Professorship of Business Analytics & Intelligent Systems
TUM School of Management
Technical University of Munich

Resolution of charge-scheduling conflicts in the strategic planning of autonomous electric bus fleets

Driven by climate change, rising environmental awareness, and financial incentives, municipalities increasingly aim to operate public transportation networks with electric vehicles (EVs). When electrifying their public transportation fleets, municipalities face a charging station location problem with semi-flexible vehicle routes. More specifically, public transit stop sequences and timetables are known apriori, and municipalities aim to determine cost-optimal charger locations with respect to the vehicles' recharging costs and construction costs for charging stations. Solving problem instances of realistic size requires the application of state-of-the-art (meta-) heuristics (e.g., iterative local search). Moreover, in problem settings with multiple vehicles potentially recharging at the same physical charging locations, conflicts may occur if, for multiple vehicles, the planning problem yields overlapping charge intervals. Such conflicts can either be avoided by the integrated planning of the routes and charge schedules of the entire fleet or by planning the routes and charge schedules for each vehicle individually and resolving occurring conflicts a posteriori in a heuristic fashion.

Aims and scope of the thesis
This thesis aims to develop a reconstruction heuristic to resolve vehicle conflicts in given solutions of the charging station location problem with semi-flexible vehicle routes. Here, the conflicting vehicle routes and schedules can be computed both by an existing standard solver implementation and an existing iterative local search implementation. In the first step, the reconstruction heuristic tries to find a charging schedule that yields a feasible solution with the given charging station configuration by restricting the available energy supply in the underlying shortest path problems of the conflicting vehicles. Subsequently, the heuristic may explore alternative configurations within a neighborhood of the original unfeasible solution.

Thus, this thesis comprises the following research tasks:

- Extension of an existing mixed integer linear programming (MILP) formulation of the charging station location problem with semi-flexible vehicle routes to exclude charging schedule conflicts from the feasible region
- Development and implementation of a scalable reconstruction heuristic to resolve vehicle charging schedule conflicts based on given infeasible solutions to the formulated problem
- Creation of artificial benchmark sets and testing the developed reconstruction heuristic on the benchmark instances
- Application of the developed solution approach to the real-world case study of the city of Munich, Germany

Requirements
This thesis targets students of the TUM-BWL (with a major in Supply Chain Management), Informatics, Engineering or similar study programs. Knowledge of mathematical programming, optimization, and a general-purpose programming language (e.g. C++, Java, Python) is required. Prior participation in one of the seminars offered by the chair (i.e. Modeling Future Mobility Systems, Advanced Seminar) is recommended. The thesis should be written in English.

Related Research
- Huang, Y. & Kockelman, K. M. (2020). Electric vehicle charging station locations: Elastic demand, station congestion, and network equilibrium. Transportation Research Part D: Transport and Environment.
- Gendreau, M. & Potvin, J.-Y (2009). Handbook of Metaheuristics. Springer, New York, NY.
- Irnich, S., Desaulniers, G. (2005). Shortest Path Problems with Resource Constraints. Springer, Boston, MA.

Begin: as soon as possible

Advisor: Paul Bischoff

Application: See `https://www.ot.mgt.tum.de/osm/education/master-thesis/`