A Framework for Railway Rolling Stock Rescheduling

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4 - An empirical test of the gravity p-median model
Kenneth Carling, Dalarna University, Sweden, kca@du.se, *Mengjie Han*, *Johan Håkansson*, *Pascal Rebreyend*

A customer is presumed to gravitate to a facility by the distance to it and the attractiveness of it. However, the presumption is that the customer opts for the nearest facility. This paradox is solved by the recent (untested) gravity p-median model. We implement it empirically for three types of businesses, and compare the solutions with those of the p-median model. We find the gravity p-median model to be of limited use for the problem of locating facilities as it either gives solutions similar to the p-median model, or it gives unstable solutions due to a non-concave objective function.

■ MD-20

Monday, 14:30-16:00
G5-11

Rolling Stock, Speed and Energy

Stream: Optimization in Public Transport
Invited session

Chair: *Anita Schöbel*, Institute for Numerical and Applied Mathematics, Georg-August Universiy Goettingen, Lotzestrasse 16-18, 37083, Göttingen, Germany, schoebel@math.uni-goettingen.de

1 - A Framework for Railway Rolling Stock Rescheduling
Richard Lusby, Department of Management Engineering, Technical University of Denmark, 2800, Kgs Lyngby, Denmark, rmlu@man.dtu.dk, *Jørgen Thorlund Haahr*, *Jesper Larsen*, *David Pisinger*

Rolling stock schedules are made months prior to the date of execution. It is, however, rare that everything goes exactly to plan due to unforeseen disturbances. If the disturbances are small, then they may be absorbed by network buffer times. However, if the problems are more severe, changes must be made to the rolling stock schedule and associated depot plans. Here we propose a branch-and-price algorithm for rescheduling rolling stock units and recovering depot plans under disruption. Preliminary results from DSB S-Train, a suburban railway network operator in Copenhagen, are presented.

2 - Comparing two MILP formulations for driver rostering
Marta Mesquita, ISA / CIO, Technical University of Lisbon, Tapada da Ajuda, 1349-017, Lisboa, Portugal, martaoliv@isa.utl.pt, *Margarida Moz*, *Ana Paias*, *Margarida Pato*

The driver rostering problem in public transit companies consists of assigning the company's drivers to a set of crew duties, ensuring transport demand in a specific area during a pre-defined time horizon. We propose and compare two MILP formulations: an assignment/covering model and a multi-commodity network flow model. To enhance the computing efficiency of the models, a lower bound on the number of drivers is derived and different branching strategies are combined with variable fixing techniques. Computational results with data from two Portuguese public transit companies are reported.

3 - Optimisation models to minimise energy consumption of rail systems
Valerio de Martinis, Department of Civil, Architectural and Environmental Engineering, University of Napoli Federico II, 80125, Naples, Italy, vdemartinis@unina.it, *Mariano Gallo*

In this paper we propose two optimisation models for defining the speed profiles that minimise the energy consumption of trains. These models are constrained optimisation models where the speed profile parameters (acceleration, deceleration, maximum speed, starting and ending times of coasting, etc.) assume the role of decision variables. We consider two cases: (a) without energy recovery; (b) with energy recovery (on board or in line). The two cases lead to different models and different optimal solutions. In the paper the proposed models are solved and applied to a test case.

4 - The expansion of movable space by railways in Tokyo metropolitan area
Takeshi Koshizuka, Information Sciences and Engineering, Nanzan University, 27 Seirei-cho, 489-0863, Seto, Aichi, Japan, koshizuk@nanzan-u.ac.jp

This paper studies the effect of the railways on travel time in Tokyo metropolitan area. At first we get the distance distribution in the area by using a method of numerical calculation on the distance distribution which shows the amount of distance between every two points distributed uniformly in an arbitrary region. Next using the railway network data (total length: 4,498km and 2,321 stations) and 100 sample points uniformly distributed in the area, we obtain the travel time distribution. So we discuss these two distributions and compare the changes of travel time.

■ MD-21

Monday, 14:30-16:00
G6-1

Scheduling and Applications

Stream: Scheduling
Invited session

Chair: *Malgorzata Sterna*, Institute of Computing Science, Poznan University of Technology, Piotrowo 2, 60-965, Poznan, Poland, Malgorzata.Sterna@cs.put.poznan.pl

1 - Mind the Gap: A Study of Large Subway Tours
Maciej Drozdowski, Institute of Computing Science, Poznan University of Technology, Poznan Univeristy of Technology, Piotrowo 2, 60-965, Poznan, Poland, Maciej.Drozdowski@cs.put.poznan.pl, *Dawid Kowalski*, *Jan Mizgajski*, *Dariusz Mokwa*, *Grzegorz Pawlak*

What is the minimum tour visiting all lines in a subway network? We study the problem of constructing the shortest tour visiting all lines of a city railway system. A set of algorithms is proposed and evaluated on example big cities of the world, as well as on simulated networks. On the basis of the performance of the algorithms we draw conclusions on the nature of the above combinatorial optimization problem and on the utility of the algorithms.

2 - Scheduling Tasks and Production Line Balancing with Workers Assignment
Grzegorz Pawlak, Institute of Computing Science, Poznan University of Technology, ul. Piotrowo 2, 60-965, Poznan, Poland, grzegorz.pawlak@cs.put.poznan.pl, *Alf Kimms*, *Tomasz Kujawa*

We consider the optimization of the production rate of the production and assembly line taking into account three sets of variables: operations (tasks), stations(production cells) and workers' qualifications. The single-model assembly line balancing problem is broaden by the introduction of the number of stations, the given value of the maximum cycle time and the set of workers with given skills, with the objective of minimizing the number of stations. The assignment of tasks and workers is carried out based on the principle that one worker can operate more than one machine at the time.

3 - The Special Case in a Malleable Task Scheduling Problem
Maciej Machowiak, Poznan University of Technology, Poland, maciej.machowiak@cs.put.poznan.pl

The problem of scheduling malleable tasks to minimize the makespan is studied. Tasks are malleable, which means that its processing speed depends on the number of assigned processors, and a set of processors can change over time for each task. The processing speed functions are strictly increasing. We present a solution for continuous problem, where a task could be performed on noninteger number of processors and the speed functions were approximated by concave functions and the same for each task. Then this solution has been transformed into descrete solution for the original problem.