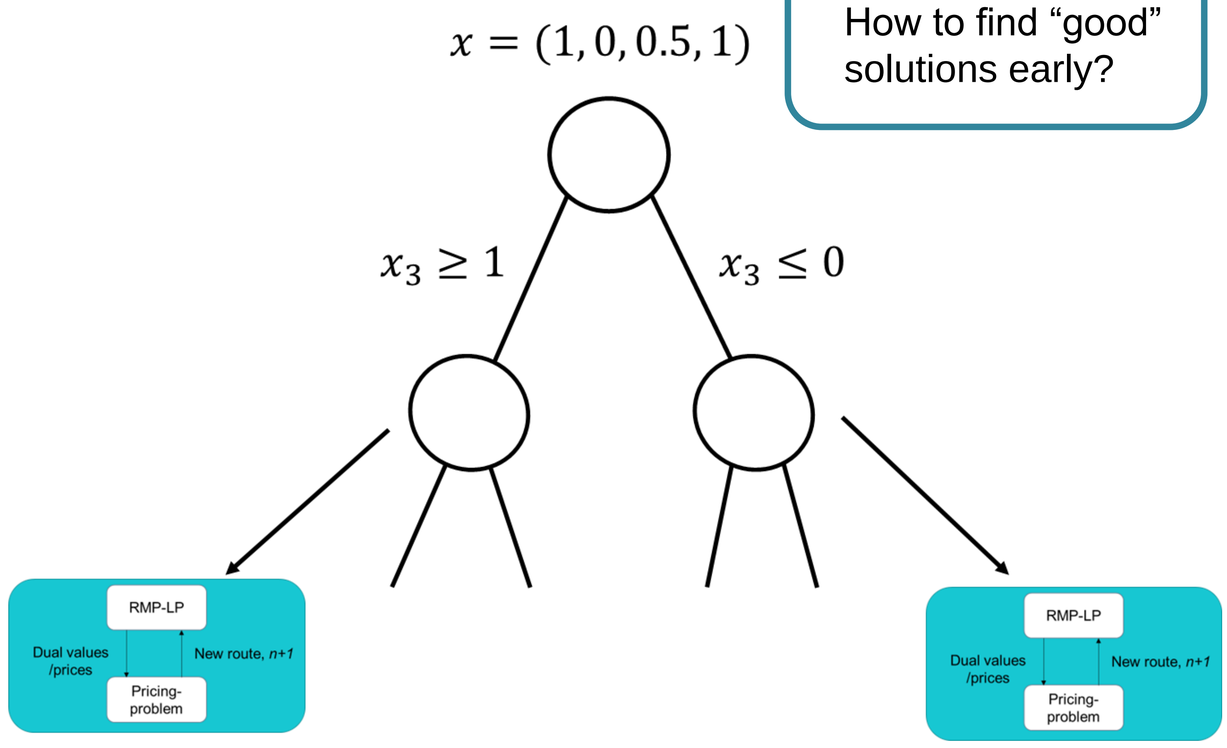
Solves the linear relaxation to obtain new dual values

Contains information on how the new route should be constructed



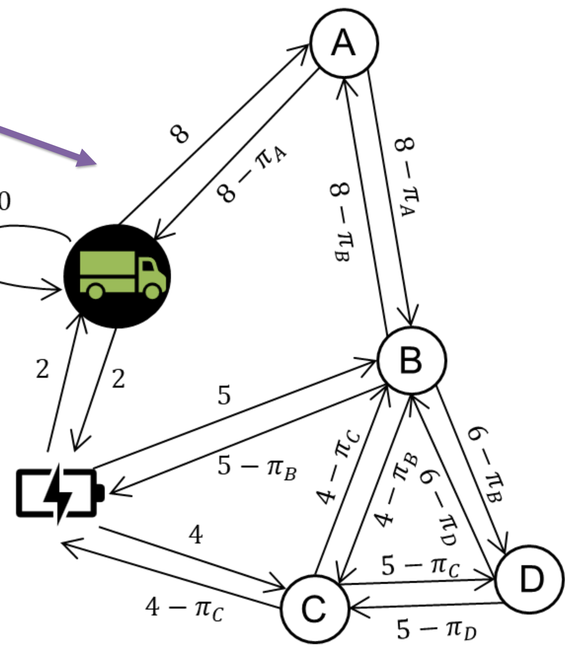
Getting an Integer Solution - Branch & Price

Ongoing work:
How to find "good" solutions early?



The Pricing Problem

The pricing problem turns out to be a special type of shortest path problem. Typically solved with dynamic programming.



Contributions (see [1]):

- New type of completion-bound taking both travel time and charging into account. This helps eliminating suboptimal partial routes during the solving process which leads to improved solving time.
- Combining this with well-known speed-up techniques.

References

1. Enerbäck, J., Eveborn, L., & Rönnberg, E. (2024). Pricing for the EVRPTW with Piecewise Linear Charging by a Bounding-Based Labeling Algorithm. *(ATMOS 2024)*

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