Aperiodic public transport timetabling with flexible line plans

Timetabling problems in public transport take as input line plans, stopping patterns and desired hourly frequencies. In the aperiodic timetabling problem with line planning elements (AT-LP) we allow changes in the line plans with the objective of maximizing passenger service, measured as a function of in-vehicle travel time, transfer time, transfer penalty, and waiting time. For a timetable to be feasible it must respect track section headways, station headways, station capacities. Furthermore we define lower and upper bounds on how much line plans may be changed. We present a heuristic approach to solve the AT-LP. Given a fixed Origin-Destination-Time matrix, we compute an initial feasible timetable. Modifications to the timetable in the form of shifting trips, adding and removing dwell time, skipping and adding stops, and increasing and decreasing frequency are then applied. Solutions that maximize passenger service respecting a budget on operational costs (measured as train.minutes cost) are accepted. Results for a case study using a train network in The Netherlands indicate that including line planning modifications allows obtaining timetables with increased passenger service when compared with using only timetable modifications. We use a lower bound on passenger service to compare the results obtained by our methodology.
Passenger service optimization through timetabling with free passenger route choice
Designing a public transport timetable that maximizes passenger service, measured in weighted travel time, is an intricate problem. The weighted travel time depends on the free route choice of passengers. Passenger route choice depends on the timetable. In turn, the timetable that minimizes weighted travel time depends on the route choice of passengers—and therefore requires passenger route choice information. Consequently, a sequential approach where timetables are designed provided pre-fixed passenger assignment to routes, may not find the optimal timetable. This paper aims to integrate passenger route choice and timetabling. It addresses the problem of designing maximal passenger service public transport timetables in systems with free route choice within a budget for operating costs. Operating costs are defined by the minimal cost vehicle schedule required to operate the timetable. The proposed methodology integrates a matheuristic for timetabling and vehicle scheduling with a passenger assignment model in an iterative framework, where different forms of integration are evaluated. Focus is on long to medium term timetabling, provided an initial timetable. Results for a realistic case study in the Greater Copenhagen area indicate that our approach consistently leads, at no additional cost, to timetables that represent a reduction in passenger weighted travel time in comparison to both an initial timetable and a non-integrated timetabling method that receives a single passenger assignment as input.

A matheuristic for transfer synchronization through integrated timetabling and vehicle scheduling
Long transfer times often add unnecessary inconvenience to journeys in public transport systems. Synchronizing relevant arrival and departure times through small timetable modifications could reduce excess transfer times, but may also directly affect the operational costs, as the timetable defines the set of feasible vehicle schedules. Therefore better results in terms of passenger service, operational costs, or both, could be obtained by solving these problems simultaneously.
Synchronizing transfers through integrated timetabling and vehicle scheduling - an iterative matheuristic approach with public transit traffic assignment

Transfer times add inconvenience to journeys and thus synchronizing departures and arrival times of relevant lines improves the service for passengers. As the timetable changes passengers may also change their travel itineraries. Additionally, introducing small timetable modifications may also affect the operational costs, as the timetable defines a set of feasible vehicle schedules. We address the Integrated Timetabling and Vehicle Scheduling Problem (IT-VSP) with Public Transit Traffic Assignment (PTTA). The IT-VSP is formulated as a MILP that minimizes transfer costs with a budget on operational costs. Given an initial noncyclical timetable, time-dependent service times and passenger demands, the transfer time cost is minimized by allowing modifications to the timetable that respect a set of headway constraints. Timetable modifications consist of shifts in departure time and addition of dwell time at intermediate stops. We propose to solve the problem iterating between solving a matheuristic for the IT-VSP and re-computing the PTTA. The matheuristic solves the ITVSP MILP allowing timetable modifications for a subset of timetabled trips only, while solving the full vehicle scheduling problem. Results for the Greater Copenhagen area indicate that our approach finds better solutions faster than a commercial solver and that allowing the addition of dwell time creates a larger potential for reducing transfer costs. We also show that the integration with the PTTA model generated solutions with lower transfer costs then the solutions obtained with a version that does not compute new passenger assignments once the timetables change.

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A matheuristic approach for solving the Integrated Timetabling and Vehicle Scheduling Problem

The Integrated Timetabling and Vehicle Scheduling Problem (IT-VSP) is a generalization of the well-known Vehicle Scheduling Problem (VSP). In the IT-VSP the trips in the original timetables may be modified in terms of arrival and departure times in order to minimize a new objective function that considers both operational costs and passenger transfer costs. Starting from a base timetable, the allowed modifications include shifting the departure time from the first station of each trip and also the extension of dwell times at important stops where large flows of passengers are expected to transfer between different trips. We consider transfers between bus trips scheduled by the model, but also transfers to other fixed lines that intersect the lines considered in the IT-VSP. We present a MIP formulation of the IT-VSP able to solve small instances of the problem, and a matheuristic approach that uses the compact MIP to solve larger instances of the problem. The idea is to iteratively solve restricted versions of the MIP selecting at each step a subset of trips where modifications are allowed, while all other trips remain fixed. The performance of the proposed matheuristic is shown on a case study with real-life instances provided by the main service provider in the greater Copenhagen area. The effect of allowing dwell times is compared to previous approaches to the problem where trips are only allowed to be shifted in time.

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The Simultaneous Vehicle Scheduling and Passenger Service Problem with Flexible Dwell Times

In this talk, we deal with a generalization of the well-known Vehicle Scheduling Problem (VSP) that we call Simultaneous Vehicle Scheduling and Passenger Service Problem with Flexible Dwell Times (SVSPSP-FDT). The SVSPSP-FDT generalizes the VSP because the original timetables of the trips can be changed (i.e., shifted and stretched) in order to minimize a new objective function that aims at minimizing the operational costs plus the waiting times of the passengers at transfer points. Contrary to most generalizations of the VSP, the SVSPSP-FDT establishes the possibility of changing trips’ dwell times at important transfer points based on expected passenger flows. We introduce a compact mixed integer linear formulation of the SVSPSP-FDT able to address small instances. We also present a meta-heuristic approach to solve medium/large instances of the problem. The effectiveness of the proposed solution methods is shown on a set of real-life instances provided by the main bus operator on the greater Copenhagen area. The effects of considering exible dwell times on the objective function and on the provided solutions are also analysed.

Cargo-mix optimization in Liner Shipping

International transportation constitutes one of the biggest challenges in limiting CO2 emission in the world: it is technically hard to find viable alternatives to fossil fuels, and due to the international nature, it is very difficult to regulate CO2 emission of intercontinental trade. Moreover, it is hard to motivate companies to pay for cleaner transport since transportation is not visible to end customers, and therefore cannot justify a higher cost. Hence, optimization may be one of the few options for limiting CO2 emission of international trade. A possible direction is to focus on vessels’ utilization. The more containers a vessel carries the smaller is the resulting CO2 emissions per transported ton of cargo. This is what can be seen as a win-win situation. Better vessel utilization will result both in cleaner transport and in better revenue margins for the shippers.

Focus on vessel intake maximization is old news for liner shippers. Container vessels are delivered with a nominal capacity that ship owners know is only theoretical. Unless the cargo weight distribution is perfect, the nominal intake cannot be
reached. Stowage coordinators fight this battle everyday. They are the planners of the cargo and have to find a load configuration (stowage plan) that both suits the current cargo to be loaded but also guarantees that the vessel can be utilized to its maximum in future ports. The size of nowadays vessels is, however, making this work harder and harder (Pacino et al. (2011)). Moreover, the cargo composition available in the different ports might not be suitable for the full utilization of the vessel. The focus of our work is the analysis of vessels’ cargo-mix, in particular finding what cargo composition is needed for a vessel to maximize its utilization on a given service. Such a model can have various applications ranging from driving rate prices, improving fleet composition and network design ((Christiansen et al., 2007; Reinhardt and Pisinger, 2012; Broer et al., 2014)).