ATMOS 2006 — Abstracts Collection

6th Workshop on Algorithmic Methods and Models for Optimization of Railways

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INVITED TALK:
Directions in Railway and Public Transport Optimization

Ralf Borndörfer (Zuse-Institute Berlin, Germany)

Optimization methods for rail and public transport have reached a high mathematical standard and can make significant contributions to the solution of the planning problems of the area. Particularly rolling stock, crew, and roster optimizers are nowadays routinely used in many companies to solve scheduling problems of unprecedented size and complexity. Such success stories often create a demand for more, such that extensions, new problems, and applications emerge directly out of practice. This demand, combined with changes in technology and regulations, result in a dynamic environment with interesting optimization challenges. The talk illustrates three of these developments from a mathematical as well as a practical point of view, namely, the more and more integrated treatment of scheduling problems, approaches to service design, and some developments related to deregulation.

TUTORIAL:
Next Generation Decision Support Systems in Railroad Scheduling

Ravindra K. Ahuja (University of Florida and Innovative Scheduling, Inc., USA)

The past few decades have witnessed numerous applications of combinatorial optimization in industry and these applications have resulted in substantial cost savings. However, the US railroad industry has been benefited from the advances and most of the planning and scheduling processes do not use modeling and optimization. Indeed, most of the planning and scheduling problems arising in railroads, which involve billions of dollars of resources annually, are currently being solved manually. The main reason for not using optimization models and methodologies is the mathematical difficulty of these problems which prevented the development of decision tools that railroads can use to obtain implementable solutions. However, this situation is now gradually changing. We are now developing cutting-edge discrete optimization and network flow based algorithms that railroads have already started using and have started deriving benefits from them. This talk will give an overview of important railroad planning and scheduling problems including blocking, train scheduling, locomotive and crew scheduling; describe new algorithms to solve some of these problems; and how these algorithms are packaged into highly interactive web-based decision support systems. We will present computational results of these algorithms on the data provided by several US railroads, demonstrating potential benefits from tens of millions of dollars annually.

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A Column Generation Approach for the Rail Crew Re-Scheduling Problem

Dennis Huisman (Erasmus University Rotterdam, Netherlands)

When tracks are out of service for maintenance during a certain period, trains cannot be operated on those tracks. This leads to a modified timetable, and results in infeasible rolling stock and crew schedules. Therefore, these schedules need to be repaired. The topic of this paper is the rescheduling of crew.

In this paper, we define the Crew Re-Scheduling Problem (CRSP). Furthermore, we show that it can be formulated as a large-scale set covering problem. The problem is solved with a column generation based algorithm. The performance of the algorithm is tested on real-world instances of NS, the largest passenger railway operator in the Netherlands. Finally, we discuss some benefits of the proposed methodology for the company.

Keywords: Column generation, crew re-scheduling, large-scale optimization, railways, transportation

An Efficient MIP Model for Locomotive Scheduling with Time Windows

Martin Aronsson, Per Kreuger (Swedish Institute of Computer Science, Kista, Sweden), and Jonata Gjerdrum (Green Cargo AB, Sweden)

This paper presents an IP model for a vehicle routing and scheduling problem from the domain of freight railways. The problem is non-capacitated but allows non-binary integer flows of vehicles between transports with departure times variable within fixed intervals. The model has been developed with and has found practical use at Green Cargo, the largest freight rail operator in Sweden.

Keywords: Vehicle routing and scheduling, rail traffic resource management, resource levelling

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/683

Locomotive and Wagon Scheduling in Freight Transport

Armin Fügenschuh, Henning Homfeld (TU Darmstadt, Germany), Andreas Huck (Deutsche Bahn AG, Germany), and Alexander Martin (TU Darmstadt, Germany)

We present a new model for a strategic locomotive scheduling problem arising at the Deutsche Bahn AG. The model is based on a multi-commodity min-cost flow formulation that is also used for public bus scheduling problems. However, several new aspects have to be additionally taken into account, such as cyclic departures of the trains, time windows on starting and arrival times, network-load dependend travel times, and a transfer of wagons between trains. The model is formulated as an integer programming problem, and solutions are obtained using commercial standard software. Computational results for several test instances are presented.

Keywords: Freight transport, vehicle scheduling, time windows, Integer Programming.

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/686

Periodic Metro Scheduling

Evangelos Bampas, Georgia Kaouri, Michael Lampis, and Aris Pagourtzis (National Technical University of Athens, Greece)

We introduce the Periodic Metro Scheduling (PMS) problem, which aims in generating a periodic timetable for a given set of routes and a given time period, in such a way that the minimum time distance between any two successive trains that pass from the same point of the network is maximized. This can be particularly useful in cases where trains use the same rail segment quite often, as happens in metropolitan rail networks.

We present exact algorithms for (PMS) in chain and spider networks, and constant ratio approximation algorithms for ring networks and for a special class of tree networks. Some of our algorithms are based on a reduction to the Path Coloring problem, while others rely on techniques specially designed for the new problem.

Keywords: Train scheduling, path coloring, delay-tolerant scheduling, periodic timetabling

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/684

A Game-Theoretic Approach to Line Planning

Anita Schöbel and Silvia Schwarze (Georg-August Universität Göttingen, Germany)

We present a game-theoretic model for the line planning problem in public transportation, in which each line acts as player and aims to minimize a cost function which is related to the traffic along its edges.

We analyze the model and in particular show that a potential function exists.

Based on this result, we present a method for calculating equilibria and present first numerical results using the railway network of *Deutsche Bahn*.

Keywords: Line planning, network game, equilibrium

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/688

QoS-aware Multicommodity Flows and Transportation Planning

George Tsaggouris and Christos Zaroliagis (CTI & University of Patras, Greece)

We consider the *QoS-aware Multicommodity Flow* problem, a natural generalization of the weighted multicommodity flow problem where the demands and commodity values are elastic to the Quality-of-Service characteristics of the underlying network. The problem is fundamental in transportation planning and also has important applications beyond the transportation domain. We provide a FPTAS for the QoS-aware Multicommodity Flow problem by building upon a Lagrangian relaxation method and a recent FPTAS for the non-additive shortest path problem.

Keywords: Quality of service, multicommodity flows, fully polynomial approximation scheme, transportation planning

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/682

Freight Service Design for the Italian Railways Company

Marco Campetella (Trenitalia Spa, Italy), Guglielmo Lulli (Università di Milano "Bicocca", Italy), Ugo Pietropaoli, and Nicoletta Ricciardi (Università di Roma "La Sapienza", Italy)

In this paper, we present a mathematical model to design the service network, that is the set of origin-destination connections. The resulting model considers both full and empty freight car movements, and takes into account handling costs. More specifically, the model suggests the services to provide, as well as the number of trains and the number and type of cars traveling on each connection. Quality of service, which is measured as total travel time, is established by minimizing the waiting time of cars at intermediate stations.

Our approach yields a multi-commodity network design problem with concave arc cost functions. To solve this problem, we implement a tabu search procedure which adopts "perturbing" mechanisms to force the algorithm to explore a larger portion of the feasible region. Computational results on realistic instances show a significant improvement over current practice.

Keywords: Railways transportation, service network design, tabu search

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/685

Robustness and Recovery in Train Scheduling - a Case Study from DSB S-tog a/s

Mads Hofman, Line Madsen, Julie Jespersen Groth, Jens Clausen, Jesper Larsen (Technical University of Denmark)

This paper presents a simulation model to study the robustness of timetables of DSB S-tog a/s, the city rail of Copenhagen. Dealing with rush hour scenarios only, the simulation model investigates the effects of disturbances on the S-tog network. Several timetables are analyzed with respect to robustness. Some of these are used in operation and some are generated for the purpose of investigating timetables with specific alternative characteristics.

Keywords: Train scheduling, simulation model, robustness, recovery

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