24th European Chapter on Combinatorial Optimization

Amsterdam
May 30 - June 1, 2011

The 24th ECCO Conference of the European Chapter on Combinatorial Optimization is jointly organized by the Vrije Universiteit, Amsterdam and the University of Amsterdam

ORTEC

ORTEC, an international consultancy company on operations research, which started in the Netherlands, has sponsored the lecture of a promising European researcher in the field of Combinatorial Optimisation / Operations Research, who is in a relatively early stage of his/her career. The ORTEC-lecture will be given by Nicole Megow from the Max Planck Institute of Informatics in Saarbrücken, Germany

Scientific Committee

Leen Stougie (co-chair), VU University & CWI, Amsterdam
Ton Volgenant (co-chair), University of Amsterdam
Rene Sitters, VU University, Amsterdam
Erik van der Sluis, University of Amsterdam

Members of the ECCO advisory board:
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Organising Committee

Leen Stougie, VU University & CWI, Amsterdam
Ton Volgenant, University of Amsterdam
Rene Sitters, VU University, Amsterdam
Erik van der Sluis, University of Amsterdam,
Hedda Werkman, VU University, Amsterdam

European Chapter on Combinatorial Optimization

The EURO Working Group on Combinatorial Optimization, ECCO (European Chapter on Combinatorial Optimization) provides an excellent opportunity to discuss recent and important issues in Combinatorial Optimization and its applications with European combinatorialists; most European countries are represented. Purpose and history

The group was created in 1987 by C. Roucairol, D. de Werra and A. Rinnooy Kan. C. Roucairol chaired for the first 10 years and now it's chaired by S. Martello. This group provides an excellent opportunity to discuss recent and important issues in Combinatorial Optimization and its applications with European combinatorialists; most European countries are represented.

The group is suitable for people who are presently engaged in Combinatorial Optimization (CO), either in theoretical aspects or in business, industry or public administration applications ... All the fields are taken in consideration: operations management - logistics, production scheduling location and distribution problem, resource allocation, flexible manufacturing ..., - engineering, VLSI design and computer design, network design, ... Recent sessions in last ECCOs have attached a particular emphasis to metaheuristics or new local search methods (tabu, genetic algorithm, ...), polyhedra approaches to difficult problems, recent developments in classical optimization problems (scheduling, assignment knapsack, partitioning, ...).

The meetings are held on a regular basis (once a year during Spring) and nicely combine scientific work and the exchange of new ideas with an exciting atmosphere, as in Paris, May 1988; Venice, June 1989; Barcelona, May 1990; Dubrovnik, May 1991; (cancelled), Graz, April 1992; Brussels, April 1993; Milan, February 1994; Poznan, May 1995; Dublin, April 1996; Tenerife, May 1997; Copenhagen, May 1998; Bendor, May 1999; Capri, May 2000; Bonn, May 2001; Lugano, May-June 2002; Molde, June 2003; Beirut, June 2004; Minsk, May 2005; Porto, May 2006; Cyprus, May 2007; Dubrovnik, May 2008; Jerusalem, May 2009; Malaga, May 2010; Amsterdam, May 2011.

http://ecco.grenoble-inp.fr/

The 24th ECCO Conference of the European Chapter on Combinatorial Optimization takes place in Amsterdam at the Amsterdam Business School of the University of Amsterdam. It is located on the eastern side of the centre of Amsterdam.

Amsterdam Business School
Plantage Muidergracht 12
1018 TV Amsterdam
Telephone: +31 (0)20 525 4286

Directions

Take the train to Amsterdam Central Station

From Amsterdam Central Station:

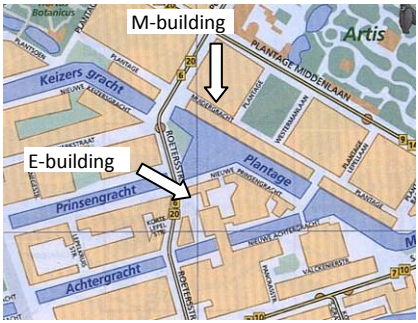
- Take the metro:
  - In any direction to 'Weesperplein', this the third stop. Follow the signs to exit 'Roetersstraat' to ground level and turn right.
- or take tram:
  - 9, the stop is "Plantage Kerklaan"
  - or 6, the stop is "Weesperplein"

From other directions than Central Station:

- Take the metro in direction Central Station (lines 51, 53 and 54) to 'Weesperplein'. Follow the signs to exit 'Roetersstraat' to ground level and turn right.
- or take the tram:
  - Tram 14: stop "Plantage Kerklaan"
  - Tram 10: stop "Weesperplein"
  - Tram 7: stop "Weesperplein"
  - Tram 9: stop "Plantage Kerklaan"
  - Tram 6: stop "Weesperplein"

Plenary sections take place in the M-building

Parallel sessions take place in the E-building



Social program

Monday May 30

18:00-20:00 Welcome Reception at Hortus Botanicus

Tuesday May 31

14:30 Walking to Rembrandthuis

15:00 Walkabout through Amsterdam

16:30 Boat tour from Rokin

18.00 Aperitive at the terrace of the IJ-kantine

19:00 Dinner at the IJ-kantine

Scientific program

Monday, May 30

8.30	Registration with Coffee and Stroopwafels in the M-building
9.30	Opening in room M1.02: - Welcome by the Organisation Committee - Welcome by Johann Hurink, Director of the Dutch Network on the Mathematics of Operations Research - Welcome by Silvano Martello, Coordinator and member of advisory board of ECCO
9.45	Plenary speaker: *Gerhard-Wilhelm Weber*, Recent discrete-continues contributions to cooperative game theory and eco-finance networks
10.30	Coffee and tea

	Room A: **Computational biology**	Room B: **Scheduling theory**	Room C: **Local search**
11.00	*Marta Szachniuk, Dominique De Werra and Jacek Blazewicz* Resonance assignment problem computational complexity	*Florian Bruns and Sigrid Knust* Crane scheduling in road-rail terminals	*David Schindl, Nicolas Zufferey and Olivier Labarthe* Tabu Search for a Job Scheduling Problem
11.20	*Maciej Antczak, Piotr Lukasiak, Krzysztof Fidelis and Jacek Blazewicz* Quality assessment of protein structure models with using systematic evaluation of local sequence-structure compatibility	*Akiyoshi Shioura, Natalia Shaklevich and Vitaly Strusevich* Using Techniques of Submodular Optimization for Solving Bicriteria Scheduling Problems with Controllable Processing Times on Parallel Machines	*José Brandão* Metaheuristics for the open vehicle routing problem with time windows
11.40	*Aleksandra Swiercz, Jacek Blazewicz, Edmund K Burke, Graham Kendall, Ceyda Oguz and Tomasz Zurkowski* One algorithm for solving different TSP problems	*Bertrand M.T. Lin, F.J. Hwang and Alexander Kononov* Resource-Constrained Scheduling with Two Parallel Dedicated Machines Subject to Fixed Processing Sequences	*Selin Özpeynirci and Burak Gökgür* A Tabu Search Algorithm for Scheduling with Tool Assignment in Flexible Manufacturing Systems
12.00	*Piotr Lukasiak, Krzysztof Fidelis, Michal Wojciechowski and Maciej Antczak* Quality assessment of protein 3D model	*Kabir Rustogi and Vitaly A. Strusevich* Using a Rectangular Assignment Problem for Single Machine Scheduling with Deterioration and Maintenance	*Tugba Saraç and Feristah Ozcelik* A Genetic Algorithm for Single Machine Early/Tardy Problem: A Case Study
12.20	*Maciej Milostan, Agnieszka Mickiewicz and Joanna Sarzynska* OR applications in modeling of biomolecular complexes – case study	*Alexander Lazarev and Dmitry Arkhiov* Polynomial algorithm for Baptiste's problem for single machine with preemptions of jobs	----
12.40	Lunch		

	Room A: **Networks**	Room B: **Geometric problems**	Room C: **Scheduling applied**
14.00	*Silvano Martello* Efficient two-dimensional packing algorithms for mobile WiMAX	*F. Javier Martin-Campo, Antonio Alonso-Ayuso and Laureano F. Escudero* Heading angle changes for the collision avoidance problem by using a mixed integer nonlinear optimization approach	*Jan Pelikan* Two level batch processing problem
14.20	*Marjan Van Den Akker, Thomas Van Dijk, Han Hoogeveen and Tim Toorop* Optimizing wireless sensor network flow by column generation	*Markus Bläser, Bodo Manthey and Raghavendra Rao* Smoothed Analysis of Geometric Heuristics	*Jan Pöschko* Optimization of a Purlin Punching Process
14.40	*Alexandre Martins, Christophe Duhamel, Philippe Mahey, Rodney Saldanha and Mauricio De Souza* Variable Neighborhood Descent with Iterated Local Search for Routing and Wavelength Assignment	*Anita Schöbel and Daniel Scholz* A geometric solution algorithm for mixed continuous and combinatorial optimization problems	*Rafal Rozycki* A heuristic approach to scheduling computational jobs on a multicore processor with respect to power and energy limits
15.00	*Laureano F. Escudero and Susana Muñoz* A one-stage stochastic programming method for the rapid transit network design problem	*Johannes Hatzl* A Parametric Flow Problem and its Application in Location Theory	*Hakan Gultekin, Hilal Dag and Onur Dalgic* Throughput Optimization in Flow shops with 2-nonidentical Machines and Flexible Operations
15.20	Coffee and tea		

	Room A: **Combinatorial optimization**	Room B: **Vehicle routing**	Room C: **E-commerce/marketing**
16.00	*Eranda Cela, Gerhard J. Woeginger and Nina S. Schmuck* The Wiener maximum quadratic assignment problem	*Alain Hertz, Marc Uldry and Marino Widmer* Integer linear programming models for a cement delivery problem	*Jacek Blazewicz and Jedrzej Musial* Heuristic algorithm with forecasting for online shopping
16.20	*Marius Posta, Jacques Ferland and Philippe Michelon* An Exact Method with Variable Fixing for solving the Generalized Assignment Problem	*Sandro Lorini, Jean-Yves Potvin and Nicolas Zufferey* Online optimization for a vehicle routing problem	*Maciej Drozdowski and Jakub Marszalkowski* Optimization of column width in website layout for advertisement fit
16.40	*Serigne Gueye, Sophie Michel, Adnan Yassine and Philippe Michelon* On A Generalization of the Optimal Linear Arrangement Problem	*Florian Jaehn* Positioning of loading units in a transshipment yard storage area	*Wim Van Ackooij, Frédéric Bréant and Nicolas Langrené* An aggregation procedure for large scale mixed integer programming in energy management
17.00	*Marcel Turkensteen* Upper Tolerances and Lagrangian Relaxation for the DCMSTP	*Erwin Pesch and Jenny Nossack* Scheduling trucks in intermodal container transportation	*Ariel Waserhole, Vincent Jost and Nadia Brauner* Pricing for vehicle sharing using densest oriented subgraph in Markov Chains
17.20	*Irène Charon and Olivier Hudry* A branch and bound method to compute median equivalence relations	*Emrah Demir, Tolga Bektas and Gilbert Laporte* A Heuristic Algorithm to Solve the Speed Optimization Problem in Vehicle Routing	*Michael Lim and Ho-Yin Mak* Dynamic Location Model with Market Learning
17.40	End of session		
18.00	Reception		

Tuesday, May 31

9.00	Plenary speaker (M1.01) *Martin Skutella*, Advanced models of network flows over time		
9.45	Coffee and tea		
	Room A: **Game theory**	Room B: **Facility location**	Room C: **Scheduling theory**
10.15	*Bo Chen, Xujin Chen, Jie Hu and Xiaodong Hu* Stability vs. Optimality in Selfish Ring Routing	*Huizhen Zhang and César Beltrán-Royo* Binary reoptimization and semi-Lagrangian relaxation applied to solve the uncapacitated facility location problem	*Malgorzata Sterna* Late Work Scheduling Problems
10.35	*Josep Freixas and Sascha Kurz* On minimal integer representations of weighted games	*Yury Kochetov, Ivan Davydov, Alexandr Plyasunov and Nina Kochetova* New heuristics for the leader-follower location problems	*Adrien Bellanger and Ammar Oulamara* Minimizing total completion time on a bounded batching machine with job compatibilities and one unavailability period
10.55	*Maxime Ogier, Van-Dat Cung and Julien Boissière* Analysis of a supply chain coordination mechanism within a lot-sizing model	*Vladimir Beresnev* Approximate Algorithm for Discrete Competitive Facility Location Problem	*Feristah Ozcelik and Tugba Saraç* Heuristics for a Single Machine Scheduling Problem with Bicriteria of Total Tardiness and Makespan
11.15	Short break		

	Room A: **Stochastic optimization**	Room B: **Vehicle routing**	Room C: **Scheduling theory**
11.30	*Sebastián Marbán, Cyriel Rutten and Tjark Vredeveld* Learning in Stochastic Machine Scheduling	*Alain Nguyen and Jean-Philippe Brenaut* Trucks fleets routing for vehicle transportation	*Jacek Blazewicz, Mikhail Y. Kovalyov and Maciej Machowiak* Scheduling malleable tasks with arbitrary processing speed functions
11.50	*Juan Carlos Rivera and Juan Manuel Ortiz* A local search-based algorithm to solve the Stochastic Job Shop Scheduling Problem	*Jean-Philippe Brenaut and Alain Nguyen* Truck loading tool for RENAULT's parts delivery	*Dolores Romero Morales, Wilco Van Den Heuvel, H. Edwin Romeijn and Albert P.M. Wagelmans* Economic Lot-Sizing models with environmental awareness: A Multi-Objective Programming approach
12.10	*Eleni Hadjiconstantinou and Evelina Klerides* Stochastic models for dispatching multi-load Automated Guided Vehicles in container terminals	*Lanah Evers, Ana Isabel Barros, Herman Monsuur and Albert Wagelmans* The Added Value of Agility in Robust UAV Mission Planning	*Nikolay Kuzjurin and Mikhail Trushnikov* Average case analysis of a new class of on-line algorithms for Multiple Strip Packing
12.30	Lunch		
13.45	Plenary speaker (M1.01) *Nicole Megow*, Models and algorithms for scheduling under uncertainty		
14.30	Start of social program		
19.00	Dinner		

Wednesday, June 1

9.00	Plenary speaker (M1.01) *Gerhard Woeginger,* Transportation under nasty side constraints	
9.45	Coffee and tea	
	Room A: **(Project) scheduling**	Room B: **Combinatorial optimization**
10.15	*Matthias Walter and Jürgen Zimmermann* Minimizing project team size in a workforce assignment problem	*Walter Habenicht* Quadtrees in combinatorial Vector Optimization Problems
10.35	*Andreas Klinkert* Days-Off Planning in Large-Scale Multi-Skill Staff Rostering	*Maciej Drozdowski, Dawid Kowalski, Jan Mizgajski and Grzegorz Pawlak* Mind the Gap: A study of Tube Tour
10.55	*Grzegorz Waligóra* Heuristic approaches to the discrete-continuous resource-constrained project scheduling problem with discounted cash flows	*Alexander Lazarev and Anton Baranov* Graphical algorithm for Knapsack and Partition problems
11.15	*Marek Mika* Multimode resource-constrained project scheduling problem with setup times and the cost minimization objective	*Sergei Chubanov* An application of a polynomial relaxation-type algorithm to systems of inequalities given by a separation oracle
11.35	Closing	

Abstracts

Plenary presentation, Monday 9.45, Room M1.02

Recent Discrete-Continuous Contributions to Cooperative Game Theory and Eco-Finance Networks

Gerhard-Wilhelm Weber

Institute of Applied Mathematics, Middle East Technical University, Ankara, Turkey

This talk presents recent research contributions in cooperative game theory, eco-finance and gene-environment networks, their dynamics, modeling and optimization. Motivations, applications and interpretations are from the sectors of finance, environment, medicine, education, development and international collaboration. We include uncertainty in polyhedral and ellipsoidal forms, and as stochastic differential equations as well. For turning from time-continuous to -discrete models, we use advanced Heun and Milstein schemes, respectively. We present hybrid models and use stochastic hybrid control. Further, we deal with cooperative ellipsoidal games, a class of transferable utility games where the worth of each coalition is an ellipsoid instead of a real number. Here, we study sharing problems under ellipsoidal uncertainty. We introduce the ellipsoidal core and study properties of this solution concept. Our talk pays a special attention to the optimization and control aspects, with an emphasis of mixed discrete-continuous features; it ends with a conclusion, an outlook and invitation to future investigations.

Joint work with:
Sırma Zeynep Alparslan Gök, Department of Mathematics, Süleyman Demirel University, Isparta, Turkey
Erik Kropat, Department of Computer Science, Universität der Bundeswehr München, Munich, Germany
Ozlem Defterli, Department of Mathematics and Computer Science, Cankaya University, Ankara, Turkey
Armin Fügenschuh, Optimierung, Zuse Institut Berlin, Germany

Plenary presentation, Tuesday 9.00, Room M1.01

Advanced Models of Network Flows Over Time

Martin Skutella

TU Berlin, Germany

Since the ground-breaking work of Ford and Fulkerson in the 1950s, the area of network flows has developed into many interesting directions. Network flows over time (also called "dynamic" network flows) form a particularly interesting area.

Network flows over time include a temporal dimension and therefore provide a more realistic modeling tool than classical "static" network flow models. While flows over time have already been introduced by Ford and Fulkerson in the 1950s, several more sophisticated models have been studied later on. After giving a general introduction to network flows over time, we are going to present recent work in this direction, including several arc capacity models and also generalized flows over time.

Plenary presentation, Tuesday 13.45, Room M1.01

ORTEC-lecture

ORTEC, an international consultancy company on operations research, which started in the Netherlands, has sponsored the lecture of a promising European researcher in the field of Combinatorial Optimisation / Operations Research, who is in a relatively early stage of his/her career. The ORTEC-lecture will be given by Nicole Megow from the Max Planck Institute of Informatics in Saarbrücken, Germany.

Models and Algorithms for Scheduling under Uncertainty

Nicole Megow

Max Planck Institute, Saarbrücken, Germany

Uncertain problem data are prevalent in real-world scheduling problems. Jobs may take more or less time than originally estimated, resources may be unreliable and slow down or become completely unavailable, material may arrive late, new jobs may have to be incorporated or others may be dropped, etc. In this talk we focus on scheduling problems with stochastic input data. We give an overview on different models, algorithms, and performance measures. The methods for obtaining provably good solutions involve linear programming, lower bounding techniques known from online scheduling, and priority indices borrowed from probability theory. We also discuss the practicability of highly adaptive solutions and recent approaches on obtaining robust schedules. In particular, for scheduling on an unreliable machine we show how to construct universal solutions that perform well without adaptation for any possible machine behavior.

Plenary presentation, Wednesday 9.00, Room M1.01

Transportation under nasty side constraints

Gerhard J. Woeginger

Department of Mathematics and Computer Science, TU Eindhoven, the Netherlands

The talk discusses planning problems where a set of items has to be transported from location A to location B subject to certain collision and/or resource constraints. We analyze the behavior of these problems, discuss their history, and derive some of their combinatorial and algorithmic properties.

Monday
11.00
Room A

Resonance assignment problem computational complexity

Marta Szachniuk, Dominique de Werra, and Jacek Blazewicz

Sequential resonance assignment is a well known problem faced by researchers during the process of bio-molecule structure determination based on Nuclear Magnetic Resonance spectroscopy. As one of the first steps following the experimental part of the process, it significantly affects the quality of a resulting molecule shape. During the talk, we will present biologically inspired graph model representing an assignment problem in multidimensional NMR spectra recorded for ribonucleic acid molecules. A short note about two-dimensional variant of the problem will be given. The 2D version has been reduced to a variant of a Hamiltonian path problem and already proved to be strongly NP-complete. This introduction will be followed by a presentation of a novel concept concerning resonance assignment in three-dimensional spectra. An analysis of 3D spectra is commonly known to provide more detailed structural information but, on the other hand, it is more computationally demanding and harder to be carried out by a human researcher. To support 3D spectra analysis we have proposed a theoretical model of the multidimensional variant and studied its computational complexity. The main theme of our presentation will be focused on this study.

We will show the theoretical backgrounds, graph model and a summary of the proof of problem NP-completeness.

The research has been supported by the Ministry of Science and Higher Education [grant NN 519314635].

> Keywords: computational complexity, sequential assignment, graph model

Monday
11.20
Room A

Quality assessment of protein structure models with using systematic evaluation of local sequence-structure compatibility

Maciej Antczak, Piotr Lukasiak, Jacek Blazewicz, Krzysztof Fidelis

Understanding details of machinery of human organism has been a great challenge for humanity. Proteins are the machinery of life as they are involved in all important processes which occur in any living organism. Function of a protein is determined by its 3D structure. Determination of protein structure is difficult and requires time

consuming experiments. Hence, prediction of protein structure using computational tools is of great interest of humanity.

In this work, we present the computational method which can be used to quality evaluation of protein structure models based on its local 3D structure. Model quality assessment (MQA) is important as currently available computational models outnumber experimentally derived. Local descriptor of protein structure (LDPS) formalism and the corresponding 3D structure libraries derived from known structures to assess the compatibility of any sequence with a known shape have been used. Putative sequences and corresponding local structures were evaluated with several types of discriminatory functions (physics and knowledge-based potentials) to distinguish between artificial and native-like structures. Model quality has been evaluated by local structure scores computed along the entire polypeptide chain of the model. This approach is particularly suited to assess the target sequence to template alignments in comparative modeling, a major source of modeling errors.

> Keywords: protein 3D structure prediction, structure model quality assessment, comparative modeling

Monday
11.40
Room A

One algorithm for solving different TSP problems

Aleksandra Swiercz, Jacek Blazewicz, Edmund K. Burke, Graham Kendall, Ceyda Oguz, and Tomasz Zurkowski

A hyper-heuristic algorithm operates on heuristic search space, rather than on a direct representation of the problem. At each decision point, the hyper-heuristic decides which heuristic should be executed from the set of those available. Heuristics are usually simple moves, which can change the solution by improving it, or by acting randomly. They are working directly in the solution space, but they do not give back to the hyper-heuristic any information about the problem. Thus, there exists a domain problem barrier between the hyper-heuristic and heuristics. The aim of hyper-heuristic approaches is to enable the search methodology to operate across different problem instances, or even different problem domains, without having to manually adapt the search algorithm. The cost of re-adapting the algorithm to a new problem is the cost of changing the set of simple heuristics.

The designed hyper-heuristic algorithm can solve different variants of traveling salesman problem (TSP) and DNA sequencing by hybridization problem (SBH). SBH is

one of the methods of recognizing DNA sequences, which can also be seen as a variant of TSP. SBH is composed of two phases: the biological one, in which the spectrum, i.e. all the subfragments of an unknown DNA sequence, is determined in the biochemical experiment, and the computational phase, in which these subfragments are combined together with combinatorial algorithms in order to reconstruct the sequence. In the real-life experiment a spectrum may contain some additional subfragments, which are positive errors, and some subfragments can be missing in spectrum, those are negative errors. The goal of the computational phase is to construct a sequence from the most number of subfragments.

> Keywords: heuristc algorithm, hyper-heuristc, tsp

Monday
12.00
Room A

Quality assessment of protein 3D model

Piotr Lukasiak, Krzysztof Fidelis, Michal Wojciechowski and Maciej Antczak

Protein structure prediction problem is one of the most important challenges in life sciences. Experimental techniques (in biological laboratories) limitated by time, and equipment, created space for mathematical algorithms used for artificial modeling of protein structure. In recent years one can observe enormous progress in development of computer-based methodologies used for protein structure prediction based on aminoacids sequence. Multiplicity of possible 3D proteinstructure corresponding to one protein sequence (gathered as a final prediction from different methods) caused the need to evaluate quality of protein structural models.

As experimental results shown, even comparison of two different protein models to real protein structure is not easy, if one has to choose the best one. The reason is that currently used measures as global RMSD or GDT represents quality of models from whole protein structure point of view. In our research one used local structural comparison based on local sphere approach. All substructures are assessed and recalculated to take into consideration local dependencies between atoms in protein structure. Proposed approach was compared with algorithms and protein structures used in CASP8 and was able to recognize good models that were rejected based on standard metrics. In CASP9 our method0logy was used as one of tools used by assessors for evaluation of protein model structures.

> Keywords: structure comparison, quality assessment, protein structure prediction assessment

Monday
12.20
Room A

OR applications in modeling of biomolecular complexes – case study

Maciej Milostan, Agnieszka Mickiewicz, and Joanna Sarzynska

One of the proteins crucial for proper functioning of RNA interference (RNAi) mechanism is a dicer which process double-stranded RNAs. Only one crystal structure of dicer protein is available at the moment and it is structure of eukaryotic Dicer from Giardia intestinalis. Dicer-Like proteins are also present in many higher eukaryotes including Arabidopsis thaliana. Moreover in this plant four DCL proteins has been identified.

Thus, we decided to generate spatial models for aforementioned DCLs to better understand the way they may function and identify the crucial structural elements.

Our modeling pipeline has been based on classical homology modeling approach extended by docking simulations.

The modeling approach can be divided into four main steps: identification of template structures (e.g. PSI-Blast, CD-Search, literature), preparation of templates-target alignment (e.g. ClustalW2, T-Coffe, Stamp from VMD, Biotools, literature), Structure modeling (Modeller), Structure evaluation and assessment (Energy minimization, ProCheck etc.).

The stability and movement of modeled structures has been tested by application of Monte Carlo (MC) and Molecular Dynamics (MD) simulations as well as by Normal Mode Analysis (NMA).

In the next step, protein models have been used to generate protein-RNA complexes by application of docking algorithms.

In the paper we are focusing on the selected problems and obstacles encountered during various stages of our analysis pipeline.

*Work partially supported by The Ministry of Science and Higher Education of Poland(grant N N519 314635)

> Keywords: Protein structures modeling, protein-rna docking, normal mode analysis, molecular dynamics

Monday
11.00
Room B

Crane scheduling in road-rail terminals

Florian Bruns and Sigrid Knust

We consider the crane scheduling problem in European road-rail terminals. In such terminals up to three rail mounted gantry cranes (RMGs) lift load units (containers, swap bodies and trailers) between trains, trucks and storage areas. Each transportation job needs to be assigned to a crane and for each crane a sequence of the assigned jobs has to be calculated. The objective is to reduce the total length of empty crane moves, setup costs for cranes and waiting times for high-priority jobs. Hard constraints are job release dates, non crossing constraints for the cranes and travel time constraints for the cranes. Besides the objective a main difference to most crane planning problems in maritime terminals is that cranes have to move load units by crane movements alongside the rails. For maritime cranes often only loaded trolley movement is considered.

We present a MIP formulation of the problem and heuristic approaches which are based on list scheduling and local search with tabu search and simulated annealing. One scheduler is based on the assumption that each crane has a fixed working area and the working areas partially overlap. So crane interference only have to be avoided within the overlapping areas and for some jobs only one crane is left for handling the job. Other jobs have to be split and handled by two cranes consecutively. Another scheduler implementation restricts the crane working areas only due to physical restrictions caused by other cranes. So nearly all jobs can be handled by every crane. We compare the solution quality and the runtimes of the two schedulers. For small size instances the scheduler solutions are also compared with solutions obtained by solving the MIP model.

> Keywords: crane scheduling, non-crossing, intermodal transportation, MIP, list scheduling

Monday
11.20
Room B

Using Techniques of Submodular Optimization for Solving Bicriteria Scheduling Problems with Controllable Processing Times on Parallel Machines

Akiyoshi Shioura, Natalia V. Shakhlevich, Vitaly A. Strusevich

This talk reports on further efforts of our team to establish links between Submodular Optimization and Scheduling. In our previous works, we have reduced

several scheduling problems with controllable processing times to linear programs over a submodular polyhedron intersected with a box. In turn, for these submodular optimisation problems, we have shown how to reformulate them in terms of optimizing the same function over a base polyhedron with an updated rank function. The purpose of this talk is to demonstrate how these techniques can be adapted to the design of polynomial-time algorithms for problems on parallel machines to find a set of Pareto-optimal solutions with respect to the makespan and the total compression cost. Among the considered models are those with identical parallel and job release dates, as well as those with uniform machines and with or without release dates. Our method either delivers algorithms with better running times than those previously known or provides the first polynomial-time algorithms.

> Keywords: scheduling, bicriteria, submodular optimization

Monday
11.40
Room B

Resource-Constrained Scheduling with Two Parallel Dedicated Machines Subject to Fixed Processing Sequences

Bertrand M.T. Lin, F.J. Hwang and Alexander Kononov

This paper investigates a variant of the relocation problem, formulated from a public housing redevelopment project in east Boston, on two parallel dedicated machines. Each job is characterized by a processing length, a weight, a due date, the amount of the resource required for commence its processing, and the amount of the resource it returns at its completion time. The processing sequences on both machines are known a priori. The problem is to determine a feasible schedule to optimize five objective functions. For the minimization of makespan, total weighted completion time or maximum lateness, we propose a polynomial dynamic programming algorithm. A simplified algorithm is also developed for the case with a common job processing time. We show that the problem is NP-hard when the objective function is the total weighted tardiness or the weighted number of tardy jobs. Pseudo-polynomial time algorithms are developed for the NP-hard cases.

> Keywords: Relocation problem, resource-constrained scheduling, parallel dedicated machines, fixed sequence, dynamic programming, NP-hardness.

Monday
12.00
Room B

Using a Rectangular Assignment Problem for Single Machine Scheduling with Deterioration and Maintenance

Kabir Rustogi and Vitaly A. Strusevich

We consider single machine scheduling models in which the processing conditions of the machine are subject to positional deterioration and can be restored, at least partially, by running machine maintenance. The duration of each maintenance-period (MP) is known, but the number of the MPs to be performed needs to be found out along with their start times and the optimal sequence of jobs in order to minimize the overall makespan.

In a schedule with k-1 MPs, n jobs are split into k groups, and the actual processing time of a job is dependent on the group a job is placed into and its position within that group. Positional deterioration within a group is job-dependent and is represented by a general non-decreasing function. We are not aware of any previously studied models that benefit from such a general set of assumptions, in particular, from a three-way dependency (job-group-position) of actual processing times.

For a given k, we formulate a rectangular assignment-problem with n rows, one for each job, and columns that correspond to potential positions in the k groups. A brute-force method would use k(n-k+1) columns and would require O(n^5) time.

By using the properties of the algorithm that solves the rectangular assignment-problem, we prove that for each k it suffices to consider the n positions that have already been used in the optimal solution found for the problem with k-1 groups and additionally the new n-k+1 positions which are made available by the introduction of the k-th group. This idea helps us to reduce the running time to O(n^4).

The same algorithm can be extended to solve the problem when the maintenance duration is not known in advance but is dependent on its start time. An optimal solution can be found in such a setting in O(n^4) time for the group-independent case and in O(n^5) time for the group-dependent case.

> Keywords: Positional Deterioration, Maintenance, Rectangular Assignment Problem

Monday
12.20
Room B

Polynomial algorithm for Baptiste's problem for single machine with preemptions of jobs

Alexander Lazarev and Dmitry Arkhipov

We study the scheduling problem for single machine with preemptions of jobs. On a machine it is necessary to process a set of n jobs. Simultaneous processing is prohibited, but interrupts in processing jobs is possible. Each job j of the set is characterize by it's weight w_j, release date r_j = j - 1 and processing time p_j = 2. The only restriction is that weights w_j are non-decreasing. The objective function can be expressed as the sum of weighted completion times.

We suggest the polynomial algorithm with complexity O(n^4) operations which gives us the Pareto-optimal schedules for each set of jobs. In the algorithm we use generalized Smith's rule, to obtain particular schedules after moment r_n and to prove some important lemmas for reduction of search of suitable schedules.

> Keywords: scheduling, preemptions, Pareto-optimal

Monday
11.00
Room C

Tabu Search for a Job Scheduling Problem

David Schindl, Nicolas Zufferey, and Olivier Labarthe

We consider a generalization of the graph coloring problem, where variable costs are encountered for assigning a color to a vertex, and incompatibility costs for giving two vertices the same color. We state this problem in terms of single-period jobs (vertices), each of which has to be assigned a time period (color). We propose a tabu search heuristic, as well as an adaptive memory algorithm, and compare them with other heuristics on large instances, and with an exact method (integer linear program) on small instances. We also show how our model permits to incorporate precedence constraints between jobs.

> Keywords: Scheduling, Coloring, Meta-heuristic, Linear programming

Monday
11.20
Room C

Metaheuristics for the open vehicle routing problem with time windows

José Brandão

The problem studied here, the open vehicle routing problem with time windows (OVRPTW), is different from the vehicle routing problem with time windows in that the vehicles do not return to the distribution depot after delivering the goods to the customers. We solve the OVRPTW using iterated local search, tabu search and iterated tabu search. The performance of these metaheuristics is tested using a large set of benchmark problems. The solutions already obtained show that the algorithm is competitive with the best algorithms existing in the literature.

> Keywords: vehicle routing, metaheuristics, tabu search, iterated local search.

Monday
11.40
Room C

A Tabu Search Algorithm for Scheduling with Tool Assignment in Flexible Manufacturing Systems

Selin Özpeynirci and Burak Gökgür

Flexible Manufacturing Systems (FMSs) are integrated systems of computer numerically controlled (CNC) machines and automated material handling devices. In an FMS, machines are capable of processing different types of operations as long as the required tools are loaded. Tool management is a vital issue in FMS management due to complexities brought by the limitations. This study presents a mixed integer programming (MIP) model that integrates the tool assignment and scheduling problems that arise in FMSs. There are a number of jobs to be processed on parallel computer numerically controlled (CNC) machines. Each job requires a set of tools and the available tools are limited because of economic restrictions. Our objective is to minimize makespan. The output of the mathematical model is the schedule of the jobs on machines with the assignment of tools. Since the problem is strongly NP-hard, finding the optimal solution requires extremely long computational times as the problem size increases. We develop a tabu search algorithm for finding near-optimal solutions in reasonable times. The results of our computational experiments show that tabu search algorithm performs well.

This study is supported by The Scientific and Technological Research Council of Turkey (TÜBİTAK).

> Keywords: Flexible Manufacturing Systems, Scheduling, Tool Assignment, Mixed Integer Programming, Tabu Search

Monday
12.00
Room C

A Genetic Algorithm for Single Machine Early/Tardy Problem: A Case Study

Tugba Saraç and Feristah Ozcelik

Our problem is motivated by a scheduling problem faced by a supplier of white good manufacturing plants. The manufacturing facility has 18 injection molding machines that produce 120 different parts in a single stage operation. The operations are conducted over two 12 h shifts, 7 days a week. Presently high volume batches are usually produced in 7-day runs. In production of plastic parts by using injection, setup times may increase considerably when a light colored part is scheduled after dark colored part or some specifically raw materials need to use after different structured raw materials. This study presents an approach for scheduling of customers' orders in factories of plastic injection machines as a case of real-world single machine scheduling problem with sequence dependent setup times. Scheduling problems involving both earliness and tardiness costs have received significant attention in recent years. This type of problem became more important with advent of lean production principles, including the just-in-time (JIT) concept. According to JIT, earliness and tardiness are considered harmful to profitability and, for this reason, must be minimized: tardiness causes loss of customer goodwill and damage reputation, as well as delay of payments, while earliness causes inventory carrying costs and possible loss of product quality. The objective of discussed work is to minimize the sum of earliness and tardiness costs. This problem is known as NP-hard. To solve this problem, a genetic algorithm is proposed. The schedule generated by the proposed algorithm is compared with the schedule generated by the method of firm. Promising results are obtained.

> Keywords: single machine scheduling, sequence dependent setup time, earliness and tardiness costs, plastic injection machine, genetic algorithm.

Monday
14.00
Room A

Efficient two-dimensional packing algorithms for mobile WiMAX

Silvano Martello

We present the result of a research, developed within Nokia Siemens Networks, to solve the downlink sub-frame allocation problem in Mobile WiMAX (IEEE 802.16) technology in its full complexity, while simultaneously fulfilling real-life constraints on processing power and delay. A theoretical analysis of the two-dimensional

packing problems originated by such models shows that they are both NP-hard in the strong sense.

From the practical point of view, the processing budget for scheduling in the base station was estimated to be 1 ms on a state-of-the-art PC. Thus we introduce two highly efficient heuristics that were developed in order to practically handle the system. A thorough computational analysis of their optimization characteristics, and a system-level evaluation in realistic scenarios proved that the algorithms offer significant capacity gain in Mobile WiMAX systems, that translate to increased operator revenues.

> Keywords: Mobile WiMAX, Two-dimensional packing, Computational complexity, Experimental analysis.

Monday
14.20
Room A

Optimizing wireless sensor network flow by column generation

Marjan van den Akker, Thomas van Dijk, Han Hoogeveen, and Tim Toorop

A wireless sensor (or smart dust) is a very small device that contains a chip with a miniature battery, and has a transmit/receive capability of limited range. Sensors have been deployed in different environments to gather data, perform surveillances and monitor situations in diverse areas such as military, medical, social networks, and traffic.

We consider the situation where sensor nodes gather data and send them via other sensor nodes to a base station. The battery power of each node is limited which gives an important constraint. Our objective is to maximize the number of packets arriving at the base station. Packets are considered as integral units and not splittable. This problem is called the integer maximum flow problem on wireless sensor networks with energy constraints and has been shown to be strongly NP-hard.

We present a column generation algorithm to solve this problem. In our algorithm each integral variable represents a path from the source node to the base station. If we maximize the flow, the column generation turns out to be slow and provides a messy division of paths over the network. Solving an ILP formulation with flow variables on edges turns out to be faster, although it uses a lot of memory for big instances.

We improved the column generation algorithm by alternating the maximization of flow and the minimization of battery usage. This is significantly faster and provides more efficient solutions in terms of energy consumption and spread of paths over the network. For big instances, it strongly outperforms the edge-based ILP formulation in terms of computation time and memory requirement. We also used the flow minus the weighted battery usage as objective function, providing similar results. Our computational results suggest that our algorithm finds optimal solutions for graphs with hundreds of nodes within a few minutes.

> Keywords: wireless sensor networks, column generation, network flow

Monday
14.40
Room A

Variable Neighborhood Descent with Iterated Local Search for Routing and Wavelength Assignment

Alexandre X. Martins, Christophe Duhamel, Philippe Mahey, Rodney R. Saldanha, and Mauricio C. de Souza

In all-optical networks a traffic demand is carried from source to destination through a lightpath, which is a sequence of fiber links carrying the traffic from end-to-end. The wavelength continuity constraint implies that to a given lightpath a single wavelength must be assigned. Moreover, a particular wavelength cannot be assigned to two different lightpaths sharing a common physical link. The routing and wavelength assignment (RWA) problem arises in this context as to establish lightpaths to carry traffic demands. We consider the min-RWA version of the problem, where a set of lightpath requests (origin-destination pairs of demand) must be established with the minimum number of wavelengths as possible.

In this work, we develop a variable neighborhood descent (VND) with iterated local search (ILS) for the min-RWA. Given an undirected graph G and a set of lightpath requests R, the problem is to find a minimal partition of R such that the requests in each subset can be routed through edge disjoint paths in G. Thus, a feasible solution is characterized by a partition of R along with edge disjoints paths to route requests belonging to each subset. In a VND phase we employ three kinds of moves trying to rearrange requests between the subgraphs associated to subsets of the partition in attempt to eliminate one of them. When VND fails, we perform a ILS phase to disturb the requests distribution among the subsets of the partition. The algorithm alternates between VND and ILS phases. The lower bounds to evaluate quality of solutions obtained by the VND-ILS heuristic are provided by column generation applied to an extended path-based integer programming formulation. We will

present numerical results improving upper bounds and showing smaller optimality gaps when compared to the literature on benchmark instances.

> Keywords: Variable Neighborhood Descent, Iterated Local Search, Heuristics, Routing and Wavelength Assignment, Network Optimization.

Monday
15.00
Room A

A one-stage stochastic programming method for the rapid transit network design problem

L.F. Escudero and S. Muñoz

Given a set of potential station locations and a set of potential links between them, the well-known extended rapid transit network design problem basically consists in selecting which stations and links to construct without exceeding the available budget, and determining an upper bounded number of noncircular lines from them, to maximize the total expected number of trips on the rapid transit network.

In this work we deal with a modification of this problem to allow the definition of circular lines provided that whichever two stations are linked by one line at most. We utilize a two-phase approach for solving this new problem. In the first phase we consider a 0-1 linear programming problem for selecting the stations and links to be constructed without exceeding the available budget, in such a way that the total expected number of trips is maximized. In the second phase we apply a greedy heuristic procedure for assigning each one of the selected links to a unique line, attempting to minimize an estimation of the total number of transfers that should be made by the users to arrive at their destinations; moreover, the number of lines going to each selected station will be minimized.

We take into consideration the uncertainty in the construction costs of the stations and the links between them, and in the origin-destination demand matrix. We propose a solving approach based on one-stage stochastic optimization via scenario analysis.

> Keywords: One-stage stochastic optimization, Branch-and-fix coordination approach, Station and link location, Line designing Transfer

Monday
14.00
Room B

Heading angle changes for the collision avoidance problem by using a mixed integer nonlinear optimization approach

A. Alonso-Ayuso, L.F. Escudero, and F.J. Martín-Campo

A mixed integer nonlinear optimization model is developed in order to tackle an important problem in Air Traffic Management, the so-called Collision Avoidance Problem. Given a set of aircraft configurations, the aim is to give a new configuration for each aircraft such that all conflicts in the airspace are avoided. There are three types of maneuvers that can be done: horizontal maneuvers based on velocity changes or on heading angle changes, and vertical maneuvers based on altitude level changes. In our case, we are going to use only horizontal maneuvers based on heading angle changes. Some particular cases are assumed in the model, avoiding unstable situations due to a null denominator and false conflicts that force aircraft to change their heading angle changes. The other important aspect is to determine what the optimal time and the new angle have to be in order to force aircraft to arrive at the predicted destination point if a heading angle change has been done. Due to a geometric construction based on trigonometric functions, there are four groups of constraints that are nonlinear ones. We report the computational experience that we have obtained so far solving the problem by using a state-of-the-art MINLP optimization engine.

> Keywords: Mixed integer nonlinear programming, Air traffic management, collision avoidance

Monday
14.20
Room B

Smoothed Analysis of Geometric Heuristics

Markus Bläser, Bodo Manthey, and Raghavendra Rao B.V.

Many Euclidean optimization problems, like the traveling salesman problem or the Steiner tree problem, are NP-hard. Others, like minimum-length perfect matching, have polynomial-time algorithms. But still these polynomial-time algorithms are sometimes too slow on large instances. Thus, fast heuristics to find near-optimal solutions are needed.

Partitioning heuristics are a very simple heuristic approach: They divide the Euclidean plane into small cells such that each cell contains only a small number of points. This allows us to quickly find optimum solutions within each cell. Finally, the

solutions of all cells are joined in order to obtain a solution to the whole set of points.

Although this is a rather simple ad-hoc approach, it works surprisingly well in practice. This is at stark contrast to the poor worst-case performance of partitioning heuristics. Thus, as is often the case, worst-case analysis is far too pessimistic to explain the performance of partitioning heuristics. The reason for this is that worst-case analysis is dominated by artificially constructed instances that often do not resemble practical instances.

In order to explain the performance of partitioning heuristics, we provide a smoothed analysis. Smoothed analysis is a hybrid of worst-case and average-case analysis. It often leads to more realistic conclusions about the performance of algorithms. In smoothed analysis, an adversary specifies an instance, and this instance is then slightly randomly perturbed. The perturbation can, for instance, model noise from measurement.

We present a framework for smoothed analysis of partitioning heuristics for optimization problems in the Euclidean plane. Our framework can be used to analyze both running-time and approximation ratio. We apply the framework to Euclidean matching, Karp's partitioning scheme for the TSP, Steiner trees, and bounded-degree minimum spanning trees.

> Keywords: geometric optimization problems, Euclidean optimization, partitioning heuristics, smoothed analysis, approximation algorithms, probabilistic analysis, traveling salesman problem, matching

Monday
14.40
Room B

A geometric solution algorithm for mixed continuous and combinatorial optimization problems

Anita Schöbel and Daniel Scholz

Geometric branch-and-bound techniques like the "big-square-small-square method" are popular solution algorithms for continuous and non-convex global optimization problems. The idea is to partition the continuous solution space into boxes and to approximate the problem on any of them. By calculating bounds some of the boxes can be deleted, while the remaining ones are split into sub-boxes. This is repeated until a certain accuracy is obtained. The most important task throughout this

branch-and-bound algorithm is the calculation of good lower bounds on the objective function. Several techniques to do so exist.

This approach has been applied so far for pure continuous objective functions. The aim of this paper is to extend such geometric branch-and-bound methods to mixed continuous and combinatorial optimization problems, i.e. to objective functions containing continuous and combinatorial variables. The idea is to do a geometric branching for the continuous variables and to approximate the remaining discrete problem in order to obtain the required bounds on the boxes. This is in contrast to the classical integer branch-and-bound in which branching is done on the discrete variables.

To this end, we derive some general bounding operations for mixed-integer problems and we present theoretical results about their rate of convergence. Moreover, we discuss an extension of the method which leads to exact optimal solutions under certain conditions. We implemented the approach and applied it to some facility location problems. The numerical results show that we succeeded in finding exact optimal solutions.

> Keywords: global optimization, non-convex optimization, geometric branch-and-bound methods, facility location problems

Monday
15.00
Room B

A Paramteric Flow Problem and its Application in Location Theory

Johannes Hatzl

In this talk, we consider the classical 1-median problem in the d-dimensional space with the Chebyshev-norm. Given n points with positive weights, find a point that minimizes the sum of the weighted distances to the given points. For a long time this problem was only well understood in two dimensions, because in this special case the Chebyshev-norm and the Manhattan-norm are closely related and an algorithm for the 1-median problem with the Manhattan-norm is known. We focus on higher dimensions and state the first combinatorial algorithm and an optimality criterion for this location problem.

Furthermore, we discuss the corresponding inverse problem where a location of the facility is already given and the task is to modify the weights of the clients at minimum cost such that the given facility is optimal with respect to the modified instance.

In turns out that this problem can be transformed to the following parametric flow problem. Let G be a directed graph with a source and an even number of sinks where the sinks are paired in groups of two sinks each. Moreover, we have some capacities on the edges of the graph. Finally, we call a flow f in G perfect if two sinks that form a pair have the same excess with respect to f. The task is to find a maximum perfect flow.

Finally, we discuss a combinatorial algorithm for this maximum perfect flow problem which gives us a method for solving the inverse 1-median problem in with the Chebyshev-norm.

> Keywords: location problem, parametric flow problem, inverse optimization

Monday
14.00
Room C

Two level batch processing problem

Jan Pelikán

The case study describes using methods of mixed integer programming at optimization of the production in a chemical company. Problem is the determination of production batches on the chemical apparatus and the batches on bottling lines, including determination of sequence of these batches and assignment them on the apparatuses and bottling lines. The goal is to minimise the total processing time.

Case study deals with manufacturing the order in the chemical company. The order composes a set of products and the required quantity in litres, which are produced on chemical apparatuses (kettle, cooker), this process is called as cooking. After that the products are bottling and packing on bottling lines.

Each product is possible to produce on arbitrary apparatus as well as each product can be bottled on arbitrary line. Production time of the batch depends on its size and consists of a fixed part and a linear part. A lot size depends on minimum and maximum allowable lot sizes on the apparatus, which differs at particular apparatus.

Product packing consists in taping into cover - bottles. It proceeds on bottling lines, for which it holds:

a) it is necessary to adjust the line on the product, setting-up time takes about 30 minutes,
b) production batch can be bottled only after producing it,
c) the packing rate differs for different products and bottling lines.

Optimization consists in:

a) determination of the size of the production batch for each product,
b) assignment of batches to the apparatuses,
c) scheduling batches on apparatuses,
e) determination of the sequence of batches on bottling lines,
f) assignment of batches to bottling lines.

It is proposed two-step optimisation model of the problem, two models: lot size production model and combined model, which utilises the results from the first optimisation model and it solves the scheduling problem on apparatuses, the assignment problem of the batches from the first model to the bottling lines and their scheduling.

> Keywords: integer programming, sheduling, batch processing

Monday
14.20
Room C

Optimization of a Purlin Punching Process

Jan Pöschko

In the production of purlins (structural members of roof constructions), screw holes of different diameters are punched into sheets of metal. This is done "on the fly", allowing the metal to move faster when there are longer distances between punches.

We present a heuristic algorithm that solves the following combinatorial optimization problem: find an equipping of the punching machine with stamps of certain diameters and a list of machine positions and respective punched holes such that the sum of the inverse squared displacements between the positions is minimized.

This can be achieved by a linear-time heuristic using randomly generated machine configurations with fixed stamp positions to solve the underlying matching problem. In a second step, the stamp positions are relaxed to account for possible adjustments that can be made to the machine during the process. In addition, the waste of metal resulting from the first machine position is minimized using other heuristics.

The algorithm was designed and implemented for a company and is in actual use, saving both time and metal in the production process.

> Keywords: matching problem, heuristics, randomization

Monday
14.40
Room C

A heuristic approach to scheduling computational jobs on a multicore processor with respect to power and energy limits

Rafal Rozycki

We consider a problem of scheduling computational jobs on a multicore processor, where each core is driven by a common power source. The cores of a processor are modeled as parallel, identical machines, whereas the jobs are treated as preemptable and independent ones.

We utilize a dynamic model to represent a characteristics of a job execution. The processing rate of a job depends on an amount of power allotted to this job in the dynamic model of execution. This relation is expressed by an increasing, concave processing speed function. Different jobs may be described by unique processing speed functions in a problem instance. The assumed dynamic model of execution lets us to consider the practical situations where allocation of power to a job may change during its execution. Moreover, we assume that energy is a scarce, doubly constrained resource, described by two parameters: power and energy limits. The problem is to schedule the jobs on machines and simultaneously to allocate power/energy for jobs in order to minimize the schedule length with respect to given restrictions.

The only known exact method of finding optimal solution of the considered problem requires a nonlinear (convex) mathematical programming problem to be solved. Unfortunately, the number of variables grows exponentially with the size of a problem instance in such approach. Thus it is justified to construct some effective heuristic approaches. We propose a few heuristic algorithms to cope with the considered problem. These algorithms have been examined during an extensive computational experiment. The results of the experiment show that using a combination of the proposed algorithms may be a promising alternative for the exact method.

> Keywords: scheduling problem, preemptable jobs, parallel identical machines, power/energy allocation

Monday
15.00
Room C

Throughput Optimization in Flow shops with 2-nonidentical Machines and Flexible Operations

Hakan Gultekin, Hilal Dag, and Ozden Onur Dalgic

We consider a 2 machine flowshop which produces n identical parts. Each part has three operations: first one will be produced on the first machine, the second one can either be produced on the first or on the second machine and the last one will be produced on the second machine. The first and the third operations are called the fixed operations and the second operation is called the flexible operation. The machines are not identical so that the processing time of the flexible operation depends on the machine that it is assigned to. The assignment can be different from one part to another. Hence, although the parts are identical, they will have different processing times on the machines. The problem is to decide on the assignment of the flexible operations for each part with the objective of maximizing the throughput rate.

One application of such production systems can be found in metal cutting industries where highly flexible CNC machines are used. These machines are capable of performing different operations as long as the required cutting tools are loaded on the tool magazines. However, these tool magazines have limited capacity. Therefore, some parts can only be processed by one of the machines. The remaining operations can be performed by any one of the machines. The machines can be technologically different from each other, which means the speeds of the machines are different. Same problems also exist in assembly lines with human operators by cross-training the workers.

We consider both the no-buffer case and the infinite capacity buffer case. We develop exact and efficient solution procedures for these problems. Furthermore, we quantify the increase in the throughput rate as the flexibility in the system increases and we determine the instances where having such flexibility is more advantageous. We provide extensive managerial insights so that the increase in the throughput rate can be compared with the cost of increasing the flexibility in the system.

> Keywords: Flowshop, Scheduling, Flexible manufacturing Systems, Throughput maximization

Monday
16.00
Room A

The Wiener maximum quadratic assignment problem

Eranda Cela, Nina S. Schmuck, and Shmuel Wimer, and Gerhard J. Woeginger

We consider a special case of the maximum quadratic assignment problem where one coefficient matrix is a nonnegative symmetric product matrix and the other matrix is the distance matrix of a one-dimensional point set. This special problem is called the Wiener maximum quadratic assignment problem (Wiener MaxQAP) because it models a problem from chemical graph theory, the so called Wiener index problem on trees, where one looks for a tree having the maximum Wiener index among all trees with a prescribed degree sequence.

We show that the Wiener maximum quadratic assignment problem is NP-hard in the ordinary sense and solvable in pseudo-polynomial time. The pseudo-polynomial time algorithm is a dynamic programming approach. This approach exploits a decomposition property of the problem which relies on the special combinatorial structure of its optimal solutions: there exists always an optimal solution (i.e. permutation) which is V-shaped, i.e. the sequence of values a(1), a(2),...,a(n) of the optimal permutation a (where n is the size of the problem, i.e. both coefficient matrices are n by n matrices decreases first until 1 is reached, and then the sequence of values increases.

The time complexity of our dynamic programming algorithm depends on the sum of the entries of the vector which generates the product matrix. In the case of the max QAP model for the Wiener index problem on trees the vector generating the product matrix is essentially the prescribed degree sequence of the tree. Therefore the sum of its entries depends linearly on the number of vertices of the tree which is essentially also the size of the corresponding max QAP. Hence the dynamic programming approach for the Wiener maxQAP yields a polynomial time algorithm for the Wiener index problem on trees with a prescribed degree sequence. This settles an open question from the literature.

> Keywords: Combinatorial optimization, computational complexity, graph theory, degree sequence, Wiener index

Monday
16.20
Room A

An Exact Method with Variable Fixing for solving the Generalized Assignment Problem.

Marius Posta, Jacques A. Ferland, and Philippe Michelon

We propose a simple and very effective algorithm for solving the generalized assignment problem exactly.

Our contribution is twofold: we reformulate the optimization problem into a sequence of decision problems, and solve these effectively using variable-fixing rules.

The decision problems are solved by a simple depth-first lagrangian branch-and-bound method, improved by the variable-fixing rules which help prune the search tree.

These rules rely on lagrangian relative costs which we compute using an existing but little-known dynamic programming algorithm.

> Keywords: Integer programming, Generalized assignment problem, Branch and bound, Lagrangian relaxation, Knapsack problem, Dynamic programming

Monday
16.40
Room A

On A Generalization of the Optimal Linear Arrangement Problem

Serigne Gueye, Sophie Michel, Adnan Yassine, and Philippe Michelon

Given a graph, the Optimal (or minimal) Linear Arrangement (OLA) problem consists in finding a vertex ordering that minimizes the sum of edge lengths. The length of an edge depends on the number assigned at its ends in the linear ordering. We study a generalization of (OLA) in which a weight is associated to each vertex, as well as a flow to each edge. The length of an edge is define as the sum of the weights of vertices which are between the ends (in the linear ordering), times the flow on the edge. As in (OLA), we seek to minimize the sum of edge lengths. Taking all weights and all flows equal to one gives the standard problem (OLA). Thus, this generalisation is NP-Hard as OLA is NP-Hard. The problem comes from an application in maritime transportation consisting in finding a suitable assignment of ships on a terminal quay viewed as a line. An original formulation in which an assignment is regarded as finding an optimal hamiltonian tour in a weighted graph is presented. The corresponding mathematical program is written and solved using a

lagrangean relaxation approach in which the dual problem involved as sub-problems shortest paths sub-problems and TSP sub-problems. To improve the corresponding lower bound, some valid inequalities are added to the shortest path sub-problems. Numerical results obtained with QAPLIB benchmark are finally shown.

> Keywords: Linear Arrangement Problem, Lagrangean Relaxation, Valid Inequalities, Traveling Salesman Problem, Shortest Path Problem

Monday
17.00
Room A

Upper Tolerances and Lagrangian Relaxation for the DCMSTP

Marcel Turkensteen

The Degree-Constrained Minimum Spanning Tree Problem (DCMSTP) is the problem of connecting a set of vertices against minimum cost, where no more than a prespecified number of edges may enter or leave each vertex. The DCMSTP is an NP-hard problem with many practical applications in the design of networks. Many efficient solution methods for the DCMSTP rely on Lagrangian relaxation for the tight lower bounds needed to solve instances.

Lagrangian procedures for the DCMSTP solve a modified version of the regular Minimum Spanning Tree Problem (MSTP) in which the degree constraint violations are penalized in the objective function. By varying the penalty values, or multipliers, the procedures can increase the resulting lower bound value. Existing Lagrangian procedures start with multiplier values equal to 0 and then iteratively adjust them. The upper tolerance based (UTB) approach from this paper supplements Lagrangian relaxation approaches by using the upper tolerances of the MSTP, which correspond to the increase in an edge weight needed to remove the edge from an MSTP solution, to set the accurate initial multiplier values. The UTB approach enables Lagrangian relaxation approaches to find better bounds within their given running times.

> Keywords: Networks, Lagrangian relaxation, Degree-Constrained Minimum Spanning Tree Problem, Tolerances

Monday
17.20
Room A

A branch and bound method to compute median equivalence relations

Irène Charon and Olivier Hudry

We consider the problem of the approximation of m symmetric relations S1, ..., Sm defined on a same set X into a median equivalence relation, i.e. a symmetric transitive relation summarizing the m relations Si "as well as possible". To define what this means mathematically, we consider the symmetric difference distance which, when applied to two relations S and S', measures the number d(S, S') of disagreements between S and S'. Given a collection C = (S1, ..., Sm) of m relations, the remoteness R(C, S) between C and a relation S is the sum of the disagreements d(Si, S) when i varies from 1 to m. A median equivalence relation of C is a symmetric transitive relation E* minimizing the remoteness from C. In other words, E* minimizes the total number of disagreements with respect to C.

This combinatorial optimization problem is NP-hard. We show how this problem can be represented as a clique partitioning problem. Indeed, C may be associated with a complete, undirected, weighted graph G of which the set of vertices is X. The weights of the edges, depending on the relations Si, are positive or negative integers. The computation of a median equivalence relation of C consists in partitioning X into k(C) subsets (note that k(C) is not given in the instance but depends on C) inducing disjoint cliques of G so that the sum of the weights of the edges with both extremities belonging to a same subgraph is minimum.

Then we design a branch and bound algorithm to compute an optimal clique partitioning of G. In particular, the evaluation function of the branch and bound algorithm is based on Lagrangean relaxation.

> Keywords: Branch and bound, Lagrangean relaxation, graph theory, clique partitioning of a graph, median equivalence relation.

Monday
16.00
Room B

Integer linear programming models for a cement delivery problem

Alain Hertz, Marc Uldry, and Marino Widmer

We consider a cement delivery problem with a heterogeneous fleet of vehicles and several depots. The demands of the customers are typically larger than the capacity

of the vehicles which means that most customers are visited several times. This is a split delivery vehicle routing problem with additional constraints.

We first propose a two phase solution method that assigns deliveries to the vehicles, and then builds vehicle routes. Both subproblems are formulated as integer linear programming problems. We then show how to combine the two phases in a single integer linear program.

Experiments on real life instances are performed to compare the performance of the two solution methods.

> Keywords: vehicle routing, split delivery, integer linear programming

Monday
16.20
Room B

Online optimization for a vehicle routing problem

Sandro Lorini, Jean-Yves Potvin and Nicolas Zufferey

We consider a dynamic vehicle routing problem where, on the one hand, some customer requests can occur in an online fashion, and, on the other hand, travel times can depend on expected rush hours, but also on non expected events like meteorological conditions or the occurrence of accidents. The developments in mobile communication technologies are a strong motivation for the study of such dynamic vehicle routing problems. In particular, the planned routes can be quickly modified to account for non expected events (e.g., the occurrence of a new request or an accident), which might imply diverting a vehicle away from its current destination.

In the tackled problem, vehicles pickup goods at customer locations (the service time is assumed to be perfectly known) and bring them back to a central depot. A number of customer requests are known at the beginning of the day and are used to create initial planned routes. One type of application could be courier services, where the goods to pick up are letters and packages. This problem can be modeled as an uncapacitated vehicle routing problem with time windows. If a vehicle arrives too early at a customer location, it has to wait until the lower bound of the time window; if it arrives too late, a penalty is added to the objective. Also, each vehicle must return to the depot before an upper bound, otherwise another penalty is incurred. The objective is to minimize, over all vehicles, a weighted sum of (1) travel time, (2) sum of lateness at customer locations and (3) lateness at the depot.

We propose an extension to an existing model, proposed in 2006 by Potvin, Xu and Benyahia, which assumes that communication between the drivers and the dispatch office can only take place at customer locations. Here, it is assumed that the dispatch office can communicate with the drivers to get their current position when a new customer request is received or when one of the drivers does not report at his current destination at the planned time (plus some tolerance). This new context leads to diversion opportunities, because the vehicle can be redirected to another customer location without ever reaching its current destination. To take advantage of diversion opportunities, it is important to react quickly because the benefits associated with a diversion at the current time may well not be present just a little bit later (since vehicles move fast).

We propose a very quick heuristic to account for such more sophisticated communication means between the drivers and the central dispatch office. Computational results are reported to empirically demonstrate the benefits of this extension. Among the possible avenues of research, we mention the consideration of dynamic service times, as well as the study of the impact of more sophisticated communication devices, like global positioning systems.

> Keywords: Vehicle routing, Online optimization, Heuristics

Monday
16.40
Room B

Positioning of loading units in a transshipment yard storage area

Florian Jaehn

We consider a decision problem as it arises in a rail-road transshipment yard when unloading a bundle of trains. The loading units, e.g. containers, arriving on trains and occasionally arriving on trucks have to be placed on storage lanes of limited capacity. Loading units are placed and removed keeping stacking and crane rail moves small. We present two NP-hard models and three heuristics for solving the problem. One of these heuristics is currently applied at the yard. The algorithms are then tested using real life data.

> Keywords: Railway Operations, Transshipment Yard, Storage Area, Heuristics

Monday
17.00
Room B

Scheduling trucks in intermodal container transportation

Jenny Nossack and Erwin Pesch

Intermodal container transportation describes the movement of containers by two or more transportation modes (rail, maritime, and road) in a single transport chain. The change of modes is thereby performed at bi- and tri-modal terminals without handling the freight itself. The route of intermodal transport is namely subdivided into the pre-, main-, and end-haulage, denoting the route segments from customer to terminal, terminal to terminal, and terminal to customer, respectively. The main-haulage generally implies the longest traveling distance and is carried out by rail or maritime, whereas the pre- and end-haulage are handled by trucks to enable house-to-house transports. Intermodal transportation has received an increased attention, e.g. by support programs introduced by the European Union, to divert freight transportation from road to rail and maritime, in order to reduce road congestion and environmental pollution. However, the fraction of the overall freight transportation by rail is steadily declining, leveling off at around 10% in 2005, its lowest level since 1945. To increase the attractiveness of intermodal container transportation, an efficient handling of the pre- and end-haulage will result in a significant cost reduction.

In this paper we address a truck scheduling problem that arises in the pre- and end-haulage of intermodal container transportation. A trucking company is considered which handles a number of transportation requests that involve container movements from customers (shippers or receivers) to terminals (rail or maritime) and vice versa. The transportation requests are carried out by a fleet of homogeneous trucks, that must be routed and scheduled to minimize the total truck operating time under hard time window constraints imposed by the customers and terminals. It is further assumed that the containers belong to the trucking company and are provided to the customers for freight transportation.

We present a new model formulation for the truck scheduling problem as Full Truckload Pickup and Delivery Problem with Time Windows (FTPDPTW) and propose a 2-stage heuristic solution approach that is insensitive against changes in the time windows. A detailed description of the truck scheduling problem is given and we present the FTPDPTW model formulation and the 2-stage heuristic solution approach, respectively. We summarize the computational study, which we conducted, to analyze the performance of the algorithm.

> Keywords: intermodal container transportation, truck routing and scheduling, container repositioning

Monday
17.20
Room B

A Heuristic Algorithm to Solve the Speed Optimization Problem in Vehicle Routing

Emrah Demir, Tolga Bektas, and Gilbert Laporte

Transportation has hazardous effects on the environment, such as noise, congestion and greenhouse gas (GHG) emissions. The transportation sector is the third largest source of GHG emissions of which road transport accounts for a large portion. The most prominent GHG is carbon dioxide (CO2), the emissions of which are directly proportional to the amount of fuel consumed by a vehicle. This amount is dependent on a variety of vehicle, environment and traffic-related parameters, such as vehicle speed, load and acceleration.

This paper considers the speed optimization problem (SOP). Given a vehicle route with a number of customers to be visited and their demands served, the SOP consists of finding the optimal speed on each link of the route between successive customers such that an objective function comprising fuel consumption costs and driver wages are minimized. The objective of SOP is nonlinear due to the function used to estimate fuel consumption of a vehicle, which is quadratic in speed.

This paper first describes a nonlinear optimization model for the SOP consisting of a convex objective function and linear constraints. The paper then presents a heuristic algorithm to solve the SOP. Computational results are presented on realistic instances to show the performance of the proposed heuristic.

> Keywords: Vehicle routing problem, Fuel consumption model, CO2 emissions, Heuristic.

Monday
16.00
Room C

Heuristic algorithm with forecasting for online shopping

Jacek Blazewicz and Jedrzej Musial

We study an optimization aspect of Internet shopping with price sensitive discounts from customer perspective (which is a specific case of the Internet Shopping Optimization Problem).

We developed and experimentally tested a simple algorithm H for problem IS. In this algorithm products are considered in a certain order.

We performed computer experiments, in which solutions obtained by algorithm H were compared against optimal solutions and those provided by algorithm of Price Comparison Sites for the examples of problem IS, which are prepared on the basis of data from the online book industry. In these examples following data are given: number of stores, number of products and discounting functions is f.

It is assumed that each bookstore has all the required books. For each pair [book;store] 10 instances were generated. In each instance, the following values were randomly generated for all shops and products in the corresponding ranges. Delivery price, publisher's recommended price of book, and price of each book in every bookstore.

In the worst case, solution found by algorithm H was 4.1% more expensive than the optimal solution, it was 36.1% cheaper than solutions provided by Price Comparison Sites without taking delivery prices into account. The average values of the above mentioned deviations are 2.3%, 45.9% respectively.

We observed that algorithm H demonstrates very good performance on the experimental data. However, it can provide a solution, where value is n times worse than the optimum.

New heuristic algorithm with forecasting H2 is under development. Changes we made will prevent to provide bad solutions for specific data (even if it is unrealistic) - it also should improve overall performance and provide even better solutions.

> Keywords: Internet shopping, optimization, algorithms, heuristics

Monday
16.20
Room C

Optimization of column width in website layout for advertisement fit

Maciej Drozdowski and Jakub Marszalkowski

As internet advertising market grows despite economy slowdowns, for most of web services ads remain basic income source. With two, three or four column layouts of web pages, column widths are usually chosen ad hoc to fit widest advertising forms or some content. In this paper website column width optimization problem is formulated. An algorithm selecting column widths for a given set of advertisement forms is presented. A modified Wang algorithm for two-dimensional stock cutting problem is used to generate all acceptable sets of ads that fit different widths of the

columns. All possible column widths are valued for several objective functions of the ad placement. Two solutions of are proposed. First is a set of all non-dominated (in the Pareto sense) column width combinations, provided with their scores for the user choice. Second is an optimal column width combination in the sense of a weighted mean of all objectives. Both solutions are examined on several data sets of internet advertising formats.

> Keywords: internet advertising optimization,, web page layout optimization,, two-dimensional cutting

Monday
16.40
Room C

An aggregation procedure for large scale mixed integer programming in energy management

Wim van Ackooij, Frédéric Bréant, and Nicolas Langrené

Mixed integer programming is frequently used in Energy Management optimization problems. Often such models are huge, or there is quite some room to increase the model size even further in order to have interesting results. A typical application of mixed integer programming is the optimization of the schedule in hydro-thermal systems. Indeed, power plants have many complex dynamic constraints that can be modelled using mixed integer programming. What is interesting to observe, is the effect of such dynamic constraints on the marginal costs of this offer-demand equilibrium model. Indeed, they are far more shaped than a model not integrating such constraints. Moreover, they resemble more closely market prices.

When considering investment problems at time horizons starting 5 years from now (mid-term), new units are often valued against prices. Since the system may be heavily constrained, it is interesting to not only value units for the additional gain, but also for the additional flexibility they offer. The former can be defined as the differential of global costs when including a unit in a specific energy mix or the gain obtained when marginally valuing it against some price signal. In such a marginal valuation approach a good "price" signal is required. Often, at mid term time horizons only marginal costs, i.e., the incremental cost of satisfying one extra MW, can be computed, as market prices may be unavailable. Such marginal costs can be obtained from a mid-term dispatch model, provided that they are sufficiently realistic. If we would content ourselves with a coarse mid-term model, modelling only the offer demand equilibrium (produced power and customer load should equate) and units by a proportional cost and maximal power constraints, resulting

marginal costs will turn out quite flat. Hence valuing a flexible but costly unit will turn out to have zero value.

In this work, we will consider such a mid-term offer-demand equilibrium model for electricity. This model can be used for investment opportunity studies, wherein new assets are valued against obtained marginal costs on a restricted set of uncertainty scenarios. In order to correctly value peak-load assets, realistic marginal costs are required and hence dynamic constraints have to be added to the problem formulation. Unfortunately due to the size of the considered problem, formulating constraints for each individual unit would lead to a huge intractable mixed integer optimization problem. We therefore propose a formulation for aggregated units, hence strongly reducing the problem size. We also demonstrate the feasibility of this formulation on a real-sized problem in a European context.

> Keywords: Investment problems, dynamic constraints, marginal costs, mid-term unit commitment, peak load asset valuation.

Monday
17.00
Room C

Pricing for vehicle sharing using densest oriented subgraph in Markov Chains

Ariel Waserhole , Vincent Jost, and Nadia Brauner

Vehicle Sharing Systems have become very popular these last years. One-way (short-term) vehicle rental seem to be promising means in order to solve problems of congestion and pollution of cities. Indeed they promote multi-modal public transportation systems, more than round trip rental, where vehicles have to be returned at the station where they have been taken.

In current (bicycle) Vehicle Sharing Systems, vehicles are parked in specific stations, the user is free to take and return a vehicle whenever and wherever he wants. The problem is that this freedom has a cost. The user is never sure to be able to do the trip he wants in the appropriate timing due to empty or full stations. Currently systems manager are trying to reduce these saturation effects by repositioning physically the vehicles at disposal. Some researchers study this possibility in light of pick-up and delivery (online, stochastic) VRP.

Our aim is to study the impact of various interfaces between the user and the system. The system is based on reservation for a specific origin / destination and

time order. Through dynamic pricing systems we are trying to maximize the number of demands (trips) that the system is able to serve.

We model the system as a Markov Decision Process and reduce it to a graph optimization problem: we introduce a new definition of density of an oriented graph and show that finding the densest oriented subgraph is polynomial. This notion will be extended to treat a price setting problem introducing revenue management in a Markov Decision Process.

> Keywords: One-way vehicle sharing system, Dynamic pricing, Markov Decision Process, Densest oriented subgraph, Revenue management

Monday
17.20
Room C

Dynamic Location Model with Market Learning

Michael Lim and Ho-Yin Mak

In this paper, we consider a two stage retail facility location problem in the presence of demand learning effect. In the first stage, only the distribution of the demand is known and the planner deploys facilities taking into account the learning effect. We assume that the learning period is endogenously determined by the first stage decisions and that demands will be fully revealed once learning is completed. Additional facilities are then deployed in the second stage. Based on the gradual covering model (where each demand is proportionally covered by the non-increasing coverage function based on the distance to its closest facility), we construct a model which maximizes the net present value of the expected profit on a discrete network. We derive interesting structural properties of the model such as nodal optimality and that the problem reduces to classical uncapacitated fixed charge location problem under certain conditions. We also study the impact of learning by contrasting the optimal solution to the myopic planner's solution in which the decision is made based on the current stage's profitability. To solve the resulting problem, we formulate a nonlinear integer programming model and develop an efficient solution algorithm that effectively converges to near-optimality for large-scale instances. Finally, we summarize the managerial insights and guidelines derived from the model.

> Keywords: facility location, discrete network, demand learning

Tuesday
10.15
Room A

Stability vs. Optimality in Selfish Ring Routing

Bo Chen, Xujin Chen, Jie Hu, and Xiaodong Hu

We study the asymmetric atomic selfish routing in ring networks, which has diverse practical applications in network design and analysis. We are concerned with minimizing the maximum latency of source-destination node-pairs over links with linear latencies. We obtain the first constant upper bound on the price of anarchy and significantly improve the existing upper bounds on the price of stability. Moreover, we show that there exists an optimal solution that is a good approximate Nash equilibrium. Finally, we present better performance analysis and fast implementation of pseudo-polynomial algorithms for computing approximate Nash equilibria.

> Keywords: Selfish routing, Price of anarchy, Price of stability

Tuesday
10.35
Room A

On minimal integer representations of weighted games

Josep Freixas and Sascha Kurzb

We study by means of linear integer programming minimum integer representations for the weights of weighted games, which is linked with some solution concepts in game theory. Closing some gaps in the existing literature we prove that each weighted game with two types of voters admits a unique minimum integer presentation and give examples for more than two types of voters without a minimum integer representation. We characterize the possible weights in minimum integer representations and give examples for more than 3 types of voters without minimum integer representations preserving types.

> Keywords: Integer programming, Weighted games in minimum representation, Threshold functions in minimum representation.

Tuesday
10.55
Room A

Analysis of a supply chain coordination mechanism within a lot-sizing model

Maxime Ogier, Van-Dat Cung, and Julien Boissière

In this paper we study planning at tactical level in a two-echelon supply chain with two actors: a manufacturer and a logistician. We propose to use a decentralized lot-sizing model on a fixed horizon with deterministic demands. Supply chains are inherently decentralized systems, preventing from a good overall optimization.

Indeed, different actors with different goals and constraints are reluctant to share information. Thus optimization using centralized models is barely possible in practice, making coordination necessary to achieve good overall performance.

Coordination is achieved using a convergent mechanism proposed by Jung, Chen and Jeong (2007), with minimal information sharing, i.e. the quantities the two actors are willing to ship / transport. The two actors negotiate by alternately establishing proposals for all periods within the horizon length, without increasing the proposals they received from each other. The manufacturer incurs a unit penalty cost if it does not accept the logistician proposal. The negotiation process terminates when the two proposals are identical.

Our contribution is to determine penalty cost which guarantees the best performance of the mechanism. The behavior of the two actors is also studied, and we point out that because of their discordance on storage management, they fail to reach the lowest total supply chain cost while optimizing a decentralized lot-sizing model. An improvement of the coordination mechanism is then proposed, with a proof of its convergence. Analytical results are given and tests are also conducted with a cost structure inspired from the literature. The results of these tests are analyzed, and the lack of significant improvement is explained. Other improvements or non convergence situation will also be discussed.

> Keywords: decentralized lot-sizing model, negotiation process, supply chain performance

Tuesday
10.15
Room B

Binary reoptimization and semi-Lagrangian relaxation applied to solve the uncapacitated facility location problem

Huizhen Zhang and César Beltrán-Royo

It is well known that in binary linear optimization one may obtain good binary solutions by Binary Simplex Pivoting (BSP): At each iteration one goes from one extreme point to an improved extreme point of the LP relaxation polyhedron. These pivots may be continuous or binary. Whenever the optimal pivot is not binary, the best binary pivot found during the pivoting is taken as the final solution. Of course this procedure may produce suboptimal binary solutions. The objective of this report is to investigate whether the BSP can be used as a binary reoptimization tool within the Semi-Lagrangian Relaxation method (SLR). We will test this idea by solving some instances of the uncapacitated facility location problem.

> Keywords: Binary reoptimization, Semi-Lagrangian relaxation, Uncapacitated facility location problem

Tuesday
10.35
Room B

New heuristics for the leader-follower location problems

Yury Kochetov, Ivan Davydov, Alexandr Plyasunov, and Nina Kochetova

We study the competitive facility location models with two noncooperative decision makers: the leader and the follower. They compete to attract clients from a given market and wish to maximize their own profits. First, the leader opens some facilities. Later on, the follower opens other facilities. Each client chooses the closest open facility. If a client is serviced from a facility, he gives a profit to owner of the facility. We aim at finding facilities for the leader to maximize his profit, anticipating that the follower will react to this decision by maximizing his own profit.

We consider two variants of the problem: discrete and continuous. In the discrete case, the sets of facilities and clients are finite and we know the distances between each client and each facility. In the continuous case, we consider a two-dimensional Euclidean plane. Facilities can be opened in arbitrary points in the plane. The finite number of clients are located in the plane as well and we can calculate the distances between each client and each facility as Euclidean distance between the corresponding points.

For both problems we have developed new heuristics and compared them with known ones. For the discrete case, we present an iterative procedure based on the integer linear formulation with the large number of constraints and variables. For the continuous case, we have improved an alternating heuristic. Computational experiments have been carried out on the test instances from the benchmark library Discrete Location Problems (http://math.nsc.ru/AP/benchmarks/english.html) and results are discussed.

> Keywords: bilevel programming, facility location, heuristics

Tuesday
10.55
Room B

Approximate Algorithm for Discrete Competitive Facility Location Problem

V. Beresnev

We consider the competitive facility location problem, where two rival firms (Leader and Follower) open facilities sequentially and each client selects one of the open facilities according to his preferences. The problem is to find a facility location for the Leader which maximizes its profit taking into account the best answer of the Follower. We formulate model as bilevel integer programming problem. The way of construction of an upper bound for optimal values of the Leader's profit is proposed. The algorithm consists of construction the classical facility location problem and finding an optimal solution of the problem. The optimal value of the problem gives the upper bound. Also we propose an algorithm for constructing an approximate solution to the competitive facility location problem. The algorithm amounts to local ascent search with a neighborhood of a particular form. The procedure starts searching from an initial approximate solution obtained simultaneously with the upper bound. The output of this algorithm is an approximate solution in the form of local maximum. Our computation results illustrate the good quality of the obtained solutions.

> Keywords: bilevel programming, upper bound, local search

Tuesday
10.15
Room C

Late Work Scheduling Problems

Malgorzata Sterna

Real world problems arising in various application domains are usually strictly related to time. Time constraints are important from two points of view. They determine feasibility conditions and they make it possible to evaluate the quality of feasible solutions. In scheduling theory, time restrictions are usually modeled by due dates or deadlines and the quality of schedules is estimated with reference to these parameters. The objective functions based on due dates are a very attractive and widely explored subject of research. A significant part of scheduling literature is devoted to classical objective functions involving lateness, tardiness or the number of tardy jobs. Late work performance measures are not so widely explored. They estimate the quality of a solution on the basis of the duration of late parts of particular jobs, combining the features of two parameters: tardiness and the number of tardy jobs. Late work criteria have been used for more than 25 years and

have been studied by a number of research teams. In the paper, the survey of the late work scheduling problems is given. The late work concept was introduced in the context of parallel identical machines scheduling problems and, then, applied to uniform machines and single machine cases. Recently, the practical motivations have directed the research to the shop environment. The review is completed with examples of real world applications of the performance measures based on the number of tardy job units.

> Keywords: scheduling problems, late work, survey

Tuesday
10.35
Room C

Minimizing total completion time on a bounded batching machine with job compatibilities and one unavailability period.

Adrien Bellanger and Ammar Oulamara

In classical scheduling theory a machine can process only one job at time and is always available, but in some production plant -like semiconductor or tire manufacturing industries- those restrictions are outdated. Machines can process several jobs simultaneously, and maintenance activities could be needed along the schedule. In this abstract, the problem of minimizing the total completion time on a bounded batching machine with job compatibilities and an unavailability period of machine that corresponding to maintenance task is studied. The machine can process k jobs simultaneously in a batch with respect to the additional constraint that, in the same batch, the job processing times are compatible. Each job has a normal processing time, which could be increased of a certain percent to be compatible with longer jobs. Note that this percent is the same for all jobs. Thus, each job has a processing time interval, and two jobs are compatible if their processing time intervals intersect. The processing time of a batch is equal to the left endpoint of the intersection of the processing time intervals of jobs in that batch. This problem has been proven to be NP-Hard even for unit capacity. We present a pseudo-polynomial dynamic programming algorithm for the considered problem and a heuristic with performance guarantee.

> Keywords: Batching machine, Maintenance activity, Job compatibilities, Total completion time

Tuesday
10.55
Room C

Heuristics for a Single Machine Scheduling Problem with Bicriteria of Total Tardiness and Makespan

Feristah Ozcelik and Tugba Saraç

A common issue of scheduling problems is the single machine scheduling problem. Single machine scheduling problems can provide help and insight into resolving, understanding, managing, and modelling more complex multi-machine scheduling problems. In many manufacturing systems, we note that the setup time of a job is required when a switch between two different jobs occurs. The operations between these consecutive jobs, such as cleaning working areas and loading work pieces, are referred to as "setups". It is sequence- dependent, if the setup time is dependent on the previous job. The single machine scheduling problem with sequence dependent setup times occurs in many different manufacturing environments. Examples include setups involving a changeover of colors in the production of plastics, die changeovers in metal processing, and changeovers for roll slitting in the paper industry. Much of the research on operations scheduling problems has either ignored setup times or assumed that setup times on each machine are independent of the job sequence. In this study, the bicriteria scheduling problem of minimizing the makespan and total tardiness on a single machine with sequence dependent setup times is considered. This problem is known as NP-hard. To solve this problem, firstly we propose a new dispatching rule named as WSST that is the weighted form of the SST (Shortest Setup Time) rule. The proposed rule is compared with EDD (Earliest Due Date), SST and ATCS (Apparent Tardiness Cost with Setups) dispatching rules. And then, a new heuristic which improves the solutions of the WSST by a local search algorithm is proposed. The performances of the proposed heuristics are tested by using randomly generated test problems. The results show that the proposed heuristics produced better results than the compared heuristics.

> Keywords: Single machine scheduling problem, Sequence dependent setup time, Heuristics

Tuesday
11.30
Room A

Learning in Stochastic Machine Scheduling

Sebastian Marban, Cyriel Rutten, and Tjark Vredeveld

We consider a stochastic scheduling problem which generalizes traditional stochastic scheduling by introducing parameter uncertainty. Two classes of independent jobs have to be processed by a single machine so as to minimize the

sum of expected completion times. The processing times of the jobs are assumed to be exponentially distributed with parameters A and B, depending on the class of the job. We adopt a Bayesian framework in which A is assumed to be known, whereas the value of B is unknown. However, the scheduler has specific beliefs about the parameter B. By processing jobs from the corresponding class, the scheduler can update these beliefs. In this way, the scheduler gradually learns about B, thereby enhancing the decision making in the future. On the other hand, experimenting with jobs can be costly in terms of the waiting times of the still to be processed jobs. Hence, learning should be conducted carefully in order to optimize the objective.

For the traditional stochastic scheduling variant, in which the parameters are known, the policy that always processes a job with shortest expected processing time (SEPT) is an optimal policy. We show that the performance guarantee, which is the worst-case ratio of the expected performance of SEPT over the expected performance of an optimal policy, is a function depending on the number of jobs in both classes. We also provide an instance with non-degenerately distributed processing times for which this performance guarantee is tight. Furthermore, we show that the performance guarantee cannot exceed 2, but might be arbitrarily close. To our knowledge, this exemplifies one of the first tight performance guarantees in stochastic scheduling. Finally, we remark that SEPT is asymptotically optimal whenever the number of jobs of one class remains fixed while the number of jobs of the second class tends to infinity.

> Keywords: Stochastic scheduling,, Bayesian learning,, Approximation algorithm

Tuesday
11.50
Room A

A local search-based algorithm to solve the Stochastic Job Shop Scheduling Problem

Juan Carlos Rivera and Juan Manuel Ortiz

In this article, a strategy to solve the Job Shop Schedulling problem with random proccesing times for the operations is presented. The method uses local search with the implementation of a neighborhood relation based on movements in the critical route of a candidate solution. Furthermore, an introduction to a method for measuring the robustness of a solution is given. The latter will allow us to decide which of two solutions, with identic makespans, is less affected by changes on the parameters, i.e which of them will be a better solution in case of high variability on the processing time values.

> Keywords: Job Shop Scheduling Problem, Local search, Robustness, Heuristics

Tuesday
12.10
Room A

Stochastic models for dispatching multi-load Automated Guided Vehicles in container terminals

E. Hadjiconstantinou and E. Klerides

Maritime cargo transportation is considered to be a critical means of transportation in international trade. As a result, the demand for designing container terminals with part or full automation has increased significantly. For example, manually driven carts are being replaced by Automated Guided Vehicles (AGVs).

We propose stochastic two-stage models for dispatching AGVs in container terminals. The complex and highly stochastic environment found in ports, coupled with the requirement for perfect synchronisation of several inter-related components of a container terminal, make this problem a very hard combinatorial optimisation problem. To the best of our knowledge, the approaches developed in the literature are based on online/real-time strategies and do not produce a schedule beforehand.

In our work, we formulate off-line two-stage stochastic programming models which are capable of both allowing multi-load settings for the vehicles but also taking into account all the jobs in the planning horizon. The uncertain parameters are assumed to be the travel times. The first (planning) stage of the model generates pre-planned sequences of operations for each AGV. The problem is formulated as a stochastic programming model to meet the various operational constraints and to achieve schedules of minimum expected lateness. In the second stage (recourse), more information is assumed to be revealed and the pre-planned routes are re-evaluated using two recourse strategies. We present an extensive computational study based on a large number of benchmark test instances which verifies the benefit of incorporating uncertainty in off-line dispatching methods as it provides an extra level of robustness against randomness.

> Keywords: AGV Dispatching, Container terminals, Stochastic Programming.

Tuesday
11.30
Room B

Trucks fleets routing for vehicle transportation

Alain Nguyen and Jean-Philippe Brenaut

In order to transport Renault's vehicles from factories to delivery centres all over Europe, our transportation contractor manages fleets of trucks from several

European countries (France, Germany, Spain etc). The goal is to design efficient circuits for each fleet (with departures and returns to the base-area of the fleet) which enable the fleet trucks to deliver vehicles at minimal cost.

A circuit is constituted by delivery arcs (to transport vehicles) and re-position arcs, which enable empty trucks to relocate to departure centres after their last delivery, so as to reload with new vehicles. An efficient circuit is one which minimizes the cost of the re-position part.

We tackle the optimization problem with a decomposition method. A sub problem is solved for each fleet, which generates the possible circuits for the fleet. Then a master problem integrating all the fleet circuits is solved so as to select and quantify the optimal subset of circuits at minimal cost.

The following sub problem is solved for each fleet in two steps:

(1) An optimisation problem which selects the arcs needed for the fleet to deliver all the vehicles (and to re-position its trucks) while minimizing kilometres.

(2) The generation of the circuits for the fleet, based on the arcs above.

In the final phase, the master problem selects the best circuits so as to minimize the overall cost (manpower, trucks maintenance, gasoline) under the capacity constraints for each fleet (number of available trucks). Sub problems and the master problem are solved within 25 minutes with CPLEX 12.1 on a 1.8 Ghz dual core Pentium. The next step is to improve the quality of the pool of circuits, either by a heuristics-driven generation of the circuits, or by feedback from the master problem.

> Keywords: transportation, routing, linear programming

Tuesday
11.50
Room B

Truck loading tool for RENAULT's parts delivery

Jean-Philippe Brenaut and Alain Nguyen

Thousands of trucks daily deliver parts from suppliers to RENAULT's factories. One can easily grasp RENAULT's motivation to optimize the loading of these trucks.

From a theoretical viewpoint, truck loading is a 3D bin-packing problem. But in order to take into account more than one hundred business rules, we adopt a two steps approach which makes truck loading a 2D placement problem:

(1) To put parts into piles of pallets

(2) To position these piles in the truck, so as to minimize the length of the used floor space.

Only the second step (the 2D placement problem) is described, since the first step is tackled with straightforward heuristics.

Piles are grouped into families according to business characteristics, and then are positioned into the truck, family after family. Each pile can be placed on the left, right or middle side of the truck, and oriented along the length or the width of the pile.

Two algorithms were implemented The first algorithm is heuristics driven: each pile is oriented along its shortest side, and placed so as to minimize the length of the used floor space, simultaneously on the left, right and middle sides of the truck.

The second algorithm applies the same heuristics, but with a look-ahead of length N: for the placement of a pile, the algorithm evaluates all the combinations for the placement of the current pile and the N following piles, and selects the placement of the current pile which generates the best solution for the N+1 piles. The best solution is the one which minimizes both the length of the used floor space and the lost space between the piles.

Mix Integer Programming and Constraint Programming techniques were also experimented, but with disappointing results.

> Keywords: truck loading, 2D bin packing, heuristics

Tuesday
12.10
Room B

The Added Value of Agility in Robust UAV Mission Planning

Lanah Evers, Ana Isabel Barros, Herman Monsuur, and Albert Wagelmans

Unmanned Areal Vehicles (UAVs) have become important assets to gather information in military missions. UAVs can be used to capture both full motion video and still imagery of specific target locations within the area of interest. In order to

improve the effectiveness of a reconnaissance mission, it is important to visit the largest number of interesting target locations possible, taking into consideration operational constraints related to required fuel usage, weather conditions and endurance of the UAV. This planning problem can be modeled as the Orienteering Problem (OP). However, the planning solutions obtained cannot cope with the dynamics of the current military operation environment. As such, other type of planning solutions are needed.

In previous research we introduced the Robust Orienteering Problem (ROP) to model the UAV planning problem as an OP in which both the fuel parameters and the target values are uncertain. Applying robust optimization techniques to the ROP significantly increases the sustainability of the preplanned tour, since the resulting tours include planned slack on fuel usage. However, this can sacrifice much of the desirable efficiency in terms of number and value of visited targets. Therefore, we introduce a new strategy that extends the robustness of UAV mission planning with agility principles. The robust tour is followed up and until the last scheduled target. At this point, the real-time information on the remaining fuel capacity is exploited in order to determinate which extra targets can be added to the initial route. The resulting strategy combines the benefits of both robustness and agility: with high probability the feasibility of the initial plan is ensured, and simultaneously it efficiently uses the planned slack as well as the potential benefits of a favorable operational environment. The added value of this strategy will be illustrated in our computational results.

> Keywords: UAV Mission Planning, Robust Optimization, Agility, Orienteering Problem

Tuesday
11.30
Room C

Scheduling malleable tasks with arbitrary processing speed functions

J.Blazewicz, M.Y.Kovalyov, and M.Machowiak

A computing task is called malleable if it can be processed on several processors at the same time, its processing speed depends on the number of assigned processors, and the set of processors assigned to the same task can change over time. The following problem will be studied. There are n malleable tasks to be scheduled for processing on m identical parallel processors. Each task is associated with its amount of work, pj . Let rj(t) denote the number of processors allotted to task j at time moment t, and let fj(r) denote the processing speed of task j if it is allotted r

processors. All fj(r) are assumed to be strictly increasing continuous integrable functions with fj(0) = 0. A schedule specifies an allocation of processors to the tasks over time. For each task, a schedule specifies the time intervals within which this task is executed and the numbers of processors allocated to the task within these intervals. The problem is to find a schedule with the minimum makespan.

Note, that parallel processors can be viewed as a discrete renewable limited resource that should be allocated to the tasks and that can speed up their execution. In the sequel, we refer to our original problem as problem P-DSCR (discrete). A relaxation of this problem is problem P-CNTN (continuous), in which the processor allocation is not required to be integer and the processors can be viewed as a continuously divisible renewable limited resource. In problem P-CNTN, processing speed functions fj(r) are assumed to be interpolated by linear functions between the integer points. In problems P-DSCR and P-CNTN, time is assumed to be continuously divisible, any task can be preempted at any time and the number of processors allocated to this task can change during its execution.

Our algorithm for problem P-DSCR converts an optimal solution for problem P-CNTN into a solution for problem P-DSCR and constructs a schedule with at most two preemptions for each task.

> Keywords: malleable task, multiprocessors scheduling, makespan

Tuesday
11.50
Room C

Economic Lot-Sizing models with environmental awareness: A Multi-Objective Programming approach

Dolores Romero Morales, Wilco Van Den Heuvel, H. Edwin Romeijn and Albert P.M. Wagelmans

Nowadays, companies are forced to think about their environmental impact and their levels of pollution. In the production setting, pollution stems from the setup of the machinery, the functioning of the machinery during production as well as from holding inventory. Bearing in mind this environmental awareness, the choice of a production plan can be modeled as a Multi-Objective Economic Lot-Sizing problem, in which we aim at minimizing the total lot-sizing costs including production and inventory holding costs, as well as minimizing the total production and inventory emission costs. Different multi-objective optimization models can be obtained depending on time horizon in which the emissions are minimized. We can minimize the emission costs of the whole planning horizon, yielding a bi-objective model

(BOLS), or we can minimize the emission costs in each period of the planning horizon yielding a truly multi-objective optimization model (MOLS) with T+1 objective functions, where T is the planning horizon. In this talk, we aim at describing Pareto efficient solutions for the models above. We first show that, in general, this task is NP-complete. We then present classes of problem instances for which these Pareto solutions can be found in polynomial time.

> Keywords: lot-sizing, multi-objective programming, polynomial time algorithms, environmental impact

Tuesday
12.10
Room C

Average case analysis of a new class of on-line algorithms for Multiple Strip Packing

Nikolay Kuzjurin and Mikhail Trushnikov

We study the Multiple Strip Packing (MSP) problem, which is a generalization of the well-known Strip Packing (SP) problem. For a given set of N rectangles of heights and widths at most 1, the goal is to find a non-overlapping orthogonal packing without rotations into k strips of width 1 minimizing the maximum of the heights. As well as the Strip Packing problem its generalization Multiple Strip Packing problem is not only of theoretical interest, but also has many applications to real-world problems as in scheduling for Grid computing, server consolidation and cutting problems. In Grid computing for example, MSP is related to the problem of finding a schedule for parallel tasks into different clusters of processors with minimum makespan.

The MSP problem is known to be NP-hard (in fact, even its special case SP problem), so the focus of research is made on efficient approximation algorithms. The important class of algorithms are on-line algorithms where rectangles are packed one by one without knowing next rectangles. An on-line algorithm for generalization of the MSP problem (where strips can have different widths) with 2e asymptotical approximation ratio (in the worst case) was proposed by Zhuk (2006). The MSP problem was considered by Ye et.al (2009) and Bougeret et. al (2010) where 2-approximation algorithm and AFPTAS for the MSP problem were presented.

We propose a new class of efficient on-line algorithms for the MSP problem and provide an average case analysis for estimation of their quality in the standard probabilistic model. In this model the width and height of each rectangle are independent random variables uniformly distributed in [0,1]. A lot of research was devoted to this model for strip packing and bin packing problems: Coffman and Shor (1993), Karp et. al (1984), Coffman et. al (2002). As a measure of packings quality we use (as usually in the standard probabilistic model) the expectation of the maximum

of heights of packings over all strips. For any fixed k we prove that as N goes to infinity the above measure is asymptotically N/(4k)+O(N^{2/3}). Note that in our on-line algorithms we do not suggest that the value N is known in advance. Intensive computational experiments with up to 10,000,000 rectangles and up to 1000 strips show that the quality of packings produced by our on-line algorithms matches theoretical bounds and the constant in O( ) term is small (between 1 and 2).

> Keywords: strip packing, on-line algorithm, average case analysis

Wednesday
10.15
Room A

Minimizing project team size in a workforce assignment problem

Matthias Walter and Jürgen Zimmermann

We present a workforce assignment problem arising in the multi-project environment of a company. For a given set of workers and for a given set of projects, we want to find one team of workers for each project that is able to satisfy the project workload during each period of project execution. The projects require certain skills offered by workers who master different subsets of skills at various levels. Workers may be assigned to more than one project, but their working time is limited in each period. The aim is to minimize average team size, i.e. to minimize the total number of assignments of workers to projects in order to improve team performance and to alleviate project workflow.

We outline two mixed integer linear programming (MIP) formulations of the NP-hard optimization problem and introduce four heuristic approaches to this problem. The first MIP formulation emanated from the problem description above, whereas the second formulation is based on a network flow model. The first two heuristic approaches are derived from the DROP and the ADD procedure, respectively, known from warehouse location problems. They provide good quality solutions, but require relatively high computational effort. A third heuristic approach is a simple stochastic construction heuristic while the fourth approach exploits matchings on a bipartite graph to construct a solution.

A numerical study for the two MIP formulations revealed the superiority of the network flow model when small-scale instances are solved by the commercial solver CPLEX. Additionally, we will present preliminary computational results for the heuristic approaches on large-scale instances.

> Keywords: multi-project management, workforce assignment, heterogeneously skilled workers

Wednesday
10.35
Room A

Days-Off Planning in Large-Scale Multi-Skill Staff Rostering

Andreas Klinkert

Staff scheduling and rostering typically involves a number of hierarchical subproblems including demand modeling, shift design, days-off scheduling, and staff assignment. When solving highly constrained large-scale rostering problems it is usually not computationally practical to deal simultaneously with all these tasks, and decomposing the problem into several separate modules is typical for real-world solutions. The problem considered here focuses on the days-off scheduling phase of the rostering process, and has been tackled in the context of an industrial project in the airport ground handling business.

The main concern in days-off scheduling is to determine the off-work days for each staff member over the rostering planning horizon. In general, there are two categories of constraints to be considered. The first type is related to the individual line of work of each employee and originates from industrial regulations, labor contract, workplace agreements and individual preferences. The second type of constraints refers to the different days of the planning horizon and is concerned with satisfying the required daily staffing levels for each shift. According to the setting in our project, we assume that the required shifts and their staffing levels for each day have been determined prior to the days-off scheduling phase. Furthermore we assume a multi-skill staff environment where shifts can only be assigned to employees with appropriate skills.

An integer programming model has been developed which is able to solve the complex large-scale problems posed by the industrial project partner. The Gurobi 4 solver generates high quality solutions within a few hours which clearly outperform the sophisticated solutions constructed manually by the experts at the planning department of the ground handling company.

> Keywords: rostering, large-scale, airport, integer programming

Wednesday
10.55
Room A

Heuristic appraoches to the discrete-continuous resource-constrained project scheduling problem with discounted cash flows

Grzegorz Waligóra

In this work discrete-continuous project scheduling problems with discounted cash flows are considered. These problems are characterized by the fact that activities of a project simultaneously require for their execution discrete and continuous resources. A class of these problems is considered, where the number of discrete resources is arbitrary, and there is one continuous, renewable resource, whose total amount available at a time is limited. Activities are non-preemptable, and the processing rate of an activity is a continuous, increasing function of the amount of the continuous resource allotted to the activity at a time. A positive cash flow (cash inflow) is associated with each activity, and the objective is to maximize the net present value (NPV). The discrete-continuous resource-constrained project scheduling problem with discounted cash flows (DCRCPSPDCF) is defined. Four payment models are considered: lump-sum payment at the completion of the project (LSP), payments at activity completion times (PAC), payments at equal time intervals (ETI), and progress payments (PP). Some properties of optimal schedules are shown for two important classes of processing rate functions: all functions not greater than a linear function (including linear and convex functions), and concave processing rate functions. For the latter case, non-linear mathematical programming problems finding optimal continuous resource allocations are formulated. Some heuristic (or metaheuristic) approaches to solve the general DCRCPSPDCF under concave processing rate functions of activities are proposed. Also heuristic procedures for allocating the continuous resource are analyzed as an alternative to solving mathematical programming problems. Directions for future research are given.

> Keywords: discrete-continuous project scheduling, discounted cash flows, net present value, heuristic

Wednesday
11.15
Room A

Multimode resource-constrained project scheduling problem with setup times and the total cost minimization objective.

Marek Mika

The multimode resource-constrained project scheduling problem (MRCPS) is a well known NP-hard optimization problem, where the set of nonpreemptable activities of the project have to be executed using /consuming renewable or nonrenewable resources from a given set. There are strict finish-start precedence constraints between activities. Each activity can be executed in one of several execution modes, which differ among themselves in the processing times and resource requirements. In this work we consider an extension of this problem in which some resources have to be set up for an execution of a given activity. These setup operations are characterized by two parameters: setup time and setup cost. Both parameters are mode-dependent. Moreover, it is assumed that these setup operations are activity setups, are separable, schedule-dependent, precedence-dependent, undivided and asynchronous.

We developed the model of the problem where the setup times are included in the constraints and the objective is to minimize the total cost of the project, which is the sum of the following components: the renewable resource usage/renting cost, the nonrenewable resource consumption cost, the setup cost and the early/tardy cost for the entire project. As in many other similar models the due date for the entire project is determined.

We propose a metaheuristic approach to find a feasible schedules (mode assignments and start times for activities and setup operations) that minimize the objective function. A special version of the serial SGS is used to build the schedule. The performance of the proposed approach was evaluated on the basis of a computational experiment. The obtained results have been compared with results obtained by two other simple approaches, and shows that the proposed metaheuristic approach performs better than two other approaches used during the experiment.

> Keywords: project scheduling, setups, metaheuristic

Wednesday
10.15
Room B

Quadtrees in combinatorial Vector Optimization Problems

Walter Habenicht

A quadtree is a data structure which supports the exploitation of dominance relations in multidimensional spaces. This ability can be used in two ways. Firstly, it can be used to identify non-dominated solutions in an enumerative or metaheuristic scheme. On the other hand, the data structure can be used to perform different versions of neighborhood searches in outcome space.

We present an interactive searching procedure for combinatorial vector optimization problems with a huge number of efficient solutions.

> Keywords: Combinatorial vector optimization, quad trees, neighborhood search

Wednesday
10.35
Room B

Mind the Gap: A study of Tube Tour

Maciej Drozdowski, Dawid Kowalski, Jan Mizgajski, and Grzegorz Pawlak

The considered problem was motivated by the question: Is it possible to visit all Tube lines in a day? More formally, this problem can be stated as follows. Consider communication network in a city. The stations correspond to nodes in a graph. The connections between the stations correspond to edges. A subway line is a chain of nodes. We will say that each line has a different color. A set of subway lines constitute a communication network. Given an initial node (starting station) find the shortest cycle that visits all the different lines (colors). The problem which seems to have the artificial motivation has led us to many interesting combinatorial problems. Especially, the considered graph corresponds to the transportation maps in the big cities. The new models of the problem have been proposed and the new class of "communication graphs" has been proposed. Examples and some properties of the graphs have been described in the paper.

This is a new type of combinatorial optimization problem which generalizes classic problems such as TSP, set cover.

We show that decision version of this problem is NP-complete, analyze similarities with the classic combinatorial optimization problems, propose algorithms and study their performance on transportation networks of several big cities of the world as well as on the randomly generated graphs.

The representative examples have been shown and the computational experiments have been performed.

> Keywords: Graph cycles, transportation, algorithm analysis, heuristics

Wednesday
10.55
Room B

Graphical algorithm for Knapsack and Partition problems

Alexander Lazarev and Anton Baranov

We consider Knapsack (KP) and Partition problems. One wishes to fill a knapsack of capacity C with items having the largest possible total utility. If any item can be put at most once into the knapsack, we get the binary (0-1) knapsack problem or k-dimension knapsack problem. This problem can be written as the following integer linear programming problem, with parameters p (price) and w (weight) of items. The variable x characterizes whether item j is put (and how many) into the knapsack or not.

There is dynamic programming algorithm (DPA) for this problem in the case of only positive integer parameters w. In this paper, we give the basic idea of a graphical modification of DPA, which is called Graphical Algorithm (GA). It's well known that DPA has pseudo-polynomial complexity O(C*n). GA looks not the entire range of C, but only suboptimal points – break points of the objective function. This essentially reduces the complexity of the problem.

The basic difference from DPA consists that it's possible to solve problems with non-integer and negative parameters of items of Knapsack and Partition problems. Need to say that Partition instance for three items with weights (3, 2, -1) can't solve by DPA and can solve by GA and complexity equals similar as for instance (30001, 20000, -10001).

Was carried out parallel implementation of DPA and GA using MPI and OpenCL. We tested instances for KP with 100000 items and compared efficiency of those algorithms.

> Keywords: Knapsack, Partition, Graphical, Parallel

Wednesday
11.15
Room B

An application of a polynomial relaxation-type algorithm to systems of inequalities given by a separation oracle

Sergei Chubanov

In combinatorial optimization it is often the case that systems of inequalities with -1,0,1 coefficient matrices have exponentially many constraints and are given implicitly by a polynomial separation oracle which either proves feasibility of a solution or returns a violated constraint if the solution is infeasible. It is well known that there are polynomial linear-programming algorithms, such as the ellipsoid method, which can be used to solve such systems. We show that the polynomial relaxation-type algorithm which we have recently developed is also applicable under these circumstances.

> Keywords: Linear programming,, combinatorial optimization,, separation oracle

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