Joint EURO/ORSC/ECCO Conference 2017

on Combinatorial Optimization

Book of abstracts

Koper, May 3–6, 2017

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Preface

Dear Colleagues and friends,

It is my great honor, on behalf of Operations Research Society of China (ORSC), to welcome all participants to attend Joint EURO/ORSC/ECCO International Conference 2017 on Combinatorial Optimization.

First of all, I would like to express my sincere thanks to the host and local organizer University of Primorska and University of Ljubljana and the team led by Prof. Andrej Brodnik for their hospitality and contributions.

In addition, I would like to express my sincere thanks to the program committee and organization committee co-chaired Prof. Guochan Zhang, Prof. Andrej Brodnik and Prof. Degang Liu for their enthusiasm and great effort put into the second joint EURO/ORSC/ECCO International Conference since 2016. I also would like to thank the four plenary speakers and colleagues submitted their work to the conference for their strong supports.

Above all, I must say special thanks to EURO, particularly, Prof. Silvano Martello and Prof. Gerhard Wäscher. In fact, it was Prof. Gerhard Wäscher, who was the president of EURO, proposed the idea of organizing joint EURO/ORSC during SINO-German Symposium on Operations Research at München in September of 2013. After that we discussed about the organization and preparation of the conference during IFORS at Barcelona in July of 2014 and his visit to Beijing in November of 2014 and 2016, respectively. The first joint EURO/ORSC International Conference on Continuous Optimization was successfully held in Shanghai, China, in May of 2015. It attracted more than 200 participants and about 100 submissions of talks. I believe the second joint EURO/ORSC International Conference will be a

great success with the strong support from ECCO, particularly, Prof. Silvano Martello.

At the last but not the least, as a relative new platform of academic exchange between Chinese and European communities, I'm sure that this conference could promote the study of operations research and its applications in China and European countries and enhance the collaboration between members from both societies.

In the end, I wish all participants benefit from this event and have a very pleasant stay at Koper, and the successful cooperation between ORSC and EURO could be sustained and extended to other areas in operations research in the future.

Xiaodong Hu
President of ORSC

Dear conference participant,

It is with great pleasure that I welcome you to Koper and to the Joint EURO/ORSC/ ECCO Conference on Combinatorial Optimization.

ECCO, the European Chapter in Combinatorial Optimization that I have the honor of chairing, is a working group of EURO created in 1987. This will be its 30th conference. In this special occasion, EURO, the Association of European Operational Research Societies, decided to sponsor a special event: a joint conference with ORSC, the Operations Research Society of China. It is my pleasure and my honor to welcome the Chinese delegates who will join the European combinatorialists in this anniversary meeting, that will provide a stimulating opportunity for a global interchange of ideas on all recent advances in Combinatorial Optimization.

The program is enriched by a distinguished set of four keynote lectures that will be delivered by famous Chinese and European scientists.

I want to take this opportunity for sincere thanks to all who supported us in the preparation of the event. I'm grateful to the members of the Program Committee, who coordinated the streams of sessions, and to the members of the Organizing Committee for priceless dedication and hard working.

I wish you all an exciting and enjoyable meeting in Koper.

Silvano Martello

Dear Conference Participants, dear Colleagues and Friends,

It is my great pleasure, as a former President of EURO – The Association of European Operational Research Societies and as one of the initiators of this conference series, to welcome you to the Joint EURO/ORSC/ECCO International Conference 2017 on Combinatorial Optimization. After the first meeting held in Shanghai in 2015, this is the second time that EURO and ORSC get together for a joint international conference. It is a very special event, also from the point of view that we will be celebrating the 30th meeting of the EURO Working Group ECCO – The European Chapter in Combinatorial Optimization.

I would like to thank the University of Primorska sincerely for hosting the meeting. I trust that this meeting will be a productive and inspiring one and take the opportunity to thank the Program Committee, chaired by Andrej Brodnik and Guochuan Zhang, and the Organizing Committee, led by Andrej Brodnik and Degang Liu, for the immense efforts they have taken. They have worked hard in order to make this meeting a success. As a conference participant, you will find a rich scientific program reflecting the latest developments concerning methods and applications of combinatorial optimization. The social events which have been scheduled will provide opportunities to make new friends and mix with old ones.

My special thanks go to the Secretary and the Representative of the Operations Research Society of China, Xiaodong Hu and Degang Liu. Again, like what had to be said about the previous Shanghai Meeting in 2015 already, without their continuing support and inspiration also this second Joint EURO/ORSC Conference wouldn't have materialized.

I wish all of you a productive conference and a very pleasant stay in Koper. And, of course, I would be glad if we would all meet again at the occasion of another edition of this Joint EURO/ ORSC International Conference series in future.

Gerhard Wäscher

Dear participants of Joint EURO/ORSC/ECCO Conference 2017 on Combinatorial Optimization.

We are pleased to welcome you at the University of Primorska – the Faculty of Mathematics, Natural Sciences and Information Technologies (UP FAMNIT) and the Institute of Andrej Marušič (UP IAM). Although our institutions are young, we are very proud of numerous academic and research achievements of our students, professors, and researchers.

Especially the last year has brought us some fantastic news; (1) the AMC journal we are publishing was placed in the first quarter of scientific journals in its discipline, making it the only Slovene journal to reach such success; (2) our Math department was placed in the top 10 % in Europe (and the world), according to Multirank; (3) UP FAMNIT was trusted to host the second largest scientific gathering of Mathematicians in the world – European Congress of Mathematics in 2020; and (4) finally, the European Commission co-funded our 45 million worth project InnoRenew CoE, which will significantly boost the development of the research in the field of renewable materials and healthy living environment.

Our colleagues at both institutions carry a fundamental and applied research in mathematics, natural sciences and technology – foundation fields for the industry. Simultaneously, close cooperation between the faculty and the institute brings a successful spill of research results into teaching. Both institutions are continuously committing their efforts to achieve excellent results and are persistently moving closer to the top of the scientific world.

Everyone can experience the enthusiasm in young institutions

like ours. It gives us proper mixture of motivation and energy needed to initiate and develop projects in various areas. Being a Faculty and Institute of science, we believe that our goals can be reached only if we open ourselves toward the future and the international community. Therefore, international cooperation and mobility has been one of our basic policies since the very beginning.

The Faculty and the Institute organise and co-organise conferences and other scientific meetings, and encourage the active participation of students at international conferences, summer schools and competitions. We encourage research collaborations with foreign experts, short and long visits from abroad and to prestigious foreign universities, placing young colleagues at the forefront of this effort. Doing this, our professors have already established a dense network of connections with professors and researchers who visit us regularly (more than 50 annually), while a few hundreds also visit our events.

We are particularly proud of the fact that 15 % of our students are from abroad and this year the number of the freshmen in the undergraduate study programme Computer Science has increased to 21 %. This clearly confirms that we are becoming an institution which attracts prospective IT experts from the wider area and therefore is our commitment to provide them a qualitative modern programme. Additionally, in the next academic year, we are expecting even more freshmen from abroad, as starting with October 2017, our undergraduate study programme Computer Science will be offered also in English language.

Researchers at the Department of Information Science and Technology are active in several research areas including data structures, database, data mining, language technology, computer vision, augmented reality, personal information management and human-computer interaction. Since we are aware that innovations can be developed only in cooperation with different sub-

jects, our research team has established numerous contacts with many European and other international institutions. For example, our research partners in the field of programming languages are Waterloo University (Canada), and the University of Luleå (Sweden). CHI – Computer-Human Interaction is an area we explore with the University of Lancaster (UK), while machine translation of natural languages and language technologies is a field we actively study with the University of Prague. Our partners are also the University of Freiburg (Germany) and Rutgers University (USA) – with whom we are working on graph theory and theoretical computer science.

Due to our international evolvement in the research and academic field, we believe that UP FAMNIT and UP IAM are the ideal environment for a vibrant meeting like the Joint EURO/ORSC/ECCO Conference 2017 and we hope that its programme will exceed your expectations. We are convinced you will establish new connections and renew old ones with the participants and that you will continue to cooperate with us and them in the future.

Klavdija Kutnar
Dean, Faculty of Mathematics, Natural Science and Information Technology

Vito Vitrih
Director, Andrej Marušič Institute

Dear Colleagues,

It is our great pleasure and honour to welcome you at the 30th Anniversary conference ECCO XXX, which this year made a big step forward to become a joint EURO/ORSC/ECCO Conference on Combinatorial Optimization. It is hosted by the University of Primorska and its *Andrej Marušič Institute* (UP IAM) and *Faculty of Mathematics, Natural Sciences and Information Technologies* (UP FAMNIT).

The Conference nicely combines scientific work and the exchange of new ideas and gives an excellent opportunity to discuss recent and important issues in the field of Combinatorial Optimization and its applications. The conference program features four invited talks: by Robert Bixby on progress in linear and mixed-integer programming, by Xiaotie Deng on constructive output of existentially proved structure in combinatorics, by Bernard Ries on some graph modification problems, and by Gerhard J. Woeginger on lower bound techniques for algorithmic problems. The 90 contributed papers cover a broad range of topics including structural operations management–logistics, production scheduling location and distribution problem, resource allocation, flexible manufacturing–engineering, VLSI design and computer design, network design,... The contributed talks are organized in parallel sessions in order to allow ample time for discussions among participants. We are glad to see over 100 participants from over 20 countries joining the event and contributing to its creative atmosphere.

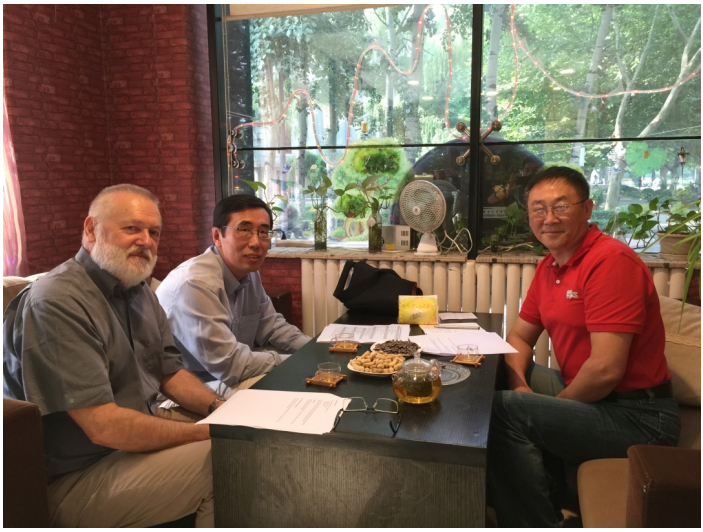
Finally, we would like to thank the members of the Local Organizers Branko, Damir, Daniel, Marko and another Marko, Nevena, and Tilen, and staff at UP IAM and UP FAMNIT that made this event possible to happen by their devoted work and help.

We wish you a pleasant stay and an inspiring conference in Koper!

Koper, April 27, 2017

Andrej Brodnik, co-chair
Rok Požar

Organizing committee:
Andrej Brodnik, co-chair
Degang Liu, co-chair
Guangting Chen
Xin Liu
Rok Požar
Yindong Shen



Gerhard Wäscherm, Degang Liu and Xiaodong Hu discussing organizing a joint conference in Beijing in Autumn 2016.

Technical Program

Wednesday			
17:00 – 20:00	***registration***		
	Armeria hall		
20:00 – 21:00	***welcome reception***		
	Armeria hall		
Thursday			
09:00 – 09:30	***Tramontana***		
	official opening and opening remarks		
09:30 – 10:30	***Tramontana***		
	Gerhard J. Woeginger (EURO Plenary, RWTH Aachen): Lower bound techniques for algorithmic problems		
10:30 – 11:00	*coffee break*		
	Armeria hall		
11:00 – 13:00	***VP***	***MP – 1***	***MP – 2***
	Scheduling-I	***Metaheuristics-I***	***Combinatorial Optimization***
13:00 – 14:30	*lunch break*		
14:30 – 16:30	***VP***	***MP – 1***	***MP – 2***
	Scheduling-II	***Graph Theory-I***	***Approximation Algorithms***
16:30 – 16:50	*coffee break*		
16:50 – 18:50	***VP***	***MP – 1***	***MP – 2***
	Scheduling-III	***Graph Theory-II***	***Bioinformatics***
Friday			
09:00 – 10:00	***Tramontana***		
	Robert Bixby (Gurobi Optimization, Inc.): Progress in Linear and Mixed-Integer Programming		
10:00 – 10:30	*coffee break*		
	Armeria hall		
10:30 – 12:30	***VP***	***MP – 1***	***MP – 2***
	Games, Scheduling and Routing	***Packing Algorithms and SDP***	***Optimization with Applications***
12:50 – 14:30	*lunch*		
14:30 – 15:30	***Tramontana***		
	Xiaotie Deng (Shanghai Jiaotong University): Constructive Output of Existentially Proved Structure in Combinatorics		
16:10 – 22:00	***excursion and conference dinner***		
Saturday			
09:00 – 10:00	***Tramontana***		
	Bernard Ries (University of Fribourg): On some graph modification problems		
10:00 – 10:30	*coffee break*		
	Armeria hall		
10:30 – 12:50	***VP***	***MP – 1***	***MP – 2***
	Scheduling-IV	***Metaheuristics-II, Coloring***	***TSP and IP***
13:00 – 13:30	***Tramontana***		
	official closing and closing remarks		

Invited Talks

Progress in Linear and Mixed-Integer Programming

Robert Bixby, Gurobi Optimization, Inc.

We will look at progress in Linear Programming (LP) and Mixed Integer Programming (MIP) software over the last 25 years. As a result of this progress, modern LP codes are capable of robustly and efficiently solving instances with multiple millions of variables and constraints.

With these LP advances as a foundation, MIP provides the modeling framework and the key solution technology behind prescriptive analytics. The performance improvements in MIP codes have been nothing short of remarkable, well beyond those of LP, and have transformed this technology into an out-of-the box tool with an almost unlimited range of real-world applications.

Dr. Robert Bixby has a BS in Industrial Engineering and Operations Research from the University of California, Berkeley (1968), and a PhD in Operations Research from Cornell University (1972). He has held numerous academic positions in USA and Germany. He is currently Noah Harding Professor Emeritus of Computational and Applied Mathematics at Rice University, and visiting Professor in the Department of Mathematics at Universität Erlangen. He is also the co-founder (2008) and CEO of Gurobi Optimization.

Dr. Bixby has published over fifty journal articles, and is an acknowledged expert on the computational aspects of linear and integer programming. He has won several awards for his work in optimization. In 1997 he was elected to the National Academy of Engineering for his contributions to the theory and practice of optimization. In 2012 he was awarded an honorary doctorate in Mathematics from the University of Waterloo, Canada.

Constructive Output of Existentially Proved Structure in Combinatorics

Xiaotie Deng, Shanghai Jiaotong University

The Sperner's lemma, as a discrete version of the Brouwer's fixed point theorem, has played a key role in our understanding of the computational complexity class PPAD, linking among the class, the 2 player's Nash equilibrium computation, and solutions for various problems possessing existential combinatorial structures. Recent development in the closely related computational complexity class PPA shows a tie of the 2D Mobius band, the simplest non-orientable topological space, in shaping our understanding of the complete problem in PPA.

In this talk, we discuss recent results for different combinatorial problems that guarantee the existence of substructures for which finding a solution is PPA-complete.

Xiaotie Deng got his BSc from Tsinghua University, MSc from Chinese Academy of Sciences, and PhD from Stanford University. He is currently a Zhiyuan Chair Professor of Shanghai Jiaotong University. He taught in the past at University of Liverpool, City Universtiy of Hong Kong, and York University. Before that, he was an NSERC international fellow at Simon Fraser University.

Deng's current research focuses on algorithmic game theory, with applications to Internet Economics. His other works cover online algorithms, parallel algorithms, and combinatorial optimization. He is an ACM fellow for his contribution to the interface of algorithms and game theory.

On some graph modification problems

Bernard Ries, University of Fribourg

A typical graph modification problem aims to modify a graph G, via a small number of operations from a specified set S, into some other graph H that has a certain desired property, which usually describes a certain graph class $\boldsymbol{G}$ to which H must belong. In this way a variety of classical graph-theoretic problems is captured. For instance, if only k vertex deletions are allowed and H must be an independent set or a clique, we obtain the *Independent Set* or *Clique* problem, respectively.

Now, instead of fixing a particular graph class $\boldsymbol{G}$, we *fix a certain graph parameter* π. That is, given a graph G, a set S of one or more graph operations and an integer k, we ask whether G can be transformed into a graph G' by using at most k operations from S, such that $\pi(G') \leq \pi(G) - d$ for some threshold $d \geq 0$. Such problems are called blocker problems, as the set of vertices or edges involved can be seen as "blocking" some desirable graph property (such as being colorable with only a few colors). Identifying the part of the graph responsible for a significant decrease of the parameter under consideration gives crucial information on the graph.

Blocker problems have been given much attention over the last few years. In this talk, I will give an overview of recent results on this topic.

Bernard Ries received his PhD in 2007 from the Swiss Federal Institute of Technology in Lausanne. In 2008-2009 he was a postdoctoral research fellow at Columbia University (US) before he moved to Warwick University (UK) as an assistant professor. From 2010 to 2015, he was an associate professor at the University Paris Dauphine (France) and in August 2015 he was hired as an associate professor at the University of Fribourg (Switzerland). He has been an invited researcher at several universities including Haifa University (Israel), University of Montreal (Canada), Memorial University of Newfoundland (Canada), University of Warsaw (Poland), Durham University (UK), Kadir Has University (Turkey), Gdansk University of Technology (Poland). His research interests are structural and algorithmic graph theory, complexity theory and combinatorial optimisation.

Lower bound techniques for algorithmic problems

Gerhard J. Woeginger, RWTH Aachen

There is only a handful of tools for establishing lower bounds on the time complexity of algorithmic problems. For instance, 3-SUM-hardness (introduced by Gajentaan and Overmars) yields conditional quadratic lower bounds for a variety of problems in computational geometry. The All-Pairs-Shortest-Paths conjecture of Williams and Williams yields conditional cubic lower bounds for many natural problems in graph algorithms. The exponential time hypothesis (ETH) has become very popular in recent years.

The talk surveys some of these tools and provides a number of illustrating examples.

Gerhard Woeginger is a professor at RWTH Aachen, where he chairs the algorithmics and complexity group in the department of computer science. His research interests lie in the intersection area of Operations Research, Theoretical Computer Science, and Discrete Mathematics. Woeginger was program chair of the European Conference on Operational Research (EURO-2009), the International Computer Science Symposium in Russia (CSR-2016), and of several other conferences. He received a Humboldt Research Award in 2011, and he was elected to the Academia Europaea in 2014.

Contributed Talks

2-Distance Coloring of Graphs

Yuehua Bu, Junlei Zhu

A 2-distance k-coloring of a graph G is a proper k-coloring such that any two vertices at distance 2 get different colors. In 1977, Wenger proposed the well-known conjecture on 2-distance coloring of planar graphs.

In this talk, I discuss recent progress on the study of Wenger's conjecture.

Also we study list 2-distance coloring in terms of specific cycles.

This is joint work with Yuehua Bu et al.

A 5/6-approximation algorithm for the TSP-max in an incomplete graph with triangle inequality

Aleksey Glebov

A metric TSP is a well-known variant of the Traveling Salesman Problem where one need to find a Hamiltonian cycle of an extremal weight in a complete weighted graph whose weight function satisfies the triangle inequality. In 1985, Kostochka and Serdyukov proposed an elegant polynomial 5/6-approximation algorithm for the maximization version of metric TSP (abbreviated as metric TSP-max) based on a delicate rearranging the edge set of a maximum-weight cycle cover of a graph. Since then the approximation ratio of that algorithm was improved several times by various authors. The best known result is a polynomial 7/8-approximation algorithm for the metric TSP-max developed by Kowalik and Mucha.

The purpose of this paper is to extend the 5/6-approximation algorithm by Kostochka and Serdyukov to the case of pseudo-metric TSP-max where the input graph is incomplete but its minimum degree is sufficiently large and the triangle inequality holds for every triangle of the graph. Observe that the weight function of such a graph is not necessarily extendible to the metric weight function of a complete graph. So our pseudo-metric setting of TSP-max is more general when the modification of metric TSP-max where some edges of a complete graph are removed (or unavailable). However, our pseudo-metric TSP-max includes such a modification of the metric TSP-max as an important subcase.

As a natural application of our Algorithm, we produce a simple 5/6-approximation algorithm for the maximization version of the metric m-Peripatetic Salesman Problem (metric m-PSP-max). In the metric m-PSP-max one need to find m edge disjoint Hamiltonian cycles of the maximum total weight in a complete weighted graph satisfying the triangle inequality. Recently, a polynomial 5/6-approximation algorithm for the metric m-PSP-max was presented by Glebov and Gordeeva. However, our approach based on the application of the Algorithm for pseudo-metric TSP-max yields a simpler (though basically the same) algorithm for m-PSP-max.

A Branch and Price Algorithm for Shipment Consolidation and Dispatching Problem with Cross-Docks

Ozgur Ozpeynirci, Sinem Tokcaer

Shipment consolidation and dispatching problem is an operational planning problem of long haul freight forwarders in their daily operations planning. Freight forwarders aims at planning the delivery of less-than truckload (LTL) customer orders within specified time-windows by using subcontracted haulers' vehicles. The orders are planned to be delivered either directly or by using a cross-dock. The annual contracts with sub-contracted haulers define the cost of vehicle's route, which is the sum of fixed cost defined by the farthest destination in the vehicle and the extra charge of additional stops. In this sense, the objective of the problem is to minimize the total cost of dispatching plan, including fixed cost of operating the vehicles, cost of additional stops and cross-docking costs. In this study, we firstly propose a mathematical model for the problem, and then reformulate the problem by using Dantzig-Wolfe decomposition. Based on reformulated problem, we propose a branch-and-price algorithm. We tested the solution procedure on randomly generated instances. Preliminary results show that the solution procedure can solve small instances in seconds, and large instances in reasonable computation time.

A branch-and-price algorithm for robust bin packing with variable size items

Alexandre Dolgui, Evgeny Gurevsky, André Rossi, Xavier Schepler

The one-dimensional bin-packing is the well-known combinatorial optimization problem. Items of different size have to be packed into bins of the same capacity, not to be exceeded, so as to minimize the number of bins used.

We consider a robust variant of this problem, which is related to the optimal design of assembly lines with manual tasks. Namely, it is supposed that there exists a subset of items whose nominal size may vary, named hereafter as uncertain. Thus, we seek not only to pack all items into bins minimizing their number as before, but also provided that all absolute size variations of uncertain items, whose sum is less than or equal to a given value, are supported. A compact 0-1 linear programming formulation of this problem is introduced, to which a Dantzig-Wolfe decomposition is applied, providing an extended formulation with a stronger linear relaxation, but an exponential number of columns. The linear relaxation of the extended formulation is solved by a dynamic column generation, and a branch-and-price algorithm is proposed to obtain integer optimal solutions. We will present and discuss results of numerical experiments, conducted on adapted benchmark sets from the literature.

A Constraint Programming Model for an Integrated Assignment and Routing Problem

Damla Kizilay, Deniz Türsel Eliiyi

This study considers a donation center, from which a number of donors and indigent residents are served by a single vehicle for the collection and distribution of several types of donated household items. A priority-based assignment between the donations and indigent residents, as well as the routing of the vehicle with time windows for each donor and indigent resident are considered simultaneously in the problem. The main objective is to maximize the total utility of the assignments while minimizing the total route distance and the penalty cost caused by the violation of time windows. The utility of the assignment between any donated item and indigent resident is determined by considering several criteria, such as the travel time between the donor and the indigent, the income level and the age of the indigent, the number of people inhabiting the indigent's residence, the prior number of donations received by the indigent, and the age and condition of the donated item. The assignments are to be made with respect to these criteria in order to have a fairer matching between the donated items and the indigent residents, while resulting in lower costs for the public service provided by the donation center. According to the levels of each criteria, a composite score is computed for any donation-indigent matching. Priorities between the criteria are also determined through a pairwise comparison scheme. Each donor and indigent resident have specific available time windows, which can be relaxed with penalties for lateness or earliness. The

planning period is one working day, where a single capacitated vehicle is used for pickup and delivery operations. We formulate the problem as a constraint programming (CP) model. Through the implementation of CP, which uses constraints to infer new constraints, the domains of the decision variables is tried to be reduced by eliminating violations of the inferred constraints. Although there has been considerable previous effort in routing problems with time windows in literature, the existing studies do not integrate assignment with routing. In our study, we propose an aggregate plan for donation centers or similar organizations that need to determine assignment and routing with time windows concurrently.

A GRASP with restarts heuristic for the Steiner traveling salesman problem

Ruben Interian, Celso Ribeiro

The Steiner traveling salesman problem (STSP) is a variant of the TSP that assumes that only a given subset of nodes must be visited by a shortest route, eventually visiting some nodes and edges more than once. We extend some constructive heuristics and neighborhood structures to the STSP. We propose a reduced 2-opt neighborhood and we show that it leads to better results in smaller computation times. Numerical results with an implementation of a GRASP heuristic using path-relinking and restarts are reported. A set of test instances and best known solutions is made available.

A Local Search Approximation Algorithm for a Sum of Squares k-Facility Location Problem

Dachuan Xu

In this talk, we introduce a sum of squares k-facility location problem (SOS-k-FLP) which is a common generalization of the classic k-means problem and the sum of squares facility location problem. In the SOS-k-FLP, we are given a client set X in d-dimensional Euclidean space, a uniform nonnegative center opening cost f, and an integer k. The goal is to open a center subset F (in d-dimensional Euclidean space) whose cardinality is less than k and to connect each client to the nearest open center such that the total cost (including center opening cost and the sum of squares of distances) is minimized. Using local search and scaling techniques, we offer a constant approximation algorithm for the SOS-k-FLP. Numerical tests indicate that a combination heuristic of our algorithm with iterated Lloyd's algorithm is

efficient and effective in practice.

(Joint work with Dongmei Zhang, Peng Zhang, and Zhenning Zhang)

A min-max risk version of some combinatorial optimization problems with controllable data

Evgeny Gurevsky, Sergey Kovalev, Mikhail Y. Kovalyov

The principal object of this study is a recently introduced bottleneck combinatorial problem of risk management, which was investigated within the framework of routing and network design and proven to be polynomially solvable. Our main contribution deals with improving this result. Namely, at first we suggest two original resolution approaches that are faster, in terms of running time, than the algorithms developed earlier. Secondly, we explore not only the maximal risk minimization problem, but also a maximal risk constrained one for which a fast polynomial time algorithm is proposed as well. Finally, based on the suggested approaches, we show how to find a tight approximation for the set of non-dominated points in the criterion space of a bi-criteria version of the considered problems.

A New Lower Bound for the Positive Semidefinite Zero Forcing

Boting Yang

The positive semidefinite zero forcing number is a variant of the zero forcing number, which is an important parameter in the study of minimum rank/maximum nullity problems. In this paper, we first introduce the propagation decomposition of graphs; then we use this decomposition to prove a lower bound for the positive semidefinite zero forcing number of a graph. We apply this lower bound to find the positive semidefinite zero forcing number of matching-chain graphs. We prove that the positive semidefinite zero forcing number of a matching-chain graph is equal to its zero forcing number. As a consequence, we prove the conjecture about the positive semidefinite zero forcing number of the Cartesian product of two paths, and partially prove the conjecture about the positive semidefinite zero forcing number of the Cartesian product of a cycle and a path. We also show that the positive semidefinite zero forcing number and the zero forcing number agree for claw-free graphs. We prove that it is NP-complete to find the positive semidefinite zero forcing number of line graphs.

A performance comparison of heuristic and metaheuristic algorithms for the Critical Node Problem

Roberto Aringhieri, Andrea Grosso, Pierre Hosteins, Rosario Scatamacchia

We consider the Critical Node Problem (CNP) where K>0 critical nodes are removed in an undirected graph so as to minimize the number of node pairs still connected by at least one path. The problem belongs to the family of so-called interdiction problems and has many real-life applications in different fields. The CNP has received significant attention in the recent literature together with other graph fragmentation problems. Apart from some exact approaches to solve graphs of limited size, the most effective solution approaches are heuristic and metaheuristic algorithms. Such algorithms include simple or hybrid greedies, local search based algorithms such as iterated local search and variable neighborhood search, simulated annealing, hybrid genetic approaches and a GRASP with path relinking. Another original approach is based on repeated phases of random nodes deletion inside the connected components of the graph.

In order to better understand strengths and drawbacks of each algorithm, we present a computational study on their performance. The analysis takes into account running times, number of iterations (when possible), the robustness of the solutions and the effectiveness of intensification and diversification strategies.

The analysis has been carried out over a wide set of benchmark instances available online on http://di.unito.it/cnp.

Finally, to provide a broader picture, we also discuss the performance of a new neighborhood search algorithm based on a sequence of different add and drop operators to change the solution instead of using a full neighborhood search; further, a simple deterministic restart procedure provides a diversification of the search in the solution space.

A polynomial 3/5-approximation algorithm for the asymmetric maximization version of 3-PSP

Surena Toktokhoeva

The m-Peripatetic Salesman Problem (m-PSP) (introduced by Krarup in 1975) is a natural generalization of the Traveling Salesman Problem (TSP). In m-PSP one need to find m edge disjoint Hamiltonian cycles of minimum or

maximum total weight in a complete weighted graph. In this paper we investigate the asymmetric maximization version of the m-Peripatetic Salesman Problem (m-APSP-max). The input of the problem is a complete directed graph G and a non-negative weight function of its edges. The task is to find m edge disjoint Hamiltonian circuits of maximum total weight in G. It is known that problems of finding one or more Hamiltonian circuits in a digraph are NP-hard. So the efforts of most researchers are concentrated on finding cases where the problem can be solved in polynomial time and developing polynomial algorithms with guaranteed approximation ratios for such problems. The best known approximation algorithm for the ATSP-max developed by Kaplan, Lewenstein, Shafrirand and Sviridenko (2005) has the guaranteed ratio 2/3. In 2015, Gimadi., Glebov, Skretneva, Tsidulko and Zambalaeva presented an algorithm with approximation ratio 2/3 for the 2-APSP-max and an algorithm on random instances for the m-APSP for which the conditions of its asymptotical exactness were established. However, for m>2, no deterministic approximation algorithms for the m-APSP-max are constructed. The main result of this paper is a deterministic Algorithm for the 3-APSP-max with approximation ratio 3/5 and cubic running time. Similarly to the 2/3-approximation algorithm for the 2-ATSP-max, our Algorithm is based on an acyclic edge colouring of a specified regular subgraph in a given complete digraph. Such a colouring allows to construct three partial tours with sufficiently large weight and to extend them to three edge-disjoint Hamiltonian circuits which form a desired 3/5-approximate solution of the 3-APSP-max.

* The research is supported by RFBR (projects 15-01-00976 and 16-01-00108).

A robust planning for shuttle scheduling in the airport

Aykan Akincilar, Ertan Güner

The ascending number of air passengers can cause significant undesired – even maybe very hard to solve– problems, which likely means high costs in terms of both airlines and airports. In this study, from the point of airports' view, a robust plan is attempted to transport air passengers from the airport to the city centre. An integer program (IP) is developed for scheduling airport shuttles in an environment under uncertainty. Demand, which is the number of arrival air passengers at the airport, is the uncertain parameter in the developed MIP. After robust counterpart (RC) of this IP is developed, its tractable version is achieved by several mathematical operations. This RC is capable of producing conservative –in other words,

fully robust– solutions regardless whatever uncertain parameter takes value as long as it stays in prespecified bounds. Thus, it is expected to avoid possibly great costs since the system becomes insensitive to the fluctuations in demand. This feature can be defined as the main contribution of this study. This talk is planned to be concluded with the discussion of results of the case study and some suggestions on future works.

A Tabu Search Approach for The Job-Shop Scheduling with Availability Constraints

Stéphane Dauzere-Peres, Jacques Pinaton, Karim Tamssaouet, Claude Yugma

The vast majority of research in scheduling assumes that resources are continuously available for processing throughout the scheduling horizon. Nevertheless, this assumption may not be true in the industrial context, since a resource may become unavailable for different reasons. The machine availability constraints encountered in production systems can either be fixed or non-fixed. In the fixed type, the starting dates and the durations of the unavailability periods are known in advance while they are flexible in the second type and must be scheduled with the production jobs. Unavailability periods can also be classified depending on whether they allow or not the preemption of the operations: resumable, semi-resumable, non-resumable or non-preemptive case. We investigate in this work the makespan minimization in a job-shop environment where the machines are not available during the whole planning horizon. The starting and finishing times of these unavailability periods are known in advance and fixed.

After developing the solution approach for the non-preemptive case, it is extended to the resumable case. Being among the most effective approaches for solving the job shop scheduling problem, Tabu search (TS) procedure is adopted and adapted to solve the considered problem. The disjunctive graph model, a fundamental problem representation form for the standard JSP, is used to represent feasible schedules without explicitly integrating the unavailability periods. These periods are taken into account during the longest paths computation. To make the local search efficient, a move evaluation based on a lower-bound estimation is used with the swap- based neighborhood. This lower bound, used during the intensification phase of the modified meta-heuristic, reduces the neighborhood size by eliminating moves that will not improve the solution. The computational experiments that were carried out on instances of literature show the efficiency of the proposed solution approach as it improves the majority of the results.

Adaptive Large Neighborhood and Variable Neighborhood Search for Parallel Machine Capacitated Lot Sizing and Scheduling

Uğur Eliiyi, Sel Ozcan, Deniz Türsel Eliiyi

The capacitated Lot Sizing and Scheduling Problem provides a mathematical visualization for large bucket lot sizing problems, where a predetermined number of periods and constant demand are incurred. Lot sizing problems are one of the most challenging production planning problems and have been studied for many years. In this study, the capacitated lot sizing and scheduling problem on parallel machines with eligibility constraints, sequence-dependent setup times and setup-carryover decisions is considered. The aim is to find a production plan for each product minimizing setup and inventory costs, as well as finding the optimal lot sizes for each period to satisfy demand. As the proposed problem is NP-hard, we employ the Adaptive Large Neighborhood Search, as well as two variants of Variable Neighborhood Search by adapting different neighborhood structures. To evaluate the effectiveness and efficiency of the proposed solution approaches, a computational study is conducted using benchmark problem instances from the literature. The results are compared with the incumbent solutions of the test problem instances.

Algorithms for the identification of the components of the secondary metabolites

Karolina Baumgart, Marcin Borowski, Piotr Formanowicz

When analyzing the metabolome of an organism, mass spectrometry in combination with liquid or gas chromatography is the most widely used high-throughput technique. Since the manual interpretation of mass spectra is tedious and time-consuming, methods for an automated analysis are required. For metabolite identification, most established methods rely on a database of reference mass spectra. But de novo identification of metabolites is highly sought: today, metabolite databases contain primary metabolites directly relevant for growth, development and reproduction of a cell or an organism. In contrast, most of the metabolites not directly involved in the aforementioned functions remain unknown. These secondary metabolites are especially abundant in plant signal transduction, but the number of genes coding for enzymes of the secondary metabolism suggests that most metabolites are still unknown.

Developing de novo techniques for metabolite mass spectra is more diffi-

cult than in case of protein spectra, because metabolites show more diverse structures: they neither possess a linear structure such as proteins, nor a tree-like structure such as glycans.

Our work focused on developing algorithms for identifications of chemical compounds of metabolites. We designed, implemented and tested a few approaches to solve this problem. Based on data from the mass spectrometer we determine the chemical composition of the tested compound. The methods, for the given mass of the particle (mass to charge ratio of the fragmentation ion is converted to molecular weight), a particular set of elements (and their respective masses and valency) are trying to find the molecular formula of this particle.

For comparison have been used 3 approaches: SCIP which is currently one of the fastest non-commercial solvers for mixed integer programming (MIP) and mixed integer nonlinear programming (MINLP) and developed by us backtracking and tabu algorithm.

Performed computational experiment (by using these three approaches) take into account the size/mass of the test particles, its composition (a set of elements) as well as the accuracy of the results obtained.

An Approximate Ore-type Result for Tight Hamilton Cycles in Uniform Hypergraphs

Guiying YAN

A Hamilton l-cycle in a k-uniform hypergraph of n-vertex is an ordering of all vertices, combined with an ordered subset C of edges, such that any two consecutive edges share exactly l vertices and each edge in C contains k consecutive vertices.

A classic result of O. Ore in 1960 is that if the degree sum of any two independent vertices in an n-vertex graph is at least n, then the graph contains a Hamiltonian cycle.In this talk, we generalize it to uniform hypergraph situation.

An ILP-based proof that 1-tough 4-regular graphs of at most 17 nodes are Hamiltonian

Giuseppe Lancia, Eleonora Pippia, Franca Rinaldi

Given a mathematical conjecture, one intriguing way to settle it would be to formulate the search of a counterexample as an ILP, to be solved by standard branch-and-bound techniques. The counterexample could optimize some ad-hoc function, or the ILP could be simply a feasibility problem. Clearly, we are well aware that it would be impossible to apply this line of approach to any generic conjecture, but there are some conjectures in fields such as combinatorics or graph teory for which this strategy could be worth trying.

In particular, in this work, we have used the above approach to attack and solve a relatively minor but still challenging conjecture by Bauer, Broesma and Veldman (1990) stating that: Every 4-regular, 1-tough graph with at most 17 nodes is Hamiltonian. Prior to our work it was known that the statement held for graphs of at most 15 nodes, and also that it is false for 18 nodes. The study of t-tough graphs was started by Chvatal in the 70's, who hypotesized that every 2-tough graph is Hamiltonian (which was later proved to be false).

We have modeled the set of counterexamples to Bauer et al.'s conjecture as a polytope in $[0,1]^n$ with variables x(i,j) associated to the edges of a complete graph of n=16 and 17 nodes. We easily modeled the 4-regular degree constraints. The non-existence of a Hamiltonian cycle is guaranteed by a set of exponentially many inequalities, stating that for each Hamiltonian cycle C, at most n-1 edges can be in the graph. These constraints are separated via a reduction to the TSP problem. It was more difficult to model the 1-tough condition. In order to achieve this result, we performed a preliminary auxiliary analysis, still by means of a suitable simple ILP model, which told us that there are only a small number of (non-isomorphic) 4-regular, 2-connected but non-1-tough graphs (namely one for n=16 and four for n=17). We then subdivided the problem into the cases sharing some particular features of the non-1-tough possibilities and the cases where simple inequalities exclude the occurrence of these features. For the former, we modeled and solved as an ILP the exact separation of the 1-tough constraints, while for the latter the 1-tough property is enforced by the 2-connection condition.

It was immediately clear that due to the high symmetry in the model, its solution could have never been reached without the use of some symmetry-breaking techniques. We have then employed the Orbital Branching approach by Ostrowski et al. (2011) which has proved key in the resolution of the conjecture in a reasonable time. Eventually, after a three-days computation on a standard PC we have been able to prove that the conjecture is true.

An Interactive Method for Inverse Multiple Criteria Sorting Problem

Ozgur Ozpeynirci, Burcu Özmen, Selin Özpeynirci

Multiple criteria sorting problem (MCSP) is to assign the objects that are evaluated on multiple criteria to one of predefined and ordered classes. Different real life examples like assigning star-ratings to hotels, credit risk assessment of countries or individuals, letter grading of students at the end of academic semesters can be given to MCSP. Multiple criteria sorting problem has been widely studied in multiple criteria decision making literature and several solution approaches have been developed by researchers.

In this study, we consider inverse multiple criteria sorting problem (IMCSP) where the assignment of objects to categories is known in advance. By taking a set of predefined actions, we can change the scores and evaluations of objects. The effects of these actions on the performances of the objects and the costs of the actions are known. We also assume that the sorting methodology used to classify the objects and the parameters are given.

Two types of problems were studied in IMCSP literature before: finding the least costly set of actions that guarantees the assignment of all objects to desired classes and improving the assignment of objects under a limited budget. In this study, we consider the tradeoff between these two decisions. We develop an algorithm that interacts with the decision maker to find the most preferred cost-assignment pair. We assume that MR-Sort method is used to assign the objects to classes. We carry out computational experiments with different problem sizes and compare the solutions of interactive algorithm with the underlying preference structure of the decision maker.

Analysis of a First Fit Decreasing Based Algorithm for the Coupled Task Problem with UET Jobs

József Békési, Gábor Galambos

In this presentation we consider the so called Coupled Task Scheduling problem.

The defition of the problem is the following: we are given n jobs and each job consists of two distinct sub-tasks. The sequence of the sub-tasks

is fixed and there is a fixed length delay-time between the two parts. A job can be represented by a triple, where the values represent the processing

time of the first sub-task, the delay time between the two sub-tasks and the processing time of the second sub-task, respectively.

During the delay time it is possible to schedule other sub-tasks in this interval. The aim is to schedule the given n coupled-tasks on one machine in such a way that no two job tasks can overlap. We want to minimize the latest finishing time of the jobs. Preemption, i.e., interrupting a task and resuming it later is not allowed.

More variants of this problem were investigated in the literature. Ageev and Baburin gave an approximation algorithm for the unit execution time version. In this specific case both sub-tasks have execution time 1 for each job. The worst case bound of this approximation algorithm is 7/4 and it is tight.

In this talk we define a new algorithm which is based on the First Fit Decreasing rule and we prove that its worst-case bound is between 30/19 and 7/4.

Approximate the scheduling of quay cranes with non-crossing constraints

Guangting Chen, Xufeng Chen, Yong Chen, An Zhang, Wenshuai Zhang

In port container terminals, the scheduling of quay cranes (QCs) for a container vessel is one of the most critical operations. This paper investigates the problem of scheduling quay cranes with non-crossing constraints, wherein QCs cannot cross over each other because they are on the same track. The objective is to minimise the makespan of a container vessel, which is the latest completion time among all handling tasks of the vessel. Compared with several 2-approximation algorithms in the literature, this paper presents an approximation algorithm with a worst case ratio less than 2 for any m QCs. This ratio is demonstrated to be the best possible among all partition-based algorithms in the literature. Besides, we study the scheduling of two quay cranes with different processing speeds. For an arbitrary speed ratio s larger than 1, an approximation algorithm with worst case ratio is provided.

Approximation Algorithm for Minimum Partial Set Multi-Cover Problem

Zhao Zhang

Set Cover (SC) is a classical combinatorial optimization problem which is important in both the fields of computational complexity and approximation algorithm. Partial Set Cover (PSC) and Set Multi-Cover (SMC) are two extensively studied generalizations of SC which have wide applications in the real world. The study of the combination of PSC and SMC, namely the minimum Partial Set Multi-Cover problem (PSMC), is motivated by viral marketing in a social network. Previous studies show that both PSC and SMC admit approximations which match the best known performance ratios for SC. However, the combination of PSC and SMC seems to be much more difficult. In this talk, I shall introduce our recent progress on PSMC.

Approximation algorithms and Parameterized algotihms of the vertex cover Pt problem

Jianhua Tu

Given a graph G=(V,E), the task in the vertex cover Pt (VCPt) problem

is to find a minimum subset of vertices $F \subseteq V$ such that every path of order t in G contains at least one vertex from F. The VCPt problem remains

NP-hard even in planar graphs and has many applications in real world. The VCPt problem can be seen as a natural generalization of the vertex cover problem. In this talk, I will present the results of approximation algorithms and parameterized algorithms of the vertex cover Pk problem.

Approximation and Hardness Results for the Max k-Uncut Problem

Dachuan Xu, Peng Zhang

In this paper, we propose the Max k-Uncut problem. Given an undirected graph with nonnegative weights defined on edges, and a positive integer k, the Max k-Uncut problem asks to find a partition of the vertex set of the input graph such that the total weight of edges that are not cut is maximized. We get this problem from the study of complex networks. For Max k-Uncut, we present three approximation algorithms with good ratios and hardness results. More importantly, we prove that Max k-Uncut and Densest k-Subgraph are in fact equivalent in approximability up to a constant factor.

Augmented Lagrangian Approaches for Semidefinite Programming via Dual Factorization

Marianna De Santis, Franz Rendl, Angelika Wiegele

Using semidefinite programming has become a promising method for solving or approximating various combinatorial optimization problems. However, solving semidefinite programs is challenging due to either the large size of the matrices involved or a huge number of constraints. The most prominent methods, interior point methods, run out of memory for many practical applications.

Other algorithms for solving semidefinite problems are based on augmented Lagrangian methods using various ways of dealing with the semidefiniteness constraint. We developed such an augmented Lagrangian algorithm where we replace the semidefiniteness constraint of the dual problem by a factorization $Z = VV^t$. Using this factorization, we end up with an unconstrained (non-convex) problem in V. We then perform updates of this matrix V towards the optimal solution of Z following an alternating direction method or in the fashion of the boundary point method. We will present preliminary results for computing the theta number of a graph.

Baggage Reclaim Assignment and Scheduling Problem

Chris Potts

As a flight approaches an airport, decisions have to made as to which baggage reclaim is to be used for that flight and the time at which the baggage is to be loaded onto the baggage conveyor. Ideally, decisions should avoid congestion in the baggage hall, account for airline preferences, and create schedules that allow luggage to be unloaded speedily.

For the static/offline problem, an integer program is presented. Included in the model are constraints that take into account the rate at which passengers pass through immigration control and arrive into the baggage hall, and the rate at which bags are loaded onto the baggage conveyor. A heuristic approach is also presented since initial tests with the integer program produce long computation times for some instances. The heuristic has two main steps. The first step creates a list of flights, which determines the order in which these flights are assigned to reclaims in the second step. The second step uses the objective function to evaluate each feasible assignment of a flight to reclaims, and then selects the best assignment.

For dynamic/offline problem, the widely-used rolling horizon approach is adopted. The essence of this method is to solve the problem for a small time horizon and then update the solution when new information becomes available, where the frequency of updates is determined by experimentation.

For the static/offline problem, the integer program and the heuristics were tested on real arrivals data from London Heathrow comprising 10 one-hour and 10 two-hour periods randomly selected from both March 2015 (a non-peak period) and July 2015 (a peak period). Average improvements in the objective function value were over 30% for the integer program and over 20% for the best of the heuristics. For the dynamic/online problem, a rolling horizon approach is proposed with a two-hour time horizon and updates produced by the best of the heuristics every 15 minutes. It is evaluated within a stochastic simulation model that exhibits similar characteristics to the real operating environment.

The project's sponsor at Heathrow Airport stated that the findings of the project "has helped us to make decisions on how we operate our baggage service, to keep improving passenger experience and baggage handling efficiency".

Balancing Efficiency and Equality in Vehicle Licenses Allocation

Changjun Wang

Due to traffic and air quality concerns in urban cities, vehicle ownership control is considered as a direct and effective method to reduce the increasing demand for private vehicles. Recently many big cities began to adopt the vehicle licenses quantitative control policies. In these cities, a limited number of licenses are allocated every month. The current allocation policies differ from city to city. Several mechanisms have been developed and implemented such as the Vickrey auction, the lottery, the lottery with reserved price, the simultaneous auction and lottery, and the sequential auction and lottery mechanism. In this work, we propose to target the dual objectives of efficiency and equality and present a unified framework that either includes or outperforms all the existing mechanisms. Besides, the unified framework also leads to easy implementation due to its truthfulness and simple structure. Under this framework, we develop the first truthful, equality-guaranteed, efficient mechanism and prove that the optimal mechanism is distribution-free under some mild condition. None of the previously proposed mechanisms possessed all these properties simultaneously. Thus, our work provides an effective tool for social planner to design truthful mecha-

nisms to maximize social efficiency under any equality level. We also discuss possible applications of our result to resource allocation in other settings.

Coloring Using Hypergraph Reformulation

Sandor Szabo, Bogdan Zavalnij

There is a known way to reduce various graph coloring problems to clique search problem in an suitably defined finite simple auxiliary graph. Examples of these reformulations includes ordinary legal coloring of the nodes, and more exotic types of coloring such as b-fold coloring, triangle free coloring and edge coloring. Some of these reformulations producing exceedingly large auxiliary graphs. To overcome this difficulty and to enhance the reformulation methods we will propose to use r-regular hypergraphs instead of ordinary graphs. As before we are looking for hypercliques in these auxiliary r-regular hypergraphs.

Our main interest lies in practical computation, and from that reason to handle these problems in a particular setting we will construct algorithms analogous to the most commonly used clique search algorithms. These will include exact algorithms as well as heuristic algorithms to locate possibly large non-trivial hypercliques. We will test and illustrate our proposal with connection of numerical cases. We will prepare several reformulations and execute numerical measurements using them.

Combinatorial approach for the multi-mode resource-constrained project scheduling problem

Mate Hegyhati, Olivér Ősz

Resource-constrained project scheduling is a well-known class of scheduling problems. It is concerned with the allocation of scarce resources to interconnected activities, and determining the starting times for these activities. The activities can require different quantities from one or more resources. Moreover, in the case of multi-mode problems, the activities can have multiple execution modes with different resource requirements and execution times. The aim is minimizing the total completion time.

The S-graph framework is a combinatorial approach, originally developed for scheduling chemical batch processes, which is a machine scheduling problem with special material handling constraints. Project scheduling is a generalization of the machine scheduling problem where each activity requires

exactly one unit of one resource. Since its introduction, the S-graph framework was extended multiple times to solve various types of scheduling problems. Recently, a new branch-and-bound method was developed for solving the single-mode resource-constrained project scheduling problem.

In this work, we propose a further extension of the S-graph framework to solve the multi-mode problem class. The method relies on minimal resource incompatible sets, i.e. the sets of activities whose parallel execution would violate the resource constraints. The method was empirically tested on instances of the PSPLIB problem sets, and its performance was compared to recent literature approaches.

The research was supported by the ÚNKP-16-4 New National Excellence Program of the Ministry of Human Capacities.

Combinatorial Optimization Problems with Interaction Costs

Ante Custic, Stefan Lendl, Abraham Punnen

We introduce combinatorial optimization problems with interaction costs (COPIC), which generalize many optimization problems studied in the literature. Given two sets of feasible 0-1-vectors F1 and F2, a cost matrix Q and two cost vectors c and d, we want to minimize x'Qy + c'x + d'y subject to x in F1, y in F2. The unconstrained 0-1 version of this problem is already known to be NP-hard. Several hard combinatorial optimization problems are special cases of COPIC, including the Bilinear Assignment Problem, the Bipartite Quadratic Assignment Problem, the Quadratic Set Covering Problem and the Quadratic Travelling Salesman Problem.

We show polynomial time solvability of COPIC, if the rank of the cost matrix Q is fixed, F1 is a set of unconstrained 0-1 vectors and the linear cost optimization problem with F2 as its set of feasible solutions is solvable in polynomial time.

The case where Q is a diagonal matrix (diagonal-COPIC) already contains many well-known problems as special cases (disjoint spanning tree problem, disjoint path problems, ...). For diagonal-COPIC we obtain results about the computational complexity and polynomial time solvable special cases for different choices of feasible sets F1 and F2.

Community detection in bipartite networks using statistically validated projections

András London

The community structure of a graph is a classification of its points. The task is to find such classification that gives meaningful information of the structure of the graph due to some natural requirements. A possibility for the classification, which often works well on graph models of real complex systems, is maximizing the so-called Newman-modularity function leads to a combinatorial optimization problem. Many complex systems are naturally organized in bipartite networks usually characterized by high heterogeneity, e.g. show heterogeneous degree distribution. Finding communities in bipartite graphs is usually performed by using one-mode projections. Although useful information can be extracted from these networks via the community structure, these projections are not always stable and robust against errors in the data or other sources of noise. A solution can be using statistically validated networks, which reduce the size of the original system by considering only the links which are statistically significant. In this way, cores of the real communities of the system are obtained with a high level of precision. We present the key concepts and steps of the methodology and show possible applications on various real data sets including the actor-movie network, co-authorship network and word co-occurrence networks.

This research was partially supported by National Research, Development and Innovation Office – NKFIH Fund No. SNN-117879

Designing credit supervision mechanism in C2B2C e-commerce

fengmei yang

Due to the information asymmetry between merchants and consumers in e-commerce markets, credit default has become an increasingly serious problem. As the major media in e-commerce, transaction platforms should take an important role in the credit supervision mechanism. A new C2B2C e-commerce can be extended from the typical C2C e-commerce by incorporating the transaction platform as a third party of credit supervision mechanism, in which security deposit policy, supervision policy and punishment policy are elaborately designed. Based on the evolutionary game model and the bivalent trading game model, the long-term trading strategies of merchants and consumers in the C2B2C e-commerce are investigated. The results indicate that enhancing security deposit, supervision strength and disguising cost will effectively avoid credit default in e-commerce.

Discrete electromagnetism-like algorithm for flexible job shop scheduling

Alkin Yurtkuran

This study addresses flexible job shop scheduling problem and a novel discrete electromagnetism-like algorithm is proposed to solve this problem effectively. The electromagnetism-like algorithm (EMA) is a physics inspired meta-heuristic algorithm, which simulates the attraction-repulsion mechanisms between charged particles in a magnetic field. In presented study, a new candidate selection procedure, force calculation step and diversion strategy is integrated to the traditional EMA to improve the exploration-exploitation behavior of the algorithm. Experimental results on benchmarks and comparisons of other well-known meta-heuristic algorithms reveal the effectiveness and efficiency of the proposed algorithm.

Energy aware scheduling of data transmission tasks

Marek Mika

The infrastructure of many currently available high performance computer environments, such as grids, clouds or virtual data centres consists of various elements that are interconnected via computer networks. Many users, computational resources, data storage equipment and large number of other devices are connected by links of such networks. The demands for services offered by such environments grows every day resulting in an increasing energy consumption. In many papers concerning the energy aware scheduling problems in distributed computer environments, which were published during the recent years only the computational tasks and resources are taken into account. But according to the literature the network contribution to the overall power consumption of ICT is from 20% to 30%. Thus, it is also very important to minimize the amount of energy consumed by network resources during the execution of data transmission tasks. In many cases the network and the computer resources belong to different owners, who have different policies for using their resources. In present-day one of the most important challenges from the point of view of the owners/operators of computing and networking resources is to minimize the energy consumed by this equipment. Some new technologies which became available in recent years provide new opportunities to the developers and operators of the networks used in distributed computer environments. Now it is possible to allocate resources and schedule network tasks taking into account various criteria including the energy aware one.

We try to model the problem of allocating network resources to data transmission tasks, and scheduling these tasks in order to minimize the total energy consumed by them. We consider different types of applications, but we mainly focus on very time consuming and data intensive type of applications known as workflows. Taking into account some recently published results which show that in many cases the best results in minimization of energy consumption associated with the execution of a set of computational and networking tasks can be obtained by turning off devices which currently are not engaged in the execution of any task we approach the problem from the viewpoint of the single owner of all network resources interconnecting the computer resources of the considered infrastructure. We assume that the owner of network resources cooperates with the owners of computer resources who provide him information about the size of the data files, the source and the destination nodes of the network between which this data files should be transmitted, as well as time windows in which a given data transmission task have to be completely executed. We defined a set of assumptions about hardware and software aspects and propose a mixed integer programing model of the problem. This model has been used to optimally solve some instances of the problem using one of the available optimization software packages.

Exact and Heuristic Approaches for the Checkpoint Ordering Problem

Philipp Hungerländer, Kerstin Maier

We consider the following row layout problem that has been recently suggested by [P. Hungerländer: The Checkpoint Ordering Problem. Optimization, to appear, 2017.]. The Checkpoint Ordering Problem (COP) asks for an optimal arrangement of departments with given lengths and weights such that the total weighted sum of their distances to a given checkpoint is minimized.

The COP is both of theoretical and practical interest. It is conceptually related to some well-studied combinatorial optimization problems, like the Single-Row Facility Layout Problem or the Linear Ordering Problem. Practical applications are for example the arrangement of rooms such that the weighted sum of their distances with the office of the head is minimized or the assignment of planes to gates such that the weighted sum of their distances from the entrance of the airport is minimized.

We extend both the dynamic programming algorithm and the integer linear

programming approach for the COP such that they now can handle an arbitrary but fixed number of checkpoints. Additionally we suggest a heuristic for the COP that is based on our dynamic program.

Finally we create a large benchmark set based on well-known benchmark instances from the facility layout literature and demonstrate the efficiency of our exact methods and our heuristic on these instances in a computational study.

Facility Location Games: From Origin to Recent Development

Minming Li

The facility location game is one of the mostly studied problem in mechanism design without money. Procaccia and tennenholtz proposed and studied the problem, where there are n agents on a line and the government will build a facility in a certain location given the agents reported information on their positions. Researchers are interested in designing strategyproof mechanism where agents cannot gain by misreporting his information. In this talk, we will briefly explain the story of the classic model and emphasize on the recent development on new models proposed by us and other groups.

From PositivestellenSatz to relaxations of combinatorial optimization problems

Janez Povh

Combinatorial optimization problems are usually very hard (often at least NP-hard), hence every approach enabling optimal or at least good solutions for non-trivial instances is appreciated. We can often encode them as linear optimization problems over the semialgebraic set. This enables a large variety of approximation tools from real algebraic geometry, which typically consist of hierarchies of tractable optimization problems, implied by some variant of PositivestellenSatz.

In this talk, we will present the approximation hierarchies, which are implied by the well-known Pólya PositivestellenSatz and the Positivestellen-Sätze by Dickinson and Povh, Putinar and Vasilescu and by Reznick. These hierarchies reduce to linear or positive semidefinite programming problems with fast increasing complexity. We will explain their real contributions to few well-known combinatorial optimization problems, including graph partitioning and assignment problems and evaluate the first few members of

the hierarchies on a decent benchmarking test sets

Geometric and ILP-based heuristics for the quadratic travelling salesman problem

Peter Greistorfer, Klaus Ladner, Ulrich Pferschy, Rostislav Staněk

The well-known travelling salesman problem (TSP) asks for a shortest tour through all vertices of a graph with respect to the costs of the edges. The quadratic travelling salesman problem (QTSP) associates a cost value with every two edges traversed in succession. We consider a symmetric special case that arises in robotics, in which the quadratic costs correspond to the turning angles or—more generally—to a linear combination of the turning angles and Euclidean distances. We introduce two heuristic approaches, exploiting the geometric properties of a "good" tour and the impressive performance of current ILP-solvers.

If the quadratic costs correspond to the turning angles, optimal tours usually have the form of large "circles" or "spiral" shapes. In each step of the first algorithm, a convex hull is built and its corresponding vertices are removed from the graph. This step is iteratively repeated until a pre-specified small number of vertices remains untouched in the centre. After computing an optimal tour on these central vertices, we obtain a set of nested subtours, which are subsequently patched into one single tour.

This idea is improved by introducing the so-called lens neighbourhood. Generally, we position lenses, i.e. quasi-elliptic areas, between the two end-vertices of an edge in such a way that their two positive curvatures intersect at these vertices. The motivation for this new idea comes from the fact that the inclusion of any vertex inside such a lens causes an additional turning angle that is upper-bounded by the gradient of the curvatures' tangents at the edges' end-vertices. Thus we iteratively enlarge each convex hull built by considering the lens neighbourhood for all its edges. This procedure leads to a smaller number of subtours, which contain a larger number of vertices.

Our second algorithm uses an LP relaxation and a rounding procedure to obtain a set of paths and isolated vertices. Afterwards, these paths are optimally patched into a single tour by means of a small auxiliary TSP instance, which is solved by an ILP-solver. Finally, the resulting tour is enlarged by adding the remaining isolated vertices using a cheapest insertion heuristic. Obviously, the number of isolated vertices should be as small as possible since the paths are patched in an optimal way, but the isolated vertices

are included heuristically. Therefore we present some further algorithmical enhancements in order to decrease the number of such vertices.

All constructive results can be improved by running a classical 3-opt improvement heuristic. We provide exhaustive computational tests, which illustrate that both introduced algorithms significantly outperform the best-known heuristic approaches from the literature with a dominance of the LP based approach.

Graph Coloring via Clique Search with Symmetry Breaking

Sandor Szabo, Bogdan Zavalnij

It is a known fact that the problem whether the nodes of a given finite simple graph can be legally colored using k colors can be reduced to a clique search problem . The clique search is happening in a suitable constructed auxiliary graph. It is clear that exchanging the colors among each other in a legal coloring of the nodes of a given graph leads to a new legal coloring of the nodes of the graph. In order to reduce the search space in an exhaustive search to locate a legal coloring via clique search we use a device to break this symmetry of the roles of the colors.

The symmetry blocked node coloring procedure is also reduced to a clique search. But this time the constructed auxiliary graph is larger than the previous auxiliary graph. (The number of the nodes doubles.) It is clear, that the above symmetry breaking maneuver must reduce the size of the search space. So we carry out a large scale numerical experiment with carefully selected standard bench mark instances. The numerical results indicate that the proposed new symmetry handling approach is in fact reduces the size of the search tree, and result in shorter running times.

There is a relatively straightforward way to fix some (but not necessarily all) colors. Namely, we locate a clique in the original graph whose nodes are under coloring. The nodes of the clique must receive pair-wise distinct colors. We may assign distinct colors to the nodes of the clique. We may fix these colors since the roles of the colors are symmetric. We locate such a clique by using a greedy or exact procedure to find a relatively big or a maximum clique in the graph. Typically such a procedure is unable to locate a clique such that the number of the nodes of the clique is equal to the given number of colors. Therefore typically not all the colors can be fixed. We will show that this clique based partial color fixing procedure can be combined with the more sophisticated symmetry breaking technique.

Heuristic algorithms for the multiple knapsack assignment problem

Silvano Martello, Michele Monaci

Given a set of items, each with a positive profit and weight, and a container (knapsacks) with a given capacity, the Knapsack Problem (KP) requires to determine a subset of items so that the total weight of the selected items does not exceed the knapsack capacity and the total profit of the selected items is a maximum. The Multiple Knapsack Problem (MKP) is a natural generalization of the KP in which multiple knapsacks are available, each with a given capacity. We consider a further extension of the problem, arising when the items are partitioned into classes and each knapsack can allocate items from a single class only. The resulting problem, denoted as Multiple Knapsack Assignment Problem (MKAP), may be encountered, e.g., in marine shipping applications. MKAP is strongly NP-hard and extremely hard to be solved in practice.

We present a heuristic algorithm for the MKAP that operates in three steps. In the first one, an Assignment Problem is solved to determine the class assigned to each knapsack. In the second step, an MKP is solved for each class. Finally, in the third step a local search procedure is applied to improve the resulting solution. We also consider a relaxation of the MKAP obtained by reduction to the classical KP. The optimal solution of the relaxation provides an upper bound that can be used to evaluate the quality of the heuristic solutions.

Preliminary computational experiments on a large set of instances from the literature show that the proposed algorithm is able to produce high-quality solutions in a reasonable computing time.

Improving an Upper Bound on the Stability Number with the Bundle Method for SDP

Malwina Duda, Elisabeth Gaar, Franz Rendl

The stable set problem is an NP-hard problem, where one wants to find the biggest set of vertices in a graph such that no two vertices are adjacent. The size of the biggest (with respect to cardinality) stable set is called the stability number of a graph.

An upper bound on the stability number of a graph is the Lovász theta function, which can be computed in polynomial time as semidefinite program (SDP). One possibility to further improve this upper bound is to include so

called exact subgraph constraints into the SDP. For a certain subgraph the exact subgraph constraint ensures, that the submatrix of the calculation of the Lovász theta function corresponding to the subgraph is contained in the convex hull of all stable set matrices of the subgraph.

Therefore, in order to get an improved upper bound on the stability number, one can start with the SDP relaxation of stable set and include the exact subgraph constraints for many small - wisely chosen - subgraphs. We call the resulting problem P1. Solving P1 is very time-consuming with off-the-shelf solvers, hence it requires alternative solution methods to calculate this improved upper bound.

By building the Lagrangian dual of P1 with respect to the exact subgraph constraints, one gets an optimization problem P2, where the objective function can be split (with common linear variables) into a part which captures the SDP and a second linear part. To P2 a specialized version of the bundle method, namely the bundle method with easy sum components, can be applied in a very natural way. In the resulting iterative solution method, in each iteration one has to solve an SDP with few constraints (for the oracle) and a very nicely structured QP (for getting the new trial point).

In the talk we will discuss different solution methods for this QP and see, that our method significantly improves the running times to solve SDP1 to our desired accuracy.

Our approach can also be used to get better bounds for the max-cut and the coloring problem by starting with an SDP relaxation and adding exact subgraph constraints.

Incentive Compatible Mechanisms for Scheduling Two-Parameter Job Agents on Parallel Identical Machines to Minimize the Weighted Number of Late Jobs

Dominik Kress, Sebastian Meiswinkel, Erwin Pesch

We consider the problem of designing polynomial time truthful mechanisms for machine scheduling problems with parallel identical machines where some of the jobs' characteristics are private information of their respective owners and a central decision maker is in charge of computing the schedule. We study a two-dimensional setting, where weights and due dates are private information while processing times are publicly known. The global objective is to minimize the sum of the weights of those jobs that are completed after their due dates. We derive a set of properties that is equivalent to the

well known condition of cycle monotonicity, which is a general condition for truthful mechanisms in multidimensional valuation function domains. Our results utilize knowledge about the underlying scheduling problem, so that the resulting properties are easier to implement and verify than the general condition of cycle monotonicity. We illustrate the use of our results by analyzing an example algorithm that has recently been proposed in the literature for the case of one machine.

Integer programming methods for special college

Peter Biro, Kolos Ágoston

We develop Integer Programming (IP) solutions for some special college admission problems arising from the Hungarian higher education admission scheme. We focus on four special features, which makes the college admissions problem NP-hard to solve. Currently, a heuristic based on the Gale-Shapley algorithm is being used in the application. The IP methods that we propose are not only interesting theoretically, but may also serve as alternative solution concept for practical application. We also present a simulation on the 2008 data of the Hungarian higher education admission scheme.

Interference-Aware Scheduling with 2D-Torus as a Case Study

Raphaël Bleuse, Giorgio Lucarelli, Gregory Mounie, Denis Trystram

To meet up the challenge of an increasing computational demand with a limited energy budget, the architecture of high performance computing platforms grows in complexity. This complexity mainly arises from the scale of the machines, the heterogeneity of the resources, and the structure of the interconnection network. The architectural evolutions of the network pose a big challenge since the network is shared by both internal and external communications of the jobs. Sharing a multi-purpose network begets complex interactions, and it has a strong impact on performances. More precisely, there are two main types of interleaved communication flows: the flows induced by data exchanges for computations (i.e., within jobs), and the flows related to I/O (i.e., jobs to external storage).

We propose here a new direction for limiting such complex interactions by adding geometric constraints to the scheduling problem.

We model a platform with two sets: nodes dedicated to computations, and

nodes that are entry points to a high performance file system. The nodes are identified by a fixed numbering. These nodes communicate via a network with a given topology. The localization of every node within the topology is known. A set of jobs has to be scheduled on the platform. Each job requires a fixed number of computing nodes, some I/O nodes (either a number of nodes or a subset), a certain time to be processed, and it is independent of every other job. Once a job has been allocated to some nodes, it runs until completion. Finally, any computing node is able to process at most one job at any time. We consider two levels of communications: compute communications (first level) are induced by data exchanges for computations. Such communications occur between two computing nodes within a job. I/O communications (second level) are induced by data exchanges between computing nodes and I/O nodes. We introduce two constraints for the first level: Contiguity and Convexity. We define the distance between any two nodes as the minimum number of hops between these nodes. Targeting the second level, three metrics are associated to the distance: Compacity, Proximity and Locality. These metrics reflect how far from I/O nodes an allocation is. They implicitly take into account external communication and potential congestion.

The Generic problem is then defined as an optimization problem with the platform (nodes and topology) and jobs' description as input. The objective is to minimize compacity or proximity along with makespan or throughput. The problem is constrained by enforcing convexity, contiguity or locality.

The second part of this work is to solve several instances for the Generic problem. We present the analysis for the 1D-torus (complexity, dominancy of some properties, greedy algorithms), and we study in detail algorithms for the 2D-torus. We consider a fixed routing scheme (by dimension), and we propose an approximation algorithm with a constant ratio.

Late Work Scheduling Problem on Two Parallel Machines

Jacek Blazewicz, Xin Chen, Kateryna Czerniachowska, Xin Han, Malgorzata Sterna

We collect the results obtained for the scheduling problem on two parallel identical machines with a common due date and the total late work criterion in two modes: online and offline one. In the offline mode all jobs are known in advance, while in the online mode jobs appear in the system one by one. We proved the binary NP-hardness of the offline problem, by showing the transformation from the partition problem, and constructing

the pseudopolynomial time dynamic programming algorithm. Moreover, some dominance relations were showed, which gave the basis for proposal of the polynomial time approximation scheme. In the online mode, we designed the online algorithm, proving its competitive ratio, which represents the upper bound of the distance between the optimal offline solution and any online solution. These theoretical results are illustrated with results of computational experiments performed for exponential exact offline methods, including dynamic programming, and for heuristic list algorithms working in offline and online modes.

LCS-TA to identify similarity in molecular structures

Maciej Miłostan, Marta Szachniuk, Jakub Wiedemann, Tomasz Żok

Identification of common features and differences in biomolecule structures is an important task whose solution requires an involvement of bioinformatics methods. There is a necessity to develop and tune similarity measures to better analyze and evaluate structures, especially those predicted by computational approaches. Here, we present LCS-TA, a new method to detect local structural similarity. It finds the longest continuous segments in 3D structures folded in like manner. The folds are compared in torsion angle space and the measure of similarity is computed as the length of a segment.

Measuring human performances on two-dimensional packing problems

Gianluca Costa, Maxence Delorme, Manuel Iori, Enrico Malaguti, Silvano Martello

Through the last decades, powerful automated process have gradually replaced human decisions regarding many daily optimization problems to obtain, in general, faster and better results.

In this work, we aim at comparing human performances with respect to simple heuristics and exact approaches on two-dimensional packing problems. After introducing TwoBinGame, the –free- visual application we developed for students to interactively solve two-dimensional packing problems, we detail the experimental plan we adopted to measure human efficiency when various parameters of the test instances (e.g., the number of items to pack or the possibility of rotation) change.

We analyze the results obtained by no less than 200 students and show that the human brain is able to obtain, for relatively small instances, results comparable or better than those produced by simple heuristics such as bottom left or best fit, even when coupled with powerful post-processing. However, it makes no doubt that human solutions cannot compete with the most recent and powerful approaches based on Bender's decomposition and non-trivial branch-and-bound in terms of execution time and solution quality.

Minimal graphs for 2-factor extension

Marie-Christine Costa, Christophe Picouleau, Dominique de Werra

Let G = (V,E) be a simple loopless finite undirected graph. We say that G is extensible if for any non-edge uv then adding uv to E there exists a 2-factor F (a collection of edge disjoint cycles covering the vertex-set V) that contains uv.

The problem we are interested is the following: Given a positive integer n, the cardinality of the vertex set V , what is the minimum cardinality of E such that it exists G = (V,E) which is extensible? This minimum number of edges is denoted by Ext(n).

For any n greater or equal than 10 we prove that $2 \times \text{Ext}(n)$ equals $3n - n/4$. For this purpose we first show that $1/2(3n-n/4)$ is a lower bound for Ext(n), then we exhibit an extensible graph with $1/2(3n - n/4)$ edges.

We also give a minimum extensible graph for any n less than 10.

Note that in a previous work authors gave the set of minimals graphs for 1-factor (perfect matching) extension.

Minimum energy allocation of power to jobs performed on a single machine

Rafal Rozycki

We consider a problem of energy allocation to computational jobs performed on one machine, where jobs may be performed with different speeds. An energy amount is related to a particular speed of a job, and this relation is nonlinear. The objective is to find a minimum energy allocation which guarantees that the last job in the sequence is finished before a deadline. A

model of job processing, a general approach, and a heuristic algorithm are proposed.

Mining of Biological Data

Maciej Miłostan

A tremendous amount of biologically related data is produced each year, stored and analyzed. Diverse and variable nature of biological data causes that there is not 'one for all' solution in Bio-oriented data analysis. During the presentation, nature of biological data, their volume, and dynamics will be the starting point for showing existing problems and possible ways to solve them. The power and weakness of a modern big data frameworks will be a light motif of the whole presentation. The technologies in focus will include graph databases, Apache Hadoop-based solutions, Apache Spark, Elasticserach and possibly a few others. In the case of graph databases, the detailed examples of their application for protein-protein interaction networks will appear during the talk. Structured and unstructured data, sequences, three-dimensional structures, relations, networks, and images are just a few examples of a wide portfolio of data consumed by biological and medical sciences. What we will mine from them depends on our creativity and ability to relate them using appropriate tools.

Models and algorithms for a partition problem arising in warehousing

Nils Boysen, Dominik Kress, Erwin Pesch

We consider a partition problem that subdivides stock keeping units (SKUs) into disjoint subsets, such that the minimum number of groups has to be accessed when retrieving a given order set under a pick-by-order policy. We formalize this SKU partition problem and show its applicability in a wide range of storage systems. We analyze the computational complexity and propose two mathematical models. Furthermore, we present an ejection chain heuristic and a branch and bound procedure. We analyze these algorithms and the mathematical models in computational tests.

Multi-Objective Optimization Approaches for Recommender Systems

Tevfik Aytekin, Ethem Canakoglu, Ibrahim Muter

Recommender systems have become one of the main components of web technologies, which helps people to cope with the information overload within. These systems are based on the analysis of the past behavior of

users to develop user models that can filter items according to users' likes and interests. Two of the most important metrics used to analyse the performance of these systems are accuracy and diversity of the recommendation lists. While all the efforts exerted in the prediction of the user interests aim at maximizing the former, the latter emerges in various forms, such as diversity in the lists across all user recommendation lists, referred to as aggregate diversity, and diversity in the lists of individuals, known as individual diversity. In this paper, we tackle the combination of the aforementioned objectives, and show through investigating their interaction that they either are in confict or have very low correlation with each other. To that end, we develop mathematical models that are formulated using multi-objective optimization approaches. To cope with the intractability of this non-linear binary programming model, its special structure is exploited by a decomposition technique, which treats each recommendation list as a clique in an item graph. For the solution of the resulting formulation, which has a large number of variables corresponding to cliques, we propose an iterative framework that is composed of a clique generating genetic algorithm and a primal constructive/improvement heuristic. The former is designed to incorporate all objective functions into the generated cliques and specifically impose a certain level of individual diversity while the latter chooses one clique for each user such that a given aggregate diversity level is fulfilled. We conduct experiments on three data sets and show that the proposed modeling approach successfully handles all objectives according to the needs of the system and the proposed methodology is capable of yielding good upper bounds.

New algorithms to encode complex pseudoknotted RNA structures in extended dot-bracket notation

Maciej Antczak, Mariusz Popenda, Marta Szachniuk, Tomasz Żok

Pseudoknots remain a great unsolved issue of structural molecular biology. These RNA motifs occur when two helical segments of a structure interlace so that 5' end of one segment lies between 5' and 3' ends of the other, but 3' does not. Due to pseudoknots topological diversity their detection and classification is a challenge. Here, we propose new algorithms - based on

dynamic programming, exact and random search approaches - to identify RNA pseudoknots and encode them in extended dot-bracket notation. We present results of computational experiments aimed to assess our algorithms quality.

Novel methods for atoms alignment score in 3D space

Maciej Antczak, Piotr Lukasiak, Tomasz Ratajczak

Comparison of two structures of proteins or RNA molecules became a challenge in the area of 3D structural models prediction. Although there are known several methods to compare two structures, it is difficult to find the one correct measure of evaluation. In our approach we focused on GDT score - the most recognizable and commonly accepted measure to assess the quality of predicted structures. GDT reports as the final score the average of percentages corresponding to maximization of the percentage of superimposed (or matched) residue pairs under each threshold. In our approach we proposed new heuristics strategies applied to CASP5 and CASP 12 data obtaining improvement in more than 60% of analyzed cases.

On Combinatorial Optimization Problems with Interval Data

Xudong Hu

In this talk, I will present a new approach for dealing with combinatorial optimization problems with uncertain parameters, where, it is assumed, given parameters of input fall into an interval. We introduced three risk models for those problems and proposed polynomial-time algorithms for solving the problems and conducted computational experiments on algorithms proposed. Our theoretical and computational results show not only the high computational efficiency but also the satisfactory flexibility of this new approach for decision makers at different levels of aversion to risk.

[Joint work with E. Alvarez-Miranda, Xujin Chen, Jie Hu, Bi Li]

On the complexity of k-rainbow cycle colouring problems

Shasha Li, Yongtang Shi, Yan Zhao

An edge-coloured cycle is rainbow if all edges of the cycle have distinct colours. For $k \geq 1$, let $\mathcal{F}_k$ denote the family of all graphs with the property

that any k vertices lie on a cycle. For $G \in \mathcal{F}_k$, a k-rainbow cycle colouring of G is an edge-colouring such that any k vertices

of G lie on a rainbow cycle in G. The k-rainbow cycle index of G, denoted by $crx_k(G)$, is the minimum number of colours needed in a k-rainbow cycle colouring of G. In this paper, we restrict our attention to the computational aspects of k-rainbow cycle colouring. First, we prove that the problem of

deciding whether $crx_1 = 3$ can be solved in polynomial time, but that of deciding whether $crx_1 \leq k$ is NP-Complete, where $k \geq 4$. Then we show that the problem of deciding whether $crx_2 = 3$ can be solved in polynomial time, but those of deciding whether $crx_2 \leq 4$ or 5 are NP-Complete. Furthermore, we also consider the cases of $crx_3 = 3$ and $crx_3 \leq 4$. Finally, We prove that the problem of deciding whether a given edge-colouring (with an unbounded number of colours) of a graph is a k-rainbow cycle colouring, is NP-Complete for $k = 1$, 2 and 3, respectively. Some open problems for further study are mentioned.

On the Slot Optimization Problem in On-Line Vehicle Routing

Philipp Hungerländer, Andrea Rendl, Christian Truden

The capacitated vehicle routing problem with time windows (cVRPTW) is concerned with finding optimal tours for vehicles that deliver goods to customers within a specific time slot (or window), respecting the maximal capacity of each vehicle. The on-line variant of the cVRPTW arises for instance in online shopping services of supermarket chains: customers choose a delivery time slot for their order online, and the fleet's tours are updated accordingly in real time, where the vehicles' tours are incrementally filled with orders.

In this presentation, we consider a challenge arising in the on-line cVRPTW that has not been considered in detail in the literature so far. When placing a new order, the customer receives a selection of available time slots that depends on his address and the current (optimized) schedule. The customer chooses his preferred time slot, and his order is scheduled. The larger the selection, the more likely the customer finds a suitable time slot, leading to higher customer satisfaction and a higher overall number of orders placed. We denote the problem of determining the maximal number of feasible time slots for a new order as the Slot Optimization Problem.

We propose several heuristics for both determining feasible slots. Our approaches combine local search techniques with strategies to overcome local

minima and integer linear programs for selected sub-problems. In an experimental evaluation, we demonstrate the efficiency of our approaches on a variety of benchmark sets and for different time restrictions that are motivated by varying customer request frequencies.

Optimal Construction Schemes for the Traveling Salesperson Problem with Forbidden Neighborhoods on Regular 3D Grids

Anja Fischer, Philipp Hungerländer, Anna Jellen

We introduce an extension of the Traveling Salesperson Problem (TSP), denoted as TSP with Forbidden Neighborhoods (TSPFN). The TSPFN with radius r asks for a shortest Hamiltonian cycle where direct connections between points that are closer than r are forbidden.

The TSPFN is motivated by an application in mechanical engineering called laser beam melting. This technology builds a workpiece in several layers by heating up the material at several points. Internal stresses should be avoided by excluding the heating of points that are too close to previously heated points.In this application the points are often arranged in a regular grid structure.

In this presentation we consider optimal TSPFN tours on regular 3D grids, i.e. adjacent vertices all have the same distance from each other. First we suggest an integer linear programming formulation for the 3D TSPFN. Then we study TSPFN tours for the smallest reasonable forbidden neighborhoods of radius 0, 1 and square root of 2. We use combinatorial counting arguments to establish lower bounds on the optimal solution values depending on the parities of the grid dimensions. Furthermore we provide construction schemes for optimal TSPFN tours for the considered cases.

Optimal shift design for irregular demand

Annelies Lejon, Greet Vanden Berghe

Shift design represents a relevant research topic given that many companies are faced with the complex challenge of matching staffing levels and demand at numerous time intervals. Moreover, proposed staffing solutions must respect the availability of a given pool of employees, each of which is associated with personal skills, preferences and contractual obligations.

The objective in such a combinatorial optimisation problem is typically to

minimize under- and overstaffing for a given planning horizon. The number of distinct shifts may be classified as either a hard or soft constraint, wherein the latter may be employed when creating a schedule which is equally fair for the employees.

When demand is highly irregular, the problem becomes even more difficult to solve . The work includes a case study where demand primarily fluctuates around some base level except for several short time windows when demand peaks at much higher levels. How the height of the peak, both as an absolute value and relative to the base level, and its width influence solution quality is examined. Mixed integer programming models from the academic literature either result in frequent overstaffing (when understaffing must be avoided at all costs) or the inability to fulfill the high demand associated with peak moments. Depending on the specific weights of under- and overstaffing, the optimal solution would thus contain frequent overstaffing (when fulfilling the peak in the demand) or frequent understaffing (when the staffing level did not capture the actual demand peak.) Clearly, neither strategy is appealing. By way of addressing this situation, this study permits a limited relaxation of demand and its corresponding constraints. Various relaxation strategies are examined with the primary motivation being to make the demand constraints fuzzy by including an additional set of decision variables which enable the satisfying of the original demand within a longer time window.

Furthermore, the problem is also interesting from an algorithmic perspective since it naturally possesses a block angular structure, making the application of Benders decomposition applicable , whereby under- and overstaffing are solved separately while the selection of shifts is made in a master problem. A comparison of a classic MIP formulation solved heuristically is compared against this Benders-based approach.

Optimization methods for LEGO structure transformation

Lujie Chen, Wei Pan

We propose several methods to optimize the process of LEGO structure transformation. The methods are able to generate an assembly map from a 3D digital model, e.g. triangle mesh model in STL format, to match overlapping area of an existing and a desired LEGO structure, to consider different sizes and colors of LEGO parts, and to produce a step-by-step moving sequence so that transformation can be executed. Several optimization metrics are investigated, such as maximizing reuse rate, minimizing

number of moves, and minimizing space occupancy. Each metric leads to an optimization methods.

Optimized Scheduling in Human-Robot Collaboration – A Use Case in the Production of Printed Circuit Boards

Karin Bogner, Ulrich Pferschy, Roland Unterberger, Herwig Zeiner

Advances in the technologies of sensors and lightweight robots increasingly enable direct physical interaction between humans and robots. This so-called human-robot collaboration is supposed to offer more flexibility in production processes, as opposed to fully automated processes. Efficient human-robot collaboration therefore needs to be well coordinated. The aim of this contribution is to describe an integer linear programming model which coordinates the distribution of tasks between humans and robots in a realistic production process of printed circuit boards (PCBs) to minimize the completion time of a board. In addition, an extension of the problem where a sequence of multiple boards – highly relevant for low volume production – is to be produced, is discussed.

First, an ILP model to optimally solve the considered problem is introduced, which can be seen as a modification of the resource constrained project scheduling problem with multiple processing modes. Each mode represents the assignment to a specific resource or agent, i.e. a human worker or a robot, resulting in different, deterministic processing times. Besides the limited number of agents, restrictions include precedence constraints, limited intermediate storage of parts and minimum distance requirements in order to avoid collisions between humans and robots. For most instances tested, an optimal solution could be found within 20 min with Gurobi 6.5.2 on a standard PC. Alternatively, a simple heuristic approach is proposed, where the tasks are scheduled in decreasing order of the sum of minimal processing times of their immediate successors. The task is then assigned to the best agent out of all currently available agents, unless an earlier finish time can be achieved by assigning it to the best agent as soon as they become available again. Although some constraints are slightly simplified, the heuristic finds feasible solutions in a fraction of a second, with objective values deviating less than 20% from the optimal solutions.

Moreover, the ILP model is extended in order to minimize the makespan of an entire sequence of PCBs, where each PCB possibly needs a different set of tasks to be fulfilled. The set of agents is assumed to consist of two humans working in parallel, who may each only process tasks of one board

at a time, and one collaborative robot, that may interchangeably process tasks of different boards, but requires some time to switch from one board to another. Since the ILP most often cannot find a solution within an acceptable time limit, a matheuristic approach was developed. Instead of optimizing the whole sequence of PCBs, only two boards are considered at each iteration, where the sum over the completion times of the two boards is minimized. Currently, various heuristic strategies are evaluated in order to determine how the boards have to be sorted for a good overall makespan to be obtained.

Order Acceptance and Scheduling Problem to Maximize Revenue

Ceyda Oguz, İstenç Tarhan

Scheduling problems are highly diverse though the principal objective of them is similar: Satisfaction of the customers' orders as utilizing the scarce resources as efficiently as possible. However, as the firms operating on a make-to-order basis not to keep the inventory of final products together with customers having tight delivery time requirements for their demand, satisfaction of the entire demand may not be possible due the capacity limitations faced by the firm. This necessitates selecting only part of customer orders to maximize the total revenue, which gives rise to the order acceptance and scheduling problems (OAS).

In this study, we are given a set of independent orders at the beginning of the planning period. For each order, there is an associated release time, processing time, due date, deadline, sequence dependent setup times, revenue and unit tardiness penalty cost. Each order is required to be started after its release time and completed before its deadline; however, satisfying all orders may not be possible due to the capacity limitations. Therefore, the problem can be defined as a joint decision of which orders to accept and how to schedule the accepted orders. The manufacturer may complete an accepted order until its deadline, but for each time unit beyond its due date, she incurs a tardiness penalty cost. Hence the underlying problem is to minimize the weighted tardiness cost which is an NP-hard problem. Since the OAS problem is combinatorially challenging, commercial solvers fail at finding acceptable solutions for even moderate problem instances and this leads the researchers to develop heuristics for the relevant problem. In order to fill a gap, we propose an exact algorithm for the OAS problem in a single machine environment.

The underlying idea of our exact algorithm is to interpret the OAS prob-

lem as a traveling salesman problem. By exploiting the characteristics of an optimal solution to the OAS problem, we use constrained longest path of a graph in which there is a node for each order and an arc among all nodes. Then the revenue of an arc is equal to the revenue of the destination order. The one and the only constraint is to satisfy the time requirements of orders. Time requirements can be covered easily by an alternative graph representation where there is an associated node for each node and its possible completion time. We can find the longest path of this graph in linear time since it is directed and acyclic. However, the longest path does not necessarily give us the optimal solution since it is possible to process the same order more than once in this representation.

Hence, in our algorithm we propose to find the longest path of the relevant graph while ensuring that each order can be processed at most once by utilizing the label setting algorithms developed for resource constrained shortest path problems. We further develop dominance rules to reduce the size of the graph, and hence, the solution time.

Order batching and routing in a warehouse logistics system

Ulrich Pferschy, Joachim Schauer

An efficient warehouse logistics system is crucial for the performance of trading companies with high turn-over. In this contribution we consider the real-world case of Blue Tomato Inc., a sporting goods and apparel sales company with a strong e-commerce business. We focus on the order picking process in its central warehouse located in Graz, Austria. Every day several thousand orders, each of them consisting of one or more individual articles, have to be manually picked from the shelfs of the warehouse. This is done by human pickers, who use a cart to store at most 15 different orders comprising a total of at most 40 articles.

The resulting planning task consists of two parts: At first, the orders have to be partitioned into batches of at most 15 orders. This order batching process should allow an efficient picking tour in the warehouse. Secondly, for each batch a picker route has to be determined. This picker routing problem can be modelled as an instance of a TSP with a special graph topology.

There are a number of special conditions which distinguish the treated problem from the standard literature: The warehouse consists not only of parallel aisles with two cross aisles but comprises additional shelf space of

irregular structure. The start and end points of picker routes do not coincide. Moreover, the warehouse consists of two floors which are connected by two elevators. As a special feature, which implies interesting combinatorial properties, for most products copies are stored in several different storage locations, some of them in more than ten locations. Thus, the order batching process also has to decide from which location each product should be picked. Finally, also different due dates of orders have to be respected.

We develop a heuristic strategy for order batching which tries to build batches in a close spatial neighborhood. The definition of this neighborhood is based on a general graph model which allows a flexible adaptation to changes in the warehouse structure. Orders are added to a partial batch if their products can be picked from locations in these neighborhoods. The subsequent routing problem could be solved to optimality by a TSP algorithm. However, we also employ a farthest-insertion type heuristic with k-opt improvement, which deviates from the optimal TSP solution by less than 1%.

Evaluating the resulting algorithmic framework with real-world data shows that we gain an improvement on the total travel distances between 33.1% and 34.4% on average. This can be seen as a significant improvement of the warehouse logistics system.

Partial Inverse Maximum Spanning Tree Problem

Xianyue Li

Maximum or minimum spanning tree problem is a classical combinatorial optimization problem. In this talk, we will introduce the partial inverse maximum spanning tree problem. Given a graph, an acyclic edge set, and an edge weight function, the goal of this problem is to modify the weight function as small as possible such that there exists a maximum spanning tree on the new weight function containing given edge set. Cai et al. show that if the weight function can only be increased, this problem can be solved in polynomial time. On the other hand, when the weight function can only be decreased, if the given edge set has at least two edges, we show that this problem is NP-Hard; if the given edge set contains only one edge, we present a polynomial time algorithm to solve it.

Portfolio Selection Under Revised CVaR Model

Yun Jiao Hu

Along with the financial regulation and supervision strengthened further, Value at Risk (VaR) model has been advocated by lots of financial institutions.Empirical studies have found that the returns of an investment showed a kurtosis, fat tail, and non-normal distribution that there was a leverage effect in stock market.So, we use the asymmetric model to estimate CVaR values under t and GED distributions.Besides, volume and liquidity also have impact on the profit of stocks , so we will take the two variables into consideration.

Power of Splitting on Parallel Machines

Alan Soper, Vitaly Strusevich

In parallel machines scheduling, the processing of a job may be interrupted to achieve a better performance. In the case of preemption, it is not allowed to process the same job on several machines simultaneously, while in the case of splitting, that requirement is relaxed, and unless stated otherwise if a job is split then the number of machines on which the job can be simultaneously processed is not restricted.

The power of preemption is defined as the supremum of the ratio of an objective function for an optimal non-preemptive schedule over the value of the function for an optimal preemptive schedule across all instances of the problem. Determining the power of preemption has received considerable attention. For the problems of minimizing the maximum completion time (makespan) and total completion time tight bounds have been found for this ratio in identical, uniform and unrelated parallel-machine environments

In this paper, we consider the power of splitting, defined similarly to the power of preemption, except we compare the best split schedule with the best non-preemptive schedule. The power of splitting shows what could be gain if an arbitrary number of splits is allowed. We also consider variations of the power of splitting, in which the number of splits in a feasible schedule is limited.

For the problem of minimizing the makespan, we give complexity results for finding an optimal schedule with a limited number of splits in all three machine environments. For identical parallel machines, we derive tight bounds on the power of splitting for any fixed number of allowed splits.

For the problem of minimizing the total completion time, we derive tight

bounds on the power of splitting for an unlimited number of splits.

All results on the power of splitting are compared to those on the power of preemption under the same processing conditions.

Production planning: easy or hard? Solving a complex scheduling model by a MILP solver, an efficient heuristic method, and their combination

Peter Auer, Gyorgy Dosa, Tibor Dulai, Armin Fügenschuh, Ronald Ortner, Ágnes Stark-Werner

We consider the following production planning problem: Several products have to be assembled by performing different tasks. These tasks are to be executed on a set of machines. The machines are capable to perform the different tasks with different efficiencies (different processing times). Switching between tasks requires a setup time. The goal is to minimize the makespan, i.e., to finish the production of all products in minimum time. The topic has rich literature, this paper presents an interesting, special case.

The problem is quite complex, and we first formulate it as a mixed-integer linear program (MILP) and solve it by a standard MILP solver. It turns out that the problem is computationally challenging: If the MILP solver works without any preprocessing, the runtime is significant even on medium-size problem instances.

Therefore, we suggest a compound heuristic method for the problem. During the heuristic, we divide the problem into three subproblems (which are solved one by one). Two of them (the first one and the last one) are solved by a simple greedy method. For the middle (main) problem we apply several simplifications, then we solve the relaxed (preemptive) version of the simplified subproblem. By a rounding procedure we get a nonpreemptive solution, and finally we apply several kinds of local search to improve the solution of the subproblem.

Comparing the two methods, the MILP solver provides an optimal solution, but runs quite slowly. The heuristic method gives quite good (often optimal) solutions very quickly, but without any performance guarantee.

The best choice turns out to be a combination of both: By applying our heuristic method and giving its solution to the MILP solver, we combine the advantages of the two methods: We get an optimal solution faster than by the MILP solver alone.

The behaviour of the presented method is empirically analysed through different problem instances. During this analysis we investigate problem instances which vary in size (number of products to be made), in the processing times (to perform the tasks), and in the lengths of setup times.

Pseudoknot order determination as graph coloring problem

Mariusz Popenda, Marta Szachniuk, Tomasz Żok

Pseudoknots are often found in RNA molecules but their identification, representation, and classification are ambiguous. Some RNA structure representations prevent pseudoknot description and most databases do not provide an information about them, in contrast to the other motifs. Here, we propose a method to classify and encode pseudoknots. We show a new graph model of RNA 2D structure allowing to represent different types of these motifs. We apply vertex coloring to determine pseudoknot order. This feature refers to motif complexity and nucleobase bounding order when RNA molecule is folded.

Ranking Alternatives Using DEA: A Dual Approach

Seda Lafcı, Ozgur Ozpeynirci, Onur Can Yılmaz

In this study, we address the problem of ranking alternatives evaluated with multiple criteria using Data Envelopment Analysis (DEA). DEA is a decision making tool for measuring relative efficiencies of a set of so called Decision Making Units (DMUs) that use multiple inputs to produce multiple outputs. There have been rapid developments in the field with a significant portion focused on DEA applications of efficiency and productivity in both public and private sector activities.

We discuss a DEA based method for ranking DMUs. The method considers a DMU and removes other DMUs until the one under consideration becomes efficient. In the literature, there is an exact method that removes alternatives through a mixed integer mathematical programming model by using binary and continuous decision variables. In this study, we propose a dual DEA based heuristic method that myopically detects the best DMU to be removed iteratively without the need of integer or binary decision variables.

We compare the performance of the exact method and our heuristic method on randomly generated test instances in terms of solution time and quality. We also conduct experiments with real data from Logistics Performance

Index (LPI) published in 2014. The data reports 160 countries logistics performance in six different criteria.

The proposed method is significantly faster especially for large data sets while it obtains nearly the same rankings. Moreover, the method reports complete rankings for several large data sets where the exact method stops in one hour CPU time limit without finishing the ranking.

Scheduling Divisible Loads with Time and Cost Constraints

Maciej Drozdowski, Natalia Shakhlevich

In this presentation we survey recent complexity results on divisible load scheduling with cost and time constraints. Then, we prove that for fixed number of processors this problem is solvable in polynomial time. A special case of negligible load distribution times, even with processor availability and memory constraints, is solvable in polynomial time by reduction to the continuous knapsack problem. The complexity status of the most general version of the problem, with purely linear cost, transfer, and computation times, for arbitrary number of processors, remains open.

Scheduling with lower rank processing times

Guochuan Zhang

We consider a classical scheduling problem on unrelated machines, where the makespan is minimized. It is known that an LP-relaxation based algorithm can achieve an approximation factor of two, while no polynomial time algorithms can have an approximation ratio strictly better than 3/2 unless P=NP. Bhaskara et al. (SODA 2013) investigated this problem from a different angle. They initiated the study with respect to the rank of the matrix formed by job processing times and showed that it admits a QPTAS when the rank is 2, and it becomes APX-hard when the rank is 4. Moreover, they proved that a lower bound of 3/2 is already there if the rank is 7.

We continue this line of research and prove that the problem is APX-hard even if the rank is 3, resolving an open problem posed by Bhaskara et al. The lower bound 3/2 holds for the rank of 4. We then turn to parameterized algorithms and show that there is an FPT algorithm parameterized by the rank and the largest job processing time. This generalizes the parameterized results for both identical machines and the unrelated machines with few different machine types.

Joint with Lin Chen, Daniel Marx, and Deshi Ye

Shrinking Gradient Descent Algorithms For Total Variation Regularized Image Denoising

Tiande Guo, Congying Han, Mingqiang Li

In this paper, we extend gradient descent schemes to a general form with a shrinking factor. Both Chambolle's algorithm and GP algorithm can be regarded as the special cases of this general form. Global convergence analysis of the proposed algorithms with various step lengths and shrinking factors are present. Numerical experiments indicate the new algorithms perform well in gray and color image denoising problems

and that the proposed algorithm with some step length and shrinking factor is significantly faster than Chambolle's algorithm and GP algorithm when high accuracy in the solution is required.

Single machine scheduling to minimize the maximum cost under the interval uncertainty of processing times and additional parameters of jobs

Ilia Fridman, Erwin Pesch, Yakov Shafransky

One of the most known and often cited results in the machine scheduling is an quadratic algorithm of Lawler (Management Science, 19(5): 544–546, 1973) that was developed to minimize the maximum cost of jobs processed by a single machine under precedence constraints. We consider an uncertain version of the same min-max cost scheduling problem. The cost function for each job depends on the job completion time and on an additional numerical parameter, which, in turn, may be a tuple of numerical parameters. For each job, both its processing time and the additional parameter are uncertain and everything that we know about these parameters are intervals of their possible values. For this problem we derive an algorithm for finding a schedule that minimizes the maximum regret. This algorithm is a generalization of Lawler's algorithm.

We consider some special cases of the cost functions of jobs and provide polynomial algorithms for constructing minmax regret solutions for the correspondent problems.

There are known only two results for constructing minmax regret solutions

for the min-max cost scheduling problem where uncertain processing times of jobs are involved. They are Kasperski's algorithm for problem of minimizing the maximum lateness for a single machine scheduling under the precedence constraints with uncertain processing times and due dates of jobs (Operations Research Letters, 33: 431–436, 2005) and algorithm of Volgenant and Duin for a similar problem to minimize the maximum weighted tardiness with uncertain processing times, due dates and weights of jobs (Computers and Operations Research, 37: 909–915, 2010). The time complexity of the both algorithms is of the fourth power of the number of jobs. In these papers, the technique is based on using so-called extremal scenarios, where some uncertain parameters take their maximum values, while all others take their minimum possible values.

For some of our problems under consideration, we show that it is impossible to confine the search to the mentioned extremal scenarios. It means that our approach should be based on some new ideas different from those lying behind algorithms proposed by Kasperski and by Volgenant and Duin. Finally, we show that our approach outperforms all known results for constructing min-max regret solutions for the min-max cost scheduling problem under uncertainty of the processing times of jobs. In particular, we propose cubic algorithms for problems considered by Kasperski and by Volgenant and Duin, and the algorithms are able to solve a considerably wider class of problems.

Single railway scheduling problem

Jacek Blazewicz, Grzegorz Pawlak, Gaurav Singh

The motivation for considering an optimization problem was taken from the actual system of Australian Railways. On the one hand the problem is similar the one elaborated in the literature the trains timetabling problem. On the other hand there is the unique scheduling problem formulated with parameters and constraints and objective functions not considered yet.

Trains journey is form the source station to the destination station traveling through the transiting stations on the single track. Trains can wait at particular stations, the number of the waiting trains depends on the station capacity. The source and target stations had unlimited capacity.

Optimization criterion is to maximize the number of trains running from the origin to the final destination and back, in the particular time windows. There are considered the constrains such as: the maximum train waiting

time on the station, the safety distance between trains, the time limit on the train traveling time in two-ways.

A mathematical model for SRSP was formulated and algorithms were proposed for the for particular cases where the unit traveling time between stations was assumed.

In the real system there appears an additional constraints like minimum stop time on the station, different speed-up time between the empty and loaded train actually not taken into account the that research stage.

Solving large-sized orienteering problem instances using an evolutionary algorithm

Gorka Kobeaga, Jose A. Lozano, María Merino

The Orienteering Problem is a routing problem where each node has an assigned profit and the goal is to find the route that maximizes the total collected profit subject to a limitation on the total route distance. To solve the problem, we propose an evolutionary algorithm, whose key characteristic is to maintain unfeasible solutions during the search. Furthermore, it includes a novel solution codification for the Orienteering Problem, a novel heuristic for node inclusion in the route, an adaptation of the Edge Recombination crossover developed for the Travelling Salesperson Problem, specific operators to recover the feasibility of solutions when required and the use of the Lin-Kernighan heuristic to improve the route lengths.

We have compared the proposed algorithm on 344 TSPLib-based benchmark instances, ranging up to 7397 nodes, with the exact branch-and-cut algorithm and two state-of-the-art heuristics: GRASP with path relinking and the two-parameter interactive algorithm. Our approach shows competitive results in medium dimensionality instances and outstanding results in large dimensionality ones, reaching new state-of-art solutions within a shorter computational time than the one used by the state-of-the-art algorithms.

Solving Selective TSP Problem Using Crowdsourced Programming Challenge

Maciej Antczak, Jan Badura, Artur Laskowski, Maciej Olszowy, Tomasz Sternal, Szymon Wasik, Krzysztof Wedrowicz

Crowdsourcing is a very powerful technique that allows for solving difficult

scientific and industrial problems by outsourcing them to the crowd of Internet users with relatively small financial cost. Using Optil.io platform developed at the Poznan University of Technology, we have conducted a crowdsourced programming challenge to solve a variant of Selective TSP problem. Optil.io is a platform implementing an Evaluation as a Service architecture which keeps all test instances in a cloud and this way hides them from the users to make the assessment process more objective. Users can submit algorithms solving the problem as a source code that is compiled on the server and then compared with other solutions in the homogeneous runtime environment. During the whole period of the challenge, users can observe a live ranking of all submissions.

During the competition, the platform automatically evaluated over 5000 submitted algorithms. Each submission was assessed using 30 test instances of varying difficulty. The results of the challenge proved that crowdsourcing could be efficiently used to solve computationally hard problems. Moreover, the Optil.io platform currently supports submitting new problems by its users so everybody can solve a scientific problem using crowdsourced challenge for free.

Solving some discrete-continuous project scheduling problems by metaheuristic approaches

Grzegorz Waligora

In this research a discrete-continuous project scheduling problem with discounted cash flows is considered. Each activity of the project requires for its processing discrete, renewable resources and an amount of a single continuous resource which is also renewable. Processing rate of an activity is an increasing function of the amount of the continuous resource allotted to this activity at a time. Activities are nonpreemptable, and are subject to finish-to-start precedence constraints with zero minimum time lags. A positive cash flow is associated with the completion of each activity. The problem is to find a feasible assignment of discrete resources and, simultaneously, a continuous resource allocation that maximize the net present value (NPV) of all cash flows of the project.

Three local search metaheuristics: simulated annealing (SA), tabu search (TS), and genetic algorithm (GA) are proposed for the defined problem, and compared a basis of a computational experiment. At the stage of calculating the objective function value (i.e. the NPV for the relevant feasible solution), a heuristic procedure is used to allocate the continuous resource. Its main

idea is to prefer activities with bigger cash flows to be executed earlier. To this end a ranking of percentage cash flows is created, i.e. a ranking of contribution of each activity's cash flow to the total cash flow of the project.

The computational experiment has been carried out for the number of activities from 20 up to 500. The results show that, in general, the genetic algorithm performs best from among the three examined metaheuristics. Starting from 100 activities, GA achieves best results in terms of the number of best solutions found, as well as the average relative deviation, and clearly outperforms the two other methods. Only for smaller problem sizes SA and TS produced better results (SA for 20 activities and TS for 50 activities), however the differences are not very significant. As far as computational times are concerned, they are rather similar, although, precisely, SA appeared to be the fastest. It can be caused by the fact that SA generates exactly one neighbouring solution in each iteration, whereas TS generates sets of neighbours and GA generates populations. As a result, the two latter methods may slightly exceed the number of visited solutions assumed as a stop criterion. In total, GA is the most effective for the considered class of problems, proving again its good efficiency for scheduling problems where solutions are represented by lists of activities.

Some future research can be carried out in several directions. Firstly, further improvement of the presented metaheuristics can be made. Also other approaches to heuristically allocating the continuous resource may be developed. Finally, alternative metaheuristic methods can also be proposed, as, e.g., scatter search or ant colony, and examined on a basis of a more extensive computational experiment.

Sufficient conditions of efficient solvability for routing open shops on a tree

Ilya Chernykh, Ekaterina Lgotina

The routing open shop problem being a generalization of metric TSP and open shop scheduling problem is considered. Jobs are located at the nodes of transportation network while machines travel between jobs' locations performing operations of each job in open shop environment. The goal is to minimize the makespan. The problem is known to be NP-hard even in the simplest case of two machines and two nodes.

We consider a two-machine problem with a tree structure of the transportation network and individual travel times. For this problem we describe a

wide class of polynomially solvable subcases.

The complexity of minimum-length path decompositions

Dariusz Dereniowski, Wieslaw Kubiak, Yori Zwols

We consider a bicriterion generalization of the pathwidth problem: given integers k, l and a graph G, does there exist a path decomposition of G of width at most k and length (i.e., number of bags) at most l? We provide a complete complexity classification of the problem in terms of k and l for general graphs. Contrary to the original pathwidth problem, which is fixed-parameter tractable with respect to k, the generalized problem is NP-complete for any fixed k $\geq$4, and also for any fixed l $\geq$2. On the other hand, we give a polynomial-time algorithm that constructs a minimum-length path decomposition of width at most k $\leq$3 for any disconnected input graph. As a by-product, we obtain an almost complete classification for connected graphs: the problem is NP-complete for any fixed k $\geq$5, and polynomial for any k $\leq$3.

The inverse matching problem for vertex weights

Miklos Kresz

Matching theory is a classical field of Combinatorics and algorithm theory, finding a maximum matching is a well-known example of the polinomially solvable problems. However, despite the well-developed theory of matching algorithms and matching structures, deeper investigation of the Maximum Vertex-weighted Matching Problem (MVWMP) has not been in the focus so far. Even though it was observed already in 1984 by Spencer and Mayr that MVWMP is closer to the unweighted counterpart than the edgeweighted one, only a few specific theoretical problems have been considered since then. On the application side, however, especially in network design, maximum vertex-weighted matchings have received a significant attention during the past few years..

In this talk we will consider the so-called inverse matching problem for vertex-weighted graphs. Since it was shown by Spencer and Mayr that the negative weights in MVWMP can be eliminated by a simple structurally equivalent transformation, we can restrict our attention to the nonnegative case. Moreover, they also noticed that the solutions of MWVMP are not influenced by the magnitudes of the weights; the order among distinct weights

uniquely determines the problem. Therefore, without loss of generality we can assume that the weights are nonnegative integers.

Principally, an inverse optimization problem is about searching parameters with minimum cost such that a prespecified solution becomes optimal. For MVWMP the natural problem statement with a single input matching results in a trivial task (a solution with „all zero weights"), but considering all maximum vertex-weighted matchings (MVWM) leads to interesting questions. Therefore the inverse matching problem for MVWM is defined as follows.

Given a graph with the status of each edge and that of each vertex. The status can be fobidden (not covered by any MVWM), mandatory (covered by all MVWM) or flexible otherwise. A weighting of the vertices is legal, if the status of each edge and each vertex in the resulted vertex-weighted graph corresponds to the prescribed pattern. The goal is to determine a legal weighting with minimum weight (as the sum of the weights of all vertices).

In this talk we will first show that the above problem is NP-complete in general case. On the other hand, by the structural decomposition of MVWM, a method will be worked out by which the problem can be polynomially reduced to searching the maximum Tutte set of a well-defined subgraph (called the matching core) of the original graph. Therefore it is shown that the problem is polynomially solvable for a graph G iff the maximum Tutte set problem is polynomially solvable for the matching core of G. As a result we will obtain a polinomial solution for several special cases such as bipaartite graphs, Hamiltonian graphs and for the case when 0-weight vertices are pre-defined.

The Minimum-Weight Kernel Problem and Polyhedral Approaches

Qin Chen, Xujin Chen, Wenan Zang

We employ polyhedral approaches to study the minimum-weight kernel problem, which arises in a rich variety of applications and has been a subject of extensive research. Let G be a digraph. A vertex subset of G is a kernel on G if it is both stable and dominating. A natural description of kernels on G can be relaxed to a linear system p(G) which consists of nonnegativity, stability, and domination inequalities. Digraph G is called kernel ideal if p(H) defines an integral polytope for each induced subgraph H of G, and kernel Mengerian if p(H)is totally dual integral for each induced subgraph H of G. We show that a digraph is kernel ideal iff it is kernel Mengerian iff

it contains none of three forbidden structures; the characterization yields a polynomial-time algorithm for the minimum weight kernel problem on kernel ideal digraphs. In contrast, we prove that it is NP-hard to find a kernel of minimum size even in a planar bipartite digraph with maximum degree at most three.

The obnoxious p-median problem in general networks

Mohammadreza Galavii

Let G=(V,E) be a graph with vertex set V and edge set E. A location problem in which all vertices are associated with negative weights is called an obnoxious facility location problem. Two different types of objective functions for the obnoxious p-median problems can be investigated: the sum of the minimum weighted distances from X in G with cardinality p to all vertices and the sum of the weighted minimum distances. For the first model, a new definition called a dominating pair (or a dominating path) will be introduced. It will be proved that only two vertices namely the dominating pair play a role and all other points of the p-maxian (i.e., the optimal solution of the p-median problem with negative weights) can be chosen arbitrarily. The question is, which graphs have the dominating pair? The present research aims to answer this. The conditions under which the graph G has the dominating pair will be presented.

The Ring Spur Assignment Problem: New formulation, valid inequalities and a branch-and-cut approach

Shahin Gelareh, Rahimeh Neamatian Monemi

The Ring Spur Assignment Problem introduced in Carroll et al. (2011) arises in the design of next generation telecommunications networks and can be considered as a location-allocation problem. The nodes in such a network structure either lie on a set of disjoint and bounded local rings or are spurred to other local ring nodes using a single arc. Another special ring (in terms of technological connections), interconnects these local rings. The latter is known as tertiary ring.

The goal is to design an economical fault tolerant next-generation network (NGN) for a given telecommunication operator. Such a resilient network is indeed a logical topology for an existing physical infrastructure, i.e., we exploit the pre-installed capacity in the physical synchronous digital hierarchy

(SDH) (Carroll et al., 2013). This means that if a given node has only one incident edge, or if the residual capacity of ring is insufficient, the node can only be a spur node connected with a single arc to another node on a local or tertiary ring.

In this work, a new mathematical model is proposed for the Ring Spur Assignment Problem (RSAP). Our new integer programming model employs only O(n2) decision variables while the previously presented works available in the literature employ O (n3) decision variables. Our proposed MIP model also has a stronger LP relaxation. Several classes of valid inequalities and separation procedures are presented giving rise to an efficient branch-and-cut solution algorithm. We report optimal solution for all instances including those that were not solved to optimality previously.

The Turan Numbers for Linear Forests

Xiao-Dong Zhang

The Turan number of a graph H is the maximum number of edges in a simple (bipartite) graph of order n which does not contain H as a subgraph. In this talk, we introduce how to determine the exact value of the Turna number when H is linear forest, i.e.,the union of disjoint paths and characterize all extremal graphs. Moreover, some problems are included.

Timed Automata based scheduling of automated wet-etch stations

Mate Hegyhati

Automated wet-etch stations are an essential part of semiconductor manufacturing, where the wafer lots must go through a sequence of chemical and water baths. Due to quality concerns, the timing of the etching operations in chemical baths is crucial, thus the transportation of lots within the system is carried out with automatic robot arms. Minimizing the whole production time while satisfying the strict timing constraints is a complex scheduling problem that has been tackled by various exact methods in the recent years including constraint programming, combinatorial approaches, and various MILP formulations.

Timed Automaton is a mathematical model with great expressive power, that is frequently applied for various analysis and diagnostic problems. By extending the original model with pricing and a branch-and-bound state-space exploration algorithm, the approach can be applied for optimization

purposes. In the last decade, several papers have presented automata based methods for batch process scheduling problems.

In this work, a priced timed automaton based approach is presented to minimize the makespan of the wet-etching process. Empirical evaluation has been carried out using the UPPAAL CORA software tool.

This research was supported by the ÚNKP-16-4 New National Excellence Program of the Ministry of Human Capacities.

Truthfulness of a Proportional Sharing Mechanism in Resource Exchange

Yukun Cheng

In this paper, we consider the popular proportional sharing mechanism and discuss the incentives and opportunities of an agent to lie for personal gains in resource exchange game. The main result is a proof that an agent manipulating the proportional sharing mechanism by misreporting its resource amount will not benefit its own utility eventually. This result establishes a strategic stability property of the resource exchang protocol. We further illustrate and confirm the result via network examples.

Uniform Information Exchange in Multi-channel Wireless Ad Hoc Networks

Yong Zhang

Information exchange is a basic primitive for maintaining the smooth running

of a network. In particular, k packets are initially stored at k nodes, and the problem is to disseminate the k packets to the whole network with the objective of minimizing the time used. We study this problem in single-hop multi-channel networks of n nodes, and target on devising uniform distributed protocols that do not rely on any prior knowledge of network parameters, such as the network size n or the number of packet holders k. Uniform protocols have better scalability and are more suitable for implementation in reality. Specifically, we propose a uniform distributed protocol that with high probability accomplishes the dissemination in $O(k/\mathcal{F}+\mathcal{F}\cdot\log n)$ rounds, assuming $\mathcal{F}$

available channels. This protocol is asymptotically optimal when k is large ($k \geq \mathcal{F}^2 \cdot \log n$), and provides the best possible linear speedup with multiple channels comparing the results using a single channel. To the best of our knowledge, this is the first uniform protocol for information exchange in multi-channel networks.

Vehicle assignment with maintenance constraints

Balazs David, Miklos Kresz

The daily schedules of a public transportation company are created by solving the vehicle scheduling problem (VSP), and contain all the timetabled travel tasks that have to be executed on the specific days. These schedules are usually given in advance for a longer planning period of several weeks or months. The solution of the VSP only assigns a required vehicle type to each schedule, but does not give the exact vehicles for their execution. However, this information is needed for solutions that are used in a real-world application.

We investigated this problem in a previous paper, which gives a network flow model for the solution of the assignment. The model considers certain important constraints: apart from their timetabled tasks, vehicles also have to carry out specific activities on the days when they are in service. The most important activities are moving vehicles from and to garages at the beginning and end of the given day, and visiting refueling stations after a daily schedule is carried out.

However, an important real-world constraint is not examined in the paper mentioned above: considering a longer planning period, vehicles also have to undergo regular mechanical inspections after a predefined time (usually after several days of service). Our aim is to expand our previously proposed model, and introduce different states for the vehicles depending on the number of days they spent in service without any inspection. Using this additional information, the status of the vehicles is easily monitored, and they can be sent to inspections if needed. The results of this expanded model are presented on real-world instances.

Vehicle scheduling based on stochastic trip times

Yindong Shen

Vehicle scheduling plays a profound role in public transit planning. Tra-

ditional approaches for the Vehicle Scheduling Problem (VSP) are based on a set of predetermined trips in a given timetable. Each trip contains a departure point/time and an arrival point/time whilst the trip time (i.e. the time duration of a trip) is fixed. Based on fixed durations, the resulting schedule is hard to comply with in practice due to the variability of traffic and driving conditions. To enhance the robustness of the schedule to be compiled, the VSP based on stochastic trip times instead of fixed ones is studied. The trip times follow the probability distributions obtained from the data captured by Automatic Vehicle Locating (AVL) systems. A network flow model featuring the stochastic trips is devised to better represent this problem, meanwhile the compatibility of any pair of trips is redefined based on trip time distributions instead of fixed values as traditionally done. A novel probabilistic model of the VSP is proposed with the objectives of minimizing the total cost and maximizing the on-time performance. Experiments show that the probabilistic model may lead to more robust schedules without increasing fleet size.

w-Centroids and Least (w,l)-Central Subtrees in Weighted Trees

Liying Kang, Erfang Shan

Let T be a weighted tree with a positive number w(v) associated with each of vertices and a positive number l(e) associated with each of its edges.

In this paper we show that each least (w,l)-central subtree of a weighted tree either contains a vertex of the w-centroid or is adjacent to a vertex of the w-centroid. Also, we show that any two least (w,l)-central subtrees of a weighted tree either have a nonempty intersection or are adjacent.

Which product to sell in addition? A machine learning approach to extract and exploit customer buying patterns

Markus Döhring, Esther Mohr

We address the problem of identifying additional selling potentials for multiple customers. In practice, products are sold mostly based on fixed lists sales representatives go through. Especially for areas with a diverse product/customer portfolio or new markets/countries this leads to improper product recommendations because the customers' actual buying patterns are unknown. We apply machine learning techniques to extract and exploit buying patterns from historic sales data. We determine additional selling

potentials and translate these into product recommendations with respect to customer insights like the highest (cross) buying potential or contribution margin potential. This enables sales representatives to take case-based decisions which product to sell in addition to which customer.

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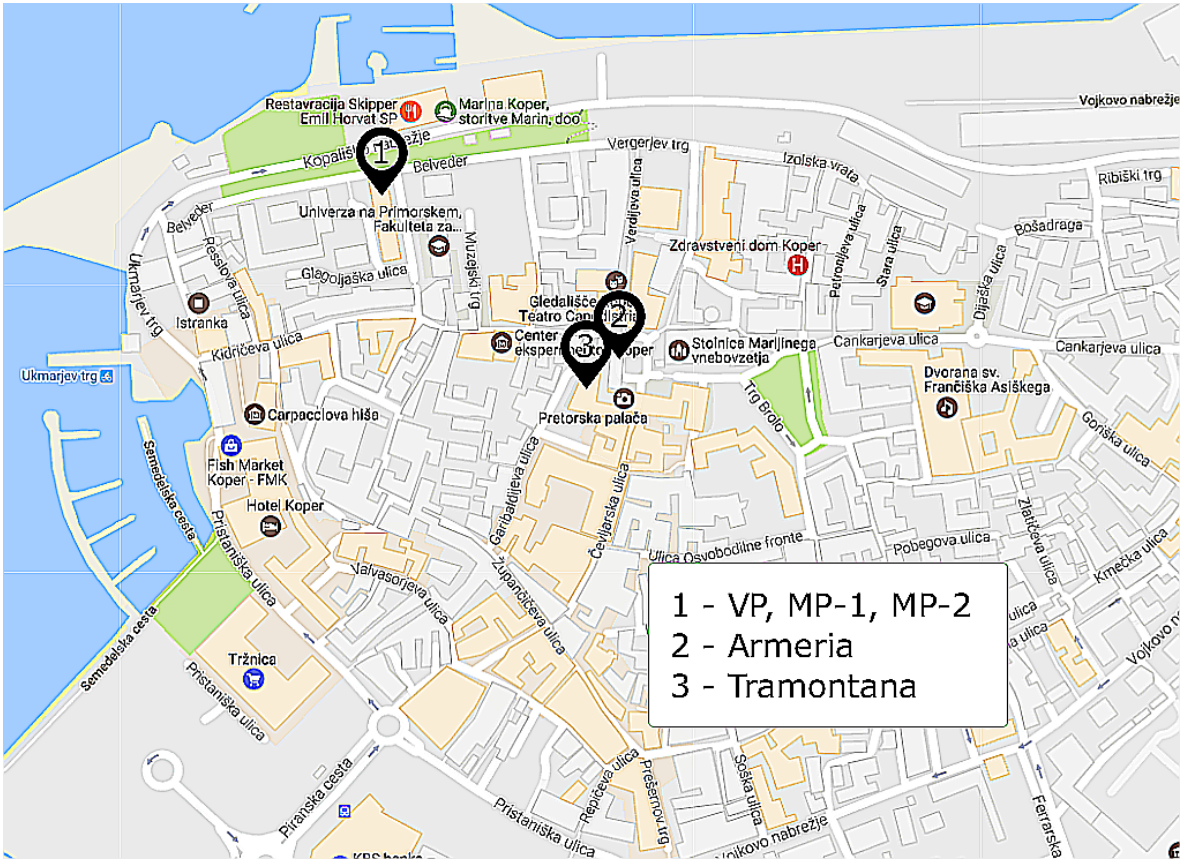
Notes


1 - VP, MP-1, MP-2
2 - Armeria
3 - Tramontana
Restavracija Skipper Emil Horvat SP
Marina Koper, storitve Marin, doo
Vojkovo nabrežje
Kopališko nabrežje
Belveder
Vergerjev trg
Izolska vrata
Ribiški trg
Univerza na Primorskem, Fakulteta za...
Verdijeva ulica
Zdravstveni dom Koper
Petronijeva ulica
Stara ulica
Dijaška ulica
Pošadraga
Ukmarjev trg
Glagoljaška ulica
Muzejski trg
Gledališče Teatro Cantrida
Istranka
Kidričeva ulica
Stolnica Marijinega vnebovzetja
Cankarjeva ulica
Dvorana sv. Frančiška Asiškega
Carpacciova hiša
Pretorska palača
Trg Brolo
Goriška ulica
Fish Market Koper - FMK
Semedelska cesta
Hotel Koper
Garibaldijeva ulica
Cevljarska ulica
Ulica Osvobodilne fronte
Pobegova ulica
Zlatoličeva ulica
Kmečka ulica
Pristaniška ulica
Valvasorjeva ulica
Župančičeva ulica
Tržnica
Piranska cesta
Repičeva ulica
Prešernov trg
Soška ulica
Ferrarska