General Network Design Problems in Research on Transportation Networks

Problem Definition

Cities and urban areas worldwide suffer from overloaded transportation systems, whose externalities cause environmental harm via CO_2 emissions, health dangers via particulate matters and NO_x, and economic harm by working hours lost in congestion. Accordingly, the need for sustainable (urban) transportation systems is prevalent in today's society, and experts discuss various concepts and technological enhancements to improve either passenger or freight transportation. One such concept is *cargo-hitching*, where a logistic service provider can utilize a public transportation system (e.g., subway network). The goal of cargo-hitching is to realize intermodal freight transportation by complementing truck-based deliveries on the last mile. Researchers and practitioners see cargo-hitching as a promising concept because of its win-win nature. First, the pressure on the road network from conventional truck-based deliveries is reduced. Second, the utilization of the existing public transportation system is increased by freight transportation during off-peak hours.

However, designing such a network is complex. On a strategic level, municipalities need to decide where to locate hubs that allow freight exchange between the public transportation system and the vehicles of a logistics fleet. Moreover, the municipality needs to decide on the share of the public transportation system's capacity that can be used for cargo-hitching. We abstract the two strategic decisions as a Hub Location Problem on the one hand and a (fixed-charge and capacitated) Network Design Problem on the other hand.

Aims and Scope of this Thesis

This thesis aims to provide an extensive overview of existing research on General Network Design Problems in which the two problems are solved in an integrated fashion. Here, we want to focus on problems that stem from real-world Transportation Systems and are relevant for designing a *cargo-hitching* network. The following tasks outline the relevant steps in this thesis.

1) Extensive and thorough literature review on General Network Design Problems combining location and network design decisions
2) The literature review should conclude with a Linear Programming Formulation (as application-agnostic as possible and following established notation)
3) Overview of existing exact and heuristic approaches to solve General Network Design Problems, also indicating the current State-of-the-Art
4) Overview of existing and publicly available problem instances from the literature
5) Commercial solver implementation (CPLEX or Gurobi) of the problem formulation provided in 2)

References

Crainic, T.G., Gendreau, M., Gendron, B. (2021). Network Design with Applications to Transportation and Logistics.

Serper, E.Z., Alumur, S.A. (2016). The design of capacitated intermodal hub networks with different vehicle types. Transportation Research Part B: Methodological, 86, 51-65.

Contreras, I., Fernández, E. (2012). General network design: A unified view of combined location and network design problems, European Journal of Operational Research, 219(3), 680-697.

Begin: as soon as possible

Advisor: Paul Bischoff (paul.bischoff@tum.de)