

ATMOS 2008 - Abstracts Collection

Selected Papers from the 8th Workshop on Algorithmic Approaches for Transportation Modeling, Optimization, and Systems

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Abstract. Proceedings of the 8th Workshop on Algorithmic Approaches for Transportation Modeling, Optimization, and Systems, held on September 18 in Karlsruhe, Germany.

ATMOS 2008 Preface – 8th Workshop on Algorithmic Approaches for Transportation Modeling, Optimization, and Systems

The 8th ATMOS workshop was held in Karlsruhe, September 18, 2008, within ALGO, a set of meetings related to algorithms. The series of ATMOS workshops, starting in Heraklion in 2001, continuing in Malaga in 2002, Budapest in 2003, Bergen in 2004, Palma de Mallorca in 2005, Zürich in 2006, and Sevilla in 2007 is by now an established series of meetings between algorithms researchers dealing with transportation problems, and practitioners, mainly from railways.

Joint work of: Fischetti, Matteo; Widmayer, Peter

Extended Abstract: <http://drops.dagstuhl.de/opus/volltexte/2008/1593>

Dynamic Algorithms for Recoverable Robustness Problems

Recently, the recoverable robustness model has been introduced in the optimization area. This model allows to consider disruptions (input data changes) in a unified way, that is, during both the strategic planning phase and the operational phase. Although the model represents a significant improvement, it has the following drawback: we are typically not facing only one disruption, but many of them might appear one after another. In this case, the solutions provided in the context of the recoverable robustness are not satisfying. In this paper we extend the concept of recoverable robustness to deal not only with one single recovery step, but with arbitrarily many recovery steps. To this aim, we introduce the notion of dynamic recoverable robustness problems. We apply the new model in the context of timetabling and delay management problems. We are interested in finding efficient dynamic robust algorithms for solving the timetabling problem and in evaluating the price of robustness of the proposed solutions.

Keywords: Robustness, optimization problems, dynamic algorithms, timetabling, delay management

Joint work of: Cicerone, Serafino; Di Stefano, Gabriele; Schachtebeck, Michael; Schöbel, Anita

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1587>

Efficient On-Trip Timetable Information in the Presence of Delays

The search for train connections in state-of-the-art commercial timetable information systems is based on a static schedule. Unfortunately, public transportation systems suffer from delays for various reasons. Thus, dynamic changes of the planned schedule have to be taken into account. A system that has access to delay information of trains (and uses this information within search queries) can provide valid alternatives in case a train change breaks. Additionally, it can be used to actively guide passengers as these alternatives may be presented before the passenger is already stranded at a station due to a broken transfer. In this work we present an approach which takes a stream of delay information and schedule changes on short notice (partial train cancellations, extra trains) into account. Primary delays of trains may cause a cascade of so-called secondary delays of other trains which have to wait according to certain waiting policies between connecting trains. We introduce the concept of a dependency graph to efficiently calculate and update all primary and secondary delays. This delay information is then incorporated into a time-expanded search graph which has to be updated dynamically. These update operations are quite complex, but turn out to be not time-critical in a fully realistic scenario. We finally present a case study with data provided by Deutsche Bahn AG showing that this approach has been successfully integrated into our multi-criteria timetable information system MOTIS and can handle massive delay data streams instantly.

Keywords: Timetable information system, primary and secondary delays dependency graph, dynamic graph update

Joint work of: Frede, Lennart; Müller-Hannemann, Matthias; Schnee, Mathias

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1584>

Engineering Time-Expanded Graphs for Faster Timetable Information

We present an extension of the well-known time-expanded approach for timetable information. By remodeling unimportant stations, we are able to obtain faster query times with less space consumption than the original model. Moreover, we show that our extensions harmonize well with speed-up techniques whose adaption to timetable networks is more challenging than one might expect.

Keywords: Timetable information, shortest path, modeling

Joint work of: Dellling, Daniel; Pajor, Thomas; Wagner, Dorothea

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1582>

Integrated Gate and Bus Assignment at Amsterdam Airport Schiphol

At an airport a series of assignment problems need to be solved before aircraft can arrive and depart and passengers can embark and disembark. A lot of different parties are involved with this, each of which having to plan their own schedule. Two of the assignment problems that the 'Regie' at Amsterdam Airport Schiphol (AAS) is responsible for, are the gate assignment problem (i.e. where to place which aircraft) and the bus assignment problem (i.e. which bus will transport which passengers to or from the aircraft). Currently these two problems are solved in a sequential fashion, the output of the gate assignment problem is used as input for the bus assignment problem. We look at integrating these two sequential problems into one larger problem that considers both problems at the same time. This creates the possibility of using information regarding the bus assignment problem while solving the gate assignment problem. We developed a column generation algorithm for this problem and have implemented a prototype. To make the algorithm efficient we used a special technique called stabilized column generation and also column deletion. Computational experiments with real-life data from AAS indicate that our algorithm is able to compute a planning for one day at Schiphol in a reasonable time.

Keywords: Gate assignment, airports, integrated planning, column generation, integer linear programming

Joint work of: Diepen, Guido; van den Akker, Marjan; Hoogeveen, Han

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1591>

IP-based Techniques for Delay Management with Priority Decisions

Delay management is an important issue in the daily operations of any railway company. The task is to update the planned timetable to a disposition timetable in such a way that the inconvenience for the passengers is as small as possible. The two main decisions that have to be made in this respect are the wait-depart decisions to decide which connections should be maintained in case of delays and the priority decisions that determine the order in which trains are allowed to pass a specific piece of track. They later are necessary in the capacitated case due to the limited capacity of the track system and are crucial to ensure that the headways between different trains are respected and that single-track traffic is

routed correctly. While the wait-depart decisions have been intensively studied in literature (e.g. [Sch06,Gat07]), the priority decisions in the capacitated case have been neglected so far in delay management optimization models. In the current paper, we add the priority decisions to the integer programming formulation of the delay management problem and are hence able to deal with the capacitated case. Unfortunately, these constraints are disjunctive constraints that make the resulting event activity network more dense and destroy the property that it does not contain any directed cycle. Nevertheless, we are able to derive reduction techniques for the network which enable us to extend the formulation of the never-meet property from the uncapacitated delay management problem to the capacitated case. We then use our results to derive exact and heuristic solution procedures for solving the delay management problem. The results of the algorithms are evaluated both from a theoretical and a numerical point of view. The latter has been done within a case study using the railway network in the region of Harz, Germany.

Joint work of: Schachtebeck, Michael; Schöbel, Anita

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1586>

Line Planning on Paths and Tree Networks with Applications to the Quito Trolebús System

Line planning is an important step in the strategic planning process of a public transportation system. In this paper, we discuss an optimization model for this problem in order to minimize operation costs while guaranteeing a certain level of quality of service, in terms of available transport capacity. We analyze the problem for path and tree network topologies as well as several categories of line operation that are important for the Quito Trolebús system. It turns out that, from a computational complexity worst case point of view, the problem is hard in all but the most simple variants. In practice, however, instances based on real data from the Trolebús System in Quito can be solved quite well, and significant optimization potentials can be demonstrated.

Keywords: Line planning, computational complexity, optimization in transportation

Joint work of: Torres, Luis M.; Torres, Ramiro; Borndörfer, Ralf; Pfetsch, Marc E.

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1583>

Recoverable Robustness for Railway Rolling Stock Planning

In this paper we explore the possibility of applying the notions of Recoverable

Robustness and Price of Recoverability (introduced by [5]) to railway rolling stock planning, being interested in recoverability measures that can be computed in practice, thereby evaluating the robustness of rolling stock schedules. In order to lower bound the Price of Recoverability for any set of recovery algorithms, we consider an "optimal" recovery algorithm and propose a Benders decomposition approach to assess the Price of Recoverability for this "optimal" algorithm. We evaluate the approach on real-life rolling stock planning problems of NS, the main operator of passenger trains in the Netherlands. The preliminary results show that, thanks to Benders decomposition, our lower bound can be computed within relatively short time for our case study.

Joint work of: Cacchiani, Valentina; Caprara, Alberto; Galli, Laura; Kroon, Leo; Maróti, Gábor

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1590>

Robust Line Planning under Unknown Incentives and Elasticity of Frequencies

The problem of robust line planning requests for a set of origin-destination paths (lines) along with their traffic rates (frequencies) in an underlying railway network infrastructure, which are robust to fluctuations of real-time parameters of the solution. In this work, we investigate a variant of robust line planning stemming from recent regulations in the railway sector that introduce competition and free railway markets, and set up a new application scenario: there is a (potentially large) number of line operators that have their lines fixed and operate as competing entities struggling to exploit the underlying network infrastructure via frequency requests, while the management of the infrastructure itself remains the responsibility of a single (typically governmental) entity, the network operator. The line operators are typically unwilling to reveal their true incentives. Nevertheless, the network operator would like to ensure a fair (or, socially optimal) usage of the infrastructure, e.g., by maximizing the (unknown to him) aggregate incentives of the line operators. We show that this can be accomplished in certain situations via a (possibly anonymous) incentive-compatible pricing scheme for the usage of the shared resources, that is robust against the unknown incentives and the changes in the demands of the entities. This brings up a new notion of robustness, which we call incentive-compatible robustness, that considers as robustness of the system its tolerance to the entities' unknown incentives and elasticity of demands, aiming at an eventual stabilization to an equilibrium point that is as close as possible to the social optimum.

Joint work of: Kontogiannis, Spyros; Zaroliagis, Christos

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1581>

Simultaneous Network Line Planning and Traffic Assignment

One of the basic problems in strategic planning of public and rail transport is the line planning problem to find a system of lines and its associated frequencies. The objectives of this planning process are usually manifold and often contradicting. The transport operator wants to minimize cost, whereas passengers want to have travel time shortest routes without any or only few changings between different lines. The travel quality of a passenger route depends on the travel time and on the number of necessary changings between lines and is usually measured by a disutility or impedance function. In practice the disutility strongly depends on the line plan, which is not known, but should be calculated. The presented model combines line planning models and traffic assignment model to overcome this dilemma. Results with data of Berlin's city public transportation network are reported.

Keywords: Line planning problem, integer programming

Joint work of: Nachtigall, Karl; Jerosch, Karl

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1175>

Solving Periodic Timetable Optimisation Problems by Modulo Simplex Calculations

In the last 15 years periodic timetable problems have found much interest in the combinatorial optimization community. We will focus on the optimisation task to minimise a weighted sum of undesirable slack times. This problem can be formulated as a mixed integer linear problem, which for real world instances is hard to solve. This is mainly caused by the integer variables, the so-called modulo parameter. At first we will discuss some results on the polyhedral structure of the periodic timetable problem. These ideas allow to define a modulo simplex basic solution by calculating the basic variables from modulo equations. This leads to a modulo network simplex method, which iteratively improves the solution by changing the simplex basis.

Keywords: Periodic event scheduling problem, integer programming, modulo network simplex

Joint work of: Nachtigall, Karl ; Opitz, Jens

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1588>

The Second Chvatal Closure Can Yield Better Railway Timetables

We investigate the polyhedral structure of the Periodic Event Scheduling Problem (PESP), which is commonly used in periodic railway timetable optimization. This is the first investigation of Chvátal closures and of the Chvatal rank of PESP instances. In most detail, we first provide a PESP instance on only two events, whose Chvatal rank is very large. Second, we identify an instance for which we prove that it is feasible over the first Chvatal closure, and also feasible for another prominent class of known valid inequalities, which we reveal to live in much larger Chvatal closures. In contrast, this instance turns out to be infeasible already over the second Chvátal closure. We obtain the latter result by introducing new valid inequalities for the PESP, the multi-circuit cuts. In the past, for other classes of valid inequalities for the PESP, it had been observed that these do not have any effect in practical computations. In contrast, the new multi-circuit cuts that we are introducing here indeed show some effect in the computations that we perform on several real-world instances - a positive effect, in most of the cases.

Joint work of: Liebchen, Christian; Swarat, Elmar

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1580>

Towards Solving Very Large Scale Train Timetabling Problems by Lagrangian Relaxation

The train timetabling problem considered is to find conflict free routes for a set of trains in a given railway network so that certain time window conditions are satisfied. We deal with the very large scale problem of constructing such timetables for the German railway network. A number of restrictions on different train types like freight trains or passenger trains have to be observed, e.g., sequence dependent headway times, station capacities, and stopping times. In order to handle the enormous number of variables and constraints we employ Lagrangian relaxation of the conflict constraints combined with a cutting plane approach. The model is solved by a bundle method; its primal aggregate is used for separation and as starting point for rounding heuristics. We present some promising results towards handling a test instance comprising ten percent of the entire network.

Joint work of: Fischer, Frank; Helmberg, Christoph; Janßen, Jürgen; Krostitz, Boris

Full Paper: <http://drops.dagstuhl.de/opus/volltexte/2008/1585>