Professorship of Business Analytics & Intelligent Systems
TUM School of Management
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Day-Ahead Planning for A Hybrid Two-Echelon City Logistics System with Swap Body Micro-hubs

E-commerce and urbanization have significantly increased city logistics worldwide, resulting in more traffic congestion and emissions. Governing bodies have enforced stricter emission regulations to mitigate these negative externalities, fostering a transition towards sustainable distribution systems. Consequently, Logistics service providers (LSPs) added electric vehicles to their fleets. However, these measures, which primarily focus on single-echelon distribution systems utilizing medium to large-sized electric vans, have not significantly reduced congestion and fine dust emissions. We propose a two-echelon city logistics system employing eco-friendly city freighters for last-mile deliveries and intermediate micro-hubs for freight replenishment. Freight is first consolidated at hubs on the outskirts. From there, trucks transport swap bodies filled with parcels to the selected micro-hub locations in dense urban areas. City freighters then perform the last-mile deliveries from these micro-hubs to the customers. The system operates on a day-ahead planning schedule, with loaded swap bodies transported into the city in the morning and returned empty in the evening. In addition, trucks can directly deliver from consolidation hubs to low-traffic areas. Accordingly, the city is partitioned into an inner and an outer zone, consolidating high-traffic areas in the inner zone. Operating such a system requires routing and location decisions in a day-ahead planning setting. Firstly, the LSP decides which customers to serve with conventional trucks and which to serve with city freighters. Secondly, the LSP decides on the location of open micro-hubs and the assignment of customers to be served by city freighters starting at these micro-hubs. Thirdly, the LSP decides on route plans for conventional trucks starting at the consolidation hubs and city freighters starting at the micro hubs. An effective algorithmic framework is needed to tackle these planning challenges.

Aims and scope of the thesis
In this setting, the LSP aims to determine the cost-optimal number and location of micro-hubs as well as the optimal routes for trucks and city freighters. Developing a scalable solution approach that can be efficiently utilized in real-world scenarios is crucial. To summarize, the work consists of the following research tasks:

- Literature review on two-echelon (two-tier) city logistics systems
- Development and evaluation of a two-echelon city logistics system against the traditional single-echelon city logistics system to assess potential benefits, including cost and environmental impact reductions.
- Development and implementation of an efficient solution approach, e.g., a (meta-)heuristic
- Generation of a relevant dataset, based on Munich as a case study upon which the methodology is applied

Requirements
This thesis targets students of the TUM School of Management. 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
- Dalla Chiara G, Alho AR, Cheng C, Ben-Akiva M, Cheah L (2020) Exploring Benefits of Cargo-Cycles versus Trucks for Urban Parcel Delivery under Different Demand Scenarios. Transportation Research Record 2674(5):553–562.
- Mühlbauer F, Fontaine P (2021) A parallelized large neighborhood search heuristic for the asymmetric two-echelon vehicle routing problem with swap containers for cargo-bicycles. European Journal of Operational Research 289(2):742–757.
- Sluijk N, Florio AM, Kinable J, Dellaert N, Van Woensel T (2023) Two-echelon vehicle routing problems: A literature review. European Journal of Operational Research 304(3):865–886.

Begin: as soon as possible

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