Abstract

Vehicle and crew scheduling are two major planning problems arising in public bus transport companies. Briefly stated, these problems aim at assigning vehicle itineraries to scheduled trips and crews itineraries to tasks resulting from the vehicle schedule.

Traditionally, both planning steps have been approached sequentially where vehicle schedules are determined before crew schedules. In this thesis, however, we focus on the integrated consideration of vehicle and crew scheduling. The integration of both planning steps discloses additional flexibility that can lead to gains in efficiency compared to sequential planning. Until recently it was not possible to solve real-world integrated vehicle and crew scheduling problems with several depots within reasonable time and guaranteed solution quality. Still, large instances with complex duty feasibility rules cannot be tackled in an integrated manner.

We formulate the integrated vehicle and crew scheduling problem as combinatorial optimization problem. The basis of our mathematical formulation is a time-space network representation of the underlying vehicle scheduling problem that has led to promising results in literature. We solve the integrated problem with column generation in combination with Lagrangian relaxation.

In this thesis, we propose an approach for the column generation pricing problem that involves two novel network formulations for a decomposed pricing problem. We show that the network complexity of our approach is beneficial compared to other approaches previously exposed in literature. We apply a dynamic programming method to solve the pricing problem. In this context, we discuss known as well as novel adaptations of preprocessing and acceleration techniques that are essential to solve large problem instances. Furthermore, we discuss three solution methods to construct integer solutions, namely a Lagrangian heuristic, a branch-and-bound method, and a novel heuristic branch-and-price method. Our computational results indicate that our method outperforms other approaches from literature in terms of computational time and solution quality. For well-known benchmark instances, we presented previously unknown solutions and were able to tackle the largest instances so far.

Furthermore, we present a novel hybrid evolutionary algorithm for the multiple-depot integrated vehicle and crew scheduling problem that combines mathematical programming techniques with an evolutionary algorithm. Our computational results show that the algorithm performs worse than the best known integrated approach, but its solution quality increases with the problem size. However, our approach discloses significant savings compared to the traditional sequential approach without requiring a fully integrated solution method.

Finally, we consider practical rules and regulations arising in public transport companies in Germany. We suggest extensions and modifications of our modeling and solution approach to cover these practical extensions. Moreover, we consider the case where timetables consist of many trips serviced everyday together with some exceptions that do not repeat daily. Traditional optimization methods for vehicle and crew scheduling in such cases usually produce schedules that contain irregularities which are not desirable in practice. We propose a solution method which improves regularity while partially integrating the vehicle and crew scheduling problems.