Integrated Optimization in Public Transportation

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Abstract

Attractive and efficient public transportation is needed for satisfying the increasing mobility demand in an environmental-friendly way. In view of growing emissions, research on optimizing public transport is more relevant than ever.

The classical approach in public transportation planning is the following: after the network design, the lines and their frequencies are planned. Based on these, the timetable is determined, and later on the vehicles' and drivers' schedules. In order to account for the passengers, their routes are estimated after each of these stages and then used as input for the next stage. These single planning stages are well understood and many of them can algorithmically be treated. However, following the above sketched sequential approach may be far away from finding an optimal solution for the whole system. This calls for integrated optimization

In this talk we present approaches for integrated optimization in public transportation, apply then to benchmark examples, and discuss how useful they are. While we focus on public transportation, many of the underlying ideas can also be used in other application areas.

Integrated versus sequential optimization. The sequential procedure sketched above can be regarded as a Greedy approach: in each planning stage one aims at the best one can do. This usually leads to suboptimal solutions. On the other hand, many of these single steps are already NP hard such that solving the integrated problem to optimality seems to be out of scope. Nevertheless, we show how improvements can be made using the Eigenmodel as a framework for (heuristic) integrated optimization. We furthermore introduce the price of sequentiality as a measure how much can be gained by integrated approaches.

Integrating passengers' routes. While many models in public transportation aim to minimize the traveling time of the passengers, the behavior of the passengers is not reflected realistically in most approaches. In many models, passengers are routed before the optimization. These routes are then fixed and are the basis for finding good line plans and timetables. We show that such

a first routing has an immense impact on the resulting line plan, the timetable, the travel time and the costs. Better results are obtained if the routes of the passengers are variables which are determined within the optimization. However, these models are even harder to solve. We show two tricks to make such models tractable.

Finally, both aspects are combined, again in the framework of the Eigenmodel. We also show how more realistic models such as taking the vehicles' capacities into account, or using logit models can be heuristically treated within this framework. In an outlook we also sketch questions and ideas which may be relevant for integrated public transportation in the future.

Bio: Anita Schöbel is head of the research group "Optimization" at the Faculty for Mathematics and Computer Science of the Georg-August University Göttingen.

After receiving her PhD in 1998 at the Technical University of Kaiserslautern, she worked as a postdoc at the Fraunhofer Institute for Industrial Mathematics for two years before she went back to university to receive her Habilitation in 2003. She received a position as associate professor in Göttingen in 2004 and has been full processor since 2007.

Her research interests focus on discrete optimization in public transportation, multi-objective robust optimization, and several topics related to facility location. She develops approaches based on integer programming, graph-based algorithms, and simulation.

She has been involved in many industrial and research projects, among them the European projects ARRIVAL and OptALI and cooperation with India. She is also the coordinator of the research unit on Integrated Transportation funded by the German Research Foundation (DFG). Anita is on the managing board of the German Society of Operations Research (GOR) and of the Center of Simulation Studies Clausthal-Göttingen (SWZ).

She is married and has two children.