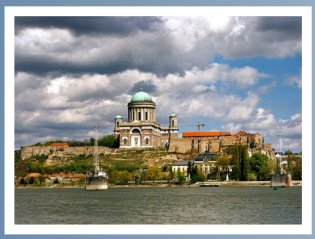

VOCAL 2016

PROGRAM and ABSTRACTS

VOCAL 2016
Program and Abstracts

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Contents

VOCAL 2016

The 7th VOCAL Optimization Conference: Advanced Algorithms is held at the St. Adalbert Conference Center in Esztergom, Hungary, December 12-15, 2016.

Conference scope

The VOCAL conference focuses on recent advances on optimization algorithms: continuous and discrete; complexity and convergence properties, high performance optimization software and novel applications are reviewed as well. We aim to bring together researchers from both the theoretical and applied communities in the framework of a medium-scale event.

Plenary Invited Speakers

Yves Crama

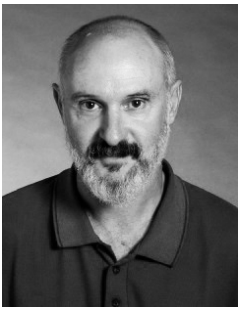
University of Liege, Liege, Belgium

Yves Crama is Professor of Operations Research and Production Management, and the former Director General of HEC Management School of the University of Liege, in Belgium. He holds a Ph.D. in operations research from Rutgers University, New Jersey, USA. Before moving to Liege, he has held faculty positions at the University of Delaware (USA) and at Maastricht University (NL). He is interested in the theory and in the applications of discrete mathematics and discrete optimization, with an emphasis on Boolean models and algorithms, and on models arising in operations management and in applied economics. He has coauthored 5 books and over 80 scientific papers on these subjects. He has delivered invited

plenary lectures at major conferences in several countries. He was the Keynote Distinguished Lecturer of the International Federation of Operations Research Societies at the INFORMS 2011 Annual Meeting, Charlotte, NC, USA. He is one of the editors-in-chief of 4OR - The Quarterly Journal of the Belgian, French and Italian Operations Research Societies, and he is an Associate Editor of Discrete Applied Mathematics, Discrete Optimization, and Journal of Scheduling.

Shmuel Onn

Technion - Israel Institute of Technology, Haifa, Israel



Shmuel Onn is a Professor of Operations Research and the Dresner Chair at IE&M, Technion. He received his Ph.D. from Cornell University in 1992 and is a frequent visitor of the Mathematical Research Institutes at Berkeley, Banff, Oberwolfach, and ETH Zürich, where he delivered the Nachdiplom Lectures in 2009. He is a recipient of the 2010 INFORMS Computing Society Prize, 2009 IBM Faculty Award, 2005 Henry Taub Prize, and 2005 ORSIS Prize. He is the author of the research monograph Nonlinear Discrete Optimization published by the European Mathematical Society in 2010. Over the last several years Shmuel Onn has been pioneering a new theory that uses Graver bases to solve large linear and nonlinear integer programs efficiently and in polynomial time.

Franz Rendl

University of Klagenfurt, Klagenfurt, Austria

Franz Rendl, a full professor at the University of Klagenfurt, is heading a research group in Operations Research and Optimization. He was visiting professor at the University of Waterloo (Ontario, Canada), Massey University (New Zealand), University of Augsburg(Germany), University Paris 6 (France), and IASI Rome (Italy). Franz Rendl is on the editorial board of the following journals: Mathematical Programming, SIAM Journal on Optimization, Computing, Journal of Combinatorial Optimization, and Discrete Optimization.

Franz Rendl has more than 100 papers in journals on mathematical optimization and operations research. His current research interest covers semidefinite programming and its applications in combinatorial optimization, in eigenvalue optimization, and to develop bundle methods for solving non-smooth optimization problems.

Robert Weismantel

ETH, Zurich, Switzerland

Robert Weismantel is a Professor of Mathematics at the ETH Zürich. Previously he worked as Associate Head of department Optimierung at ZIB, Berlin, and Professor (C4) for Mathematical Optimization at the University of Magdeburg. The last several years Robert Weismantel has received many honors. In 1997 he rewarded with the Research award of the Gerhard Hess-Program for young scientists of the German Science Foundation. In 2007 and 2010 he honored with the IBM-Faculty Award. Furthermore in 2010 he was Invited speaker at the International Congress of Mathematicians in Hyderabad, India. In 2015 Robert Weismantel rewarded with the Farkas Prize for outstanding contributions to the field of optimization, from the INFORMS Optimization Society.

Ramin Zabih

Cornell University, Ithaca, NY, USA

Ramin Zabih is professor of computer science at Cornell University, Ithaca, NY, USA. His research interests lie in computer vision and in medical imaging. He has worked on a variety of problems in early vision, including motion and stereo; many of these problems can be solved very accurately using algorithms based on graph cuts, which was given the Helmholtz Prize at ICCV 2011/13 and the Koenderink prize at ECCV 2012 for contribution that have stood the test of time. He served as a Program Chair for CVPR 2007, and for the International Workshop on Computer Vision 2008, 2010, 2012 and 2014, and was General Chair for CVPR 2013. He was the Editor-in-Chief of the IEEE Transactions on Pattern Analysis and Machine Intelligence from 2009 through 2012, and from 2013 through mid 2015 he chaired the PAMI-TC, which runs the main vision conferences. He is the president and founder of the Computer Vision Foundation, a non-profit which now co-sponsors CVPR and ICCV with the IEEE Computer Society, and for which he was awarded the 2016 Everingham Prize. Since the fall of 2013 he is at Cornell NYC Tech with a joint appointment in Weill Cornell Radiology. His medical work has focused on the problem of MR image reconstruction, as well as on workflow issues. During 2016 and 2017 he is on leave at Google Research in NYC.

Technical Program

December 12, 2016 (Monday)

2:00 pm – 6:20 pm **Registration Office Open**

3:30 pm – 5:00 pm **Tutorial Session**
Free Software for the Education of Supply Chain Optimization
Éva König, Anikó Bartos, Botond Bertók

5:00 pm – 5:20 pm **Coffee break**

5:20 pm – 6:20 pm **Invited Plenary Tutorial Session**
Pseudo-boolean Optimization in Computer Vision
Ramin Zabih

6:30 pm – 7:10 pm **Orientation walk:** 2,5 km easy guided sightseeing in the old town (additional registration required)

7:10 pm – 7:50 pm **Prímás Winery wine-tasting** (additional registration required)

December 13, 2016 (Tuesday)

8:00 am – 5:30 pm **Registration Office Open**

9:00 am – 9:30 am **Opening ceremony**

9:30 am – 10:20 am **memorial Lecture**

In memoriam prof. András Prékopa
Endre Boros

10:20 am – 11:20 am **Invited Plenary Session 1**

Integer Polynomial Optimization
Robert Weismantel

11:20 am – 11:40 am **Coffee break**

11:40 am – 12:55 pm **Parallel Session 1A: András Prékopa memorial stream**

Bounds and Approximations for Stochastic Optimization Problems
Georg Pflug

PNBSolver: A modelling and solution system for two and multi-stage stochastic programming problems
Achim Koberstein, Csaba I. Fábián, Christian Wolf

Production order scheduling with stochastic operation times
Tamás Ruppert, János Abonyi

11:40 am – 12:55 pm **Parallel Session 1B: Networks and graphs**

Function based estimation of infection spreading
András Bóta,Lauren Gardner

Approximability of some scheduling and graph coloring problems
Zsolt Tuza, György Dósa, Hans Kellerer

Exact values of the enforcement value of soft correlated equilibria for simple, two-person, linear congestion games
Ferenc Forgó

1:00 pm – 2:30 pm **Lunch**

2:30 pm – 3:30 pm **Guided tour in the Esztergom Basilica**

3:30 pm – 4:00 pm **Organ Concert in the Esztergom Basilica**

4:00 pm – 4:15 pm **Coffee break**

4:15 pm – 5:30 pm **Parallel Session 2A: András Prékopa memorial stream**

Contributions to the modeling and forecasting of nonlinear time series
Edith Kovács, Tamás Szántai

Information driven machine learning method for forecasting supply chain demand
Tamás Szántai, Edith Kovács, Csaba Rendek

Optimizations of free polynomials in non-symmetric variables using NCSOStools
Kristijan Cafuta

4:15 pm – 5:30 pm **Parallel Session 2B: Heuristics**

Tight Online Bin Packing Algorithm with Buffer and Parametric Item Sizes
József Békési, Gábor Galambos

The strip covering problem and heuristic algorithms
Tamás Bartók, Csanád Imreh

Bin packing problem with scenarios
Attila Bódis, Csanád Imreh

4:15 pm – 5:30 pm **Parallel Session 2C: Applications**

The formalization of a multi-objective optimization problem for molecular design
Gyula Dörgő, János Abonyi

Process mining based analysis of changeover times - an integrated approach to support line balancing
Dániel Leitold,Ágnes Vathy-Fogarassy, János Abonyi

Test sequence optimization using survival analysis
János Baumgartner, Zoltán Süle, Péter Mezőségi, János Abonyi

6:00 pm – **Dinner** & **Wine:**
6 sort of wine-tasting at the famous Hilltop Winery and an excellent dinner at the end (additional registration required)

December 14, 2012 (Wednesday)

8:30 am – 5:30 pm **Registration Office Open**

9:00 am – 10:00 am **Invited Plenary Session 2**

Quadratic reformulations of nonlinear binary optimization problems
Yves Crama

10:00 am – 10:20 am **Coffee break**

10:20 am – 12:25 pm **Parallel Session 3A: Linear optimization**

A class of valid inequalities for multilinear 0-1 optimization problems
Elisabeth Rodriguez Heck, Yves Crama

Monotonic build up simplex algorithms for the maximum flow problem
Richárd Molnár-Szipai, Tibor Illés

Preprocess algorithm for Linear Programming
Zsolt Benczúr

Runtime problem relaxation to improve the simplex algorithm
Péter Böröcz, Péter Tar, István Maros

Towards the inclusion of artificial intelligence in the simplex method
Bálint Stágel, István Maros

10:20 am – 12:25 pm **Parallel Session 3B: Scheduling**

Allocation of resources to time constrained jobs with S-graph
Tibor Holczinger

Mobile Workforce Assignment and Scheduling Optimization
Márton Frits, Botond Bertók

S-graph based reactive scheduling
Zsolt Nemes, Máté Hegyháti

A novel combinatorial approach for the resource-constrained scheduling problem

Olivér Ősz, Máté Hegyháti

Heuristics for creating vehicle schedules in practice
Balázs Dávid, Miklós Krész

10:20 am – 12:25 pm **Parallel Session 3C: Optimization software and simulation**

The ABFC defuzzification method in Critical Path Method models and its application
Dombi József, Vincze Nándor

Integrating combinatorial algorithms into an LP-solver
Anita Varga, Richárd Molnár-Szipai

Numerical analysis of parallel implementation of the reorthogonalized ABS methods
Szabina Fodor , Zoltán Németh

Secure Distributed Maximum and Maximal Clique Algorithms
Szilvia Lestyán

High Level Interface for Turing Machine Simulation
György Maróti

12:25 pm – 2:00 pm **Lunch**

2:00 pm – 3:00 pm **Invited Plenary Session 3**

Semidefinite Relaxations for some Graph Problems based on the Exact Subgraph Idea
Franz Rendl

3:00 pm – 3:20 pm **Coffee Break**

3:20 pm – 5:25 pm **Parallel Session 4A: Theory of optimization**

Support theorems in an abstract setting
Anrzej Olbrys, Zsolt Páles

On computing the principal eigenvector of nonnegative matrices by the method of cyclic coordinates
Kristóf Ábele-Nagy, János Fülöp

On the additivity of ranking in generalized tournaments
László Csató

Strengthening the Lovász theta number towards the chromatic number of a (small) graph
Igor Dukanovic

Pairwise comparison matrices and efficient weight vectors
Sándor Bozóki

3:20 pm – 5:25 pm **Parallel Session 4B: András Prékopa memorial stream**

Recent developments in Optimization Services (OS)
Horand Gassmann, Jun Ma, Kipp Martin

Scenario Min-Max Optimization and the Risk of Empirical Costs
Algo Carè, Simone Garatti, Marco C. Campi

Reliability Analysis of Production Systems
Ákos Orosz, Zoltán Kovács, Ferenc Friedler

A note on computational experience with modified L-shaped decomposition for convex stochastic programs
Jakub Kůdela, Pavel Popela

A Waste Management System Modelled by Stochastic Programming
Pavel Popela, Dušan Hrabec, Jan Roupec, Radovan Šomplák, Martin Pavlas, Jakub Kůdela

7:00 pm – **Conference Banquette in the Primate Cellar**

December 15, 2016 (Thursday)

8:30 am – 2:00 pm **Registration Office Open**

9:00 am – 10:00 am **Invited Plenary Session 4**

A Polynomial Time Theory of Integer Programming
Shmuel Onn

10:00 am – 10:20 am **Coffee break**

10:20 am – 12:25 pm **Parallel Session 5A: András Prékopa memorial stream**

Mathematical models from sports rating to portfolio optimization
András London

Enhanced cutting-plane methods for two-stage stochastic programming problems
Csaba I. Fábián

Third-order stochastic dominance in portfolio optimization
Miklós Kopa, Thierry Post

A financial systemic risk analysis using copula orderings
Sándor Guzmics, Georg Pflug

Stress-testing of pension fund ALM models with stochastic dominance constraints
Sebastiano Vitali, Miklós Kopa, Vittorio Moriggia

10:20 am – 12:25 pm **Parallel Session 5B: Applications**

Evaluation of the energy options of a manufacturing firm by the P-graph methodology
András Éles, Adrián Szlama, István Heckl, Heriberto Cabezas

General Mixed-Integer Linear Programming model for mobile workforce management with handling of unexpected delays
András Éles, István Heckl

Optimal Line Balamncing and Production Scheduling for Computer Assembly Lines
Botond Bertók

Optimal scheduling of examination appointments focusing on oncology protocol
János Baumgartner, Éva König, Zoltán Süle

A Two-Step Approach for Planning Building-Evacuation Routes via the P-graph Methodology
Juan Carlos García Ojeda, Botond Bertók, Ferenc Friedler

12:25 am – 2:00 pm **Lunch**

2:00 pm – 3:40 pm **Parallel Session 6A: Global optimization**

Parallel Implementation of GLOBAL with Applications to Nanophotonical Detector Development
Tibor Csendes, Balázs Bánhelyi, Mária Csete, Dániel Zombori, Gábor Szabó, András Szenes

Interior point algorithm for sufficient LCPs using Darvay's directions
Tibor Illés, Csilla Majoros

An Optimization-based Reconstruction Algorithm for Multivalued Discrete Tomography
Petra Renáta Takács, Zsolt Darvay

Multi- Objective Time-Cost- Reliability Optimization in Supply Chain Network by a Novel Hybrid Meta-Heuristic Algorithm
Hamed Asadi, Nasser Shahsavari-Pour

2:00 pm – 3:40 pm **Parallel Session 6B: P-graph**

Process Network Synthesis for Steady State and Dynamic Behavior by P-graphs and Petri Nets
Rozália Lakner, Botond Bertók

Effective algorithm for synthesizing optimal multiperiod production processes by P-graphs
Zsolt Ercsey, Zoltán Kovács, Botond Bertók

Parameter tuning for a cooperative parallel implementation of process-network synthesis algorithms
Anikó Bartos, Botond Bertók

3:40 pm – **Closing the Conference**

Abstracts

Pseudo-boolean optimization in computer vision

Ramin Zabih
Cornell University, Ithaca, NY, USA

Pseudo-boolean optimization methods have had a surprisingly large impact on computer vision over the last 15 years. They are widely used for problems such as computing stereo depth, stitching images together, and segmenting images into foreground and background. Their impact extends to industry as well as academia; these methods are used in Microsoft Office and in Google Maps. I will summarize the most important algorithms, and talk about some work on the research frontier.

Integer Polynomial Optimization

Robert Weismantel
ETH, Zurich, Switzerland

This talk deals with the problem of optimizing polynomial functions over the lattice points in a polyhedron when the number of variables is a constant.

We explain why the problem is already hard in dimension two for polynomial functions of degree four. Then we will discuss how to solve the problem in polynomial time when the function is a quadratic polynomial in two variables.

Further complexity results about optimizing homogeneous polynomials and cubic polynomials over the integer points in polyhedra in dimension two will be presented too.

In arbitrary but fixed dimension the optimization of a polynomial over the lattice points in a polyhedron remains computationally challenging.

When the polynomial is positive over a polytope, we show that there exists an FPTAS for approximating its maximal value that is based on Barvinok's algorithm for counting the number of lattice points in polyhedra. In order to develop an FPTAS for further classes of nonlinear functions to be minimized over integer points in polyhedra, we propose a framework that combines the techniques of Papadimitriou and Yannakakis with ideas similar to those commonly used to derive certificates of positivity for polynomials over semialgebraic sets. Generally speaking, we work with classes of "basic functions". Then, for a given f, we try to detect a decomposition of f as a finite sum of products of a so-called "sliceable function" and a basic function f_i. Roughly speaking, sliceable functions can be approximated by subdividing the given polyhedron. For instance, the set of all convex functions presented by a first order oracle that are nonnegative over a given polytope could serve as a class of basic functions, because we can solve the problem for any member in the class in polynomial time when n is fixed. Our technique allows us to prove the following result.

Let Q be a symmetric matrix with integer coefficients and let n be fixed. Then there is an FPTAS for minimizing $f(x) = x^T Qx$ over the integer vectors x in a polytope in the following cases:

1. Q has at most one negative eigenvalue;

2. Q has at most one positive eigenvalue.

The talk is based on four papers that emerged from joint work with the following people: Robert Hildebrand, Raymond Hemmecke, Matthias Köppe, Alberto del Pia, Jesus de Loera and Kevin Zemmer.

Bounds and Approximations for Stochastic Optimization Problems

Georg Pflug
University of Vienna, Austria

Stochastic Optimization Problems are typically large and cumbersome to solve. On the other hand, there are numerous ways of finding bounds for optimal values, which are much easier to get. We review some bounding techniques for multistage problems based on subtrees. Other methods require convexity and are based on known convex inequalities. Notice that Andras Prekopa's work dealt to a large extent with bounding techniques for distributions, the moment problem and related questions. Although our goal is slightly different, there is some relation to Andras' work.

PNBSolver: A modelling and solution system for two and multi-stage stochastic programming problems

Achim Koberstein
European University Viadrina, Germany
Csaba I. Fábián
Pallasz Athéné University, Hungary

Over the recent years we have been developing a modelling and solution system for two and multi-stage stochastic programming problems. Embedded in the COIN-OR framework, it extends the FlopC++ modelling language for stochastic programs and provides a parallelized implementation of the nested Benders' decomposition algorithm. Several computational techniques have been devised and combined to speed up the solution process, such as cut aggregation and consolidation, dynamic sequencing, level regularization and on-demand accuracy. Furthermore, the on-demand accuracy approach has been extended to a conditional value at risk constraint. In this talk we would like to give an overview of the system and discuss projected future extensions.

Production order scheduling with stochastic operation times

Tamás Ruppert
University of Pannonia, Hungary

János Abonyi
University of Pannonia, Hungary

The capacity of multi product production lines can be optimized by determining the optimal production order when changeovers frequently occur and the products have significantly different complexity. The problem becomes difficult when the operation times show significant stochastic nature due to the variation of the performance and skills of the human operators.

We utilize Monte-Carlo simulation to study the effect of the stochastic nature of operational times in a well-balanced assembly line and study the performance losses caused by the product changeovers. We apply a genetic algorithm to determine the optimal sequence of the production and analyse how the uncertainties of the assembly times influences the optimal strategy of the scheduling.

We demonstrate the applicability of the proposed method in realistic and reproducible examples. These examples illustrate how the integrated analysis of uncertainties should production scheduling.

Function based estimation of infection spreading

András Bóta
University of New South Wales, Australia
Lauren Gardner
University of New South Wales, Australia

Infection models can be used to model the spread of disease, information, behaviour and many other things through a network composed of connected nodes. The field received much attention in recent years and has many applications in sociology, economics and the medical sciences. The specific models we discuss in this talk are all variants of the traditional discrete compartmental models including the SI, SIR and SEIR models. These models assign states to the nodes of the network and transition from state to state is guided by real values on the links of the network called transmission or edge infection probabilities.

One of the common challenges arising in the application of infection models is the lack of available edge infection values. The task of inverse infection is the systematic estimation of these values. Several methods have been proposed recently for the estimation of these values. While most of the proposed methods aim to compute methods directly, in this talk we take a different approach. A handful of existing methods [1, 2, 3] formulate the missing values as functions of node or edge attributes, using additional information available on the task. This information is available in many real-life applications, only their relation to the transmission probability is unknown, hence the function formulation. In this situation the task of inverse infection changes to the estimation of either the function itself or its coefficients. This can be justified in two ways. 1. It makes the estimation task somewhat easier (the difficulties lay elsewhere) 2. Since it identifies the relation between the attributes and the transmission probability, it helps to put the latter into proper context.

In this talk we follow the framework proposed in [2], to show a general way to formulate the function based edge estimation task, show a novel application in epidemics and elaborate on the feasibility of such tasks.

References

[1] A. Bóta, M. Krész, A. Pluhár, The inverse infection problem. Proceedings of the 2014 Federated Conference on Computer Science and Information Systems (2014) 75-83. http://dx.doi.org/10.15439/978-83-60810-58-3.

[2] L. M. Gardner, D. Fajardo, S. T. Waller, O. Wang, S. Sarkar, A Predictive Spatial Model to Quantify the Risk of Air-Travel-Associated Dengue Importation into the United States and Europe. Journal of Tropical Medicine, 2012 (2012). http://dx.doi.org/10.1155/2012/103679

[3] X. Wu, A. Kumar, D. Sheldon, S. Zilberstein, Parameter Learning for Latent Network Diffusion. Proceedings of the Twenty-Third international joint conference on Artificial Intelligence (2013) 2923-2930.

Approximability of some scheduling and graph coloring problems

Zsolt Tuza
MTA Rényi Institute, Hungary
University of Pannonia, Hungary

György Dósa
University of Pannonia, Hungary

Hans Kellerer
University of Graz, Austria

We consider problems of scheduling jobs on a given number of machines, with some further restrictions on the assignments. The objective is to minimize the makespan, i.e., to finish all jobs as soon as possible. Two types are discussed: Multiprofessor Scheduling, and Restricted Assignment Scheduling with Resources. Several variants admit handling with graph-theoretic methods to design efficient exact or approximation algorithms, and also to prove hardness results for some others. A natural subproblem leads to the chromatic number of graphs whose independence number is equal to 3. Our main negative result states that this problem is APX-complete, i.e. cannot be approximated in polynomial time within (1+c) precision for all c¿0, unless P=NP (while the number of vertices is a trivial 3-approximation for the optimum).

An Optimization Approach for the Eigenvalue Method

Ferenc Forgó
Corvinus University, Hungary

It was shown in Forgó F. (2010, A generalization of correlated equilibrium: A new protocol. Mathematical Social Sciences 60:186-190) that a new concept called "soft correlated equilibrium" can improve Nash outcomes even for games where other means of correlation fail to do so. Simple, two-person, linear congestion games are good examples for its effectiveness. A worst case measure of its power is the enforcement value which relates the absolute maximum of achievable social welfare (defined as the sum of utilities of the players) to the maximum social welfare obtainable by correlation. Exact values of the enforcement value are determined for non-increasing and mixed simple, two-person, linear congestion games. It is shown how certain social dilemma games and their generalizations can be represented by congestion games and how the bounds determined for the enforcement value can be interpreted in this context.

Contributions to the modeling and forecasting of nonlinear time series

Edith Kovács
Department of Diff.equ. BUTE, Hungary

Tamás Szántai
Department of Diff.equ. BUTE, Hungary

In various domains as engineering, finance, business intelligence, meteorology, telecommunication the forecasting of future values starting from an observed time series represents a crucial problem. These time series very often are nonlinear. In these cases the time horizon and the lag cannot be detected by using the sample autocorrelation (ACF) and partial autocorrelation (PAC) matrices.

Starting from 1994 the statistic R was introduced by Granger and Liu in the field of time series. This uses the concept of relative entropy (mutual information) and the partial Rp statistic based on the partial mutual information. Also many papers were dealing with the case of Gaussian time series.

In the last decades many machine learning procedures have drawn the attention of this field and have established themselves as serious contender to the classical statistical methods. The empirical accuracy of several machine learning models has been explored in several forecasting competitions.

In our talk first we will present a new information theoretic approach for detecting the time horizon. Then we introduce probabilistic machine learning approach for the forecasting problem. We only suppose the stationary property to be fulfilled for the time series. Our methodology will be illustrated on financial data.

Information driven machine learning method for forecasting supply chain demand

Tamás Szántai
Department of Diff.equ. BUTE, Hungary

Edith Kovács
Department of Diff.equ. BUTE, Hungary

Forecasting of demands is one of the central problems of supply chain management. Many times the experts or the classical models cannot properly understand the changing demand patterns and fluctuations. The problem studied in the paper is to forecast the periodic demand as good as possible.

The method presented in the talk consists of two steps. In the first step there are discovered some conditional independencies which reduces the size of the probabilistic machine learning task in step two. The first step is very useful for cases when the data size is not big enough for the machine learning task based on multiple attributes. The method is illustrated on real and simulated data.

Optimizations of free polynomials in non-symmetric variables using NCSOStools

Kristijan Cafuta
University of Ljubljana, Slovenia

Numerous applied problems have matrices as variables, and the formulas therefore involve polynomials in matrices. To handle such polynomials we need to study non-commutative polynomials.

In this talk we will present algorithms and their implementations in the free Matlab package NCSOStools using semidefinite programming: - to check whether a given non-commutative polynomial in non-symmetric variables can be written as a sum of hermitian squares (SOHS); - to compute a global (eigenvalue) minimum of a symmetric non-commutative polynomial in non-symmetric variables and to extract the minimizers using the Gelfand-Naimark-Segal construction.

Tight Online Bin Packing Algorithm with Buffer and Parametric Item Sizes

József Békési
University of Szeged, Hungary

Gábor Galambos
University of Szeged, Hungary

In this talk we investigate the online bin packing problem with constant buffer size, where the item sizes are in the interval $(0, \frac{1}{r}]$, where $r \geq 2$ is an integer. The problem was originally given by Zheng et al. They gave a lower bound and an algorithm, which were later improved by Zhang et al. We close the gap on the competitive ratio and give a First Fit based optimal algorithm for the parametric version for arbitrary r.

References

[1] M. Zhang, X.Han, Y. Lan, and H-F. Ting: Online bin packing problem with buffer and bounded size revisited. *Journal of Combinatorial Optimization*, DOI 10.1007/s10878-015-9976-5.

[2] Feifeng Zheng, Li Huo, E. Zhang: NF-based algorithms for online bin packing with buffer and bounded item size. *Journal of Combinatorial Optimization*, pp. 360–369, 30(2), (2015).

The strip covering problem and heuristic algorithms

Tamás Bartók
University of Szeged, Hungary

Csanád Imreh
University of Szeged, Hungary

In the strip covering problem our goal is to cover the maximal height from a unit width strip by a given set of rectangles. We present some simple shelf based heuristic algorithm and a more sophisticated local search based algorithm for the solution of the problem. We used worst case analysis to analyse the shelf algorithms and executed an empirical analysis to compare the efficiency of the algorithms.

Our model is an extended version of the restricted strip covering problem where an interval U of the real line is given with a set of sensors, and each of them covers some subinterval and is powered with a battery of limited duration. The goal is to schedule the active time of the sensor to maximize the time interval while the sensors cover the whole interval U. The mathematical model of this problem yields a strip covering, where the width of the strip is the interval U the height is the time.

We also note that our strip covering problem is the dual of the widely studied strip packing problem where one has to pack the rectangles without overlapping into the strip minimizing the height of the used part.

Bin packing problem with scenarios

Attila Bódis
University of Szeged, Hungary
Csanád Imreh
University of Szeged, Hungary

The scenario based scheduling is one of the latest approaches in modeling scheduling problems including uncertainty. In this model, every job is assigned to one or more scenarios and only the jobs of one scenario are realized. However, this chosen scenario is unknown in the time of scheduling, so the algorithms have to consider each scenario.

We introduce a similar model to the bin packing problem which is the dual problem of scheduling. We have a set of items with sizes between 0 and 1, and every item is assigned to one or more scenarios. The items have to be packed into bins such, that for any scenario, the summarized size of items in this scenario is at most 1 in every bin.

The objective function of the standard bin packing problem is to minimize the number of bins. We show some extensions of this objective to the scenario based model. One can consider the scenario with maximal number of bins, or try to minimize the sum of the bins in the scenarios. The objective function can be defined as the number of bins used for all the scenarios. We also introduce a multi-objective optimization model regading the scenarios as the simultaneously optimized objective functions.

We describe the scenario based bin packing problem with the different objectives, and we show some competitive analysis of the standard bin packing algorithms adapted for scenarios.

The formalization of a multi-objective optimization problem for molecular design

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The aim of molecular design is to find the structure with the desired properties, as some properties need to be maximized, or minimized or need to be close to the given targets. We incorporate these conflicting targets into a set of utility functions and apply multi-objective genetic algorithm to generate the set of Pareto optimal solutions.

The genes of the chromosomes represent the molecular fragments, while the originally huge chemical search space is conveniently described by the Joback estimation method. For the satisfaction of the design task property constraints can be defined, while targets are defined in the utility functions. The structural constraints of the molecule can be conveniently described by the relational constraints, these are the number of available groups (fragments) and their relation to each other defined by the octet rule and further equations. The modification of the multi-objective Nondominated Sorting Genetic Algorithm-II (NSGA-II) was carried out for the testing of the proposed methodology, and novel genetic operators were also introduced to ensure reliable structures.

The efficiency of the defined formalization is tested on several benchmark problems, as the search for compounds having desired physical and chemical properties is an essential, yet complex problem in chemical, petrochemical and pharmaceutical industry.

Process mining based analysis of changeover times - an integrated approach to support line balancing

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Since market demands are getting more and more diverse, manufacturing processes need to adapt to decreasing lot sizes. The capacity and (cost) efficiency of assembly lines can be significantly affected by line balancing, which means the optimization of how the minimum rational work elements (tasks) are assigned to workstations and to operators. Line balancing optimization algorithms require detailed models of the production process. The bottleneck of the development of these models is the collection of accurate information about the minimum rational work elements. Instead of the demanding working time and motion analysis we propose an algorithm based on the analysis of historical data of tasks and manufacturing processes. With the novel combination of process mining, time series analysis and systems identification we developed novel tools to estimate process times and evaluate how the production line is balanced.

The maintaining of a continuous flow of processing tasks is desired with a minimum of idle time and a minimum of waiting time. This task is difficult when product changeovers frequent occur, especially when the products have significantly different complexity. To determine the performance loss of these changeovers we developed a mathematical and simulation model and utilized historical data of the production line for model validation. The resulted performance loss model can be used to determine the optimal manufacturing order of products, which can be considered as a special case of the well-known flow shop scheduling problem.

The proposed approached is implemented in Python environment. We demonstrate the applicability of the proposed method in

realistic and reproducible examples. These examples illustrate how the integrated analysis of process data can support line balancing and production scheduling.

Test sequence optimization using survival analysis

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Data mining is an efficient tool to reveal information and to discover correlations derived out of this data. Process mining and event analysis become more and more popular research area for investigating a sequence of events. Examining the available set of information leads straight to the opportunity of either iterative process development or optimization. According to the general interpretation of survival analysis [1][2] a process can be investigated by focusing on a special event of interest, thus an estimation can be given for the expected duration of surviving time.

The Cox's proportional hazard model is capable to divide the entire investigation period into spells (i.e. sub periods) [3]. Thus, the possibility for investigation of different sub periods can be ensured, so the entire process is influenced by each sub process in every well-defined time slot, hence the overall risk and the shape of the survival or hazard function also differs from time to time. We introduce a novel methodology by which time and also cost can be saved by determining the optimal sequence of sub processes in the considered process. Contrary to the classical survival analysis the core idea is to examine the data of a test process consisting of sub process steps, and based on the gained information the sequence of these sub elements can be redesigned. Additionally, when parameters also have to be taken into account, the result of the investigation is affected accordingly. Therefore, parametrical survival patterns can be fitted to the problem, so the risks for each time period can be determined. Using Cox regression we can highlight

those process steps including those relevant parameters which increase significantly the risk. It is also important to emphasize that the fault of a process step not exclusively means the fault of the entire process, it assumes a rising risk of the overall fault. These individual sub hazard functions assigned to the different time periods build up a complex characteristical survival function of the regarded process. An integer programming model will be introduced to formally provide the problem, and the results are illustrated through a realistic example taken from manufacturing data.

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Quadratic reformulations of nonlinear binary optimization problems

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A *pseudo-Boolean function* is a real-valued function $f(x) = f(x_1, x_2, \ldots, x_n)$ of n binary variables. It is well-known that every pseudo-Boolean function can be uniquely represented as a multilinear polynomial in its variables.

Nonlinear binary optimization problems, or *pseudo-Boolean optimization* (PBO) *problems*, of the form $\min\{f(x) : x \in \{0,1\}^n\}$, where $f(x)$ is a pseudo-Boolean polynomial, have attracted the attention of numerous researchers for more than 50 years. These problems are notoriously difficult, as they naturally encompass a broad variety of models such as maximum satisfiability, max cut, graph coloring, simple plant location, and so on.

In this talk, I present recent results (obtained in collaboration Martin Anthony, Endre Boros and Aritanan Gruber) regarding reformulations of nonlinear PBO problems as quadratic PBO problems.

For a pseudo-Boolean function $f(x)$ on $\{0,1\}^n$, we say that $g(x,y)$ is a *quadratization* of f if $g(x,y)$ is a quadratic polynomial depending on x and on m *auxiliary* binary variables $y_1, y_2, \ldots, y_m$ such that $f(x) = \min\{g(x,y) : y \in \{0,1\}^m\}$ for all $x \in \{0,1\}^n$. By means of quadratizations, minimization of f is reduced to minimization (over its extended set of variables) of the quadratic function $g(x,y)$.

The talk addresses two main types of questions. First, we investigate the minimum number of auxiliary y-variables required in a quadratization of an arbitrary function f. This question is rather natural since the complexity of minimizing the quadratic function $g(x,y)$ heavily depends (among other factors) on the number of binary variables (x,y). We establish tight lower and upper bounds on the number of auxiliary variables needed in such a reformulation.

Next, we determine more precisely the number of auxiliary variables required by quadratizations of *symmetric* pseudo-Boolean functions $f(x)$, where a function is symmetric if its value only depends on the number of variables equal to 1.

A class of valid inequalities for multilinear 0-1 optimization problems

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We are interested in the unconstrained minimization of multilinear polynomials in 0-1 variables. A common approach to this problem consists in defining first a linear reformulation of the objective function and then using classical integer linear programming techniques to optimize the reformulation. The standard linearization is a well-known reformulation technique, which has however the drawback of providing weak LP relaxations. We present new valid inequalities, called 2-links, which strengthen the LP relaxation of the standard linearization. The addition of the 2-links to the standard linearization provides a complete description of the convex hull for the case of a function consisting of at most two nonlinear monomials. In our experiments, it results in better bounds and in an improvement of the computational performance of exact resolution methods.

Monotonic build up simplex algorithms for the maximum flow problem

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The maximum flow problem has a cornucopia of algorithms with varying degrees of theoretical and practical efficiency. As a special linear problem, it can be solved with pivot algorithms as well. In fact, the so-called network simplex algorithm is one of the fastest algorithms in practice. As for theoretical results, the primal and the dual simplex algorithms are proven to have strongly polynomial variants (Goldfarb and Hao, 1990; Armstrong, Goldfarb, Hao, Jin, 1997) .

These are not the only pivot algorithms, however, numerous neither primal nor dual pivot algorithms have been devised. One such algorithm family is the monotonic build-up (MBU) algorithms. In the presentation we show that the so-called primal MBU, dual MBU, as well as the feasibility MBU algorithms all have a strongly polynomial variant for the maximum flow problem, expanding upon the labelling technique used by Goldfarb et al.

Preprocess algorithm for Linear Programming

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In my presentation I would like to introduce my preprocess algorithm, which is designed to help solving standard linear programming problems. My method filters out the unnecessary constraints very efficiently with the help of the B-space and n-dimensional hyperboloids, and then these constraints will be executed from the problem, thus the original solving algorithm will have a reduced-size problem, which can be solved more quickly than the initial problem. My algorithm works in any of the dimensions. The point of the process is that the algorithm converts every constraints in B-space and there they can be filtered according to geometric rules. The rules contain the n-dimensional hyperboloids for instance. The B-space form of the conditions that are above the hyperboloid are dominated and hence are redundant. Then the remaining constraints will be classified according to the proportion of its n dimension in the B-space and n dimension of the same point in the hyperboloid. The difficulty of constructing the hyperboloid is that it does not bow toward the usual axes, but toward the positive area in the space with an optional angle. To filter a problem that has n variables and L constraint the algorithm uses $O(n^3L)$ arithmetic operations.

Runtime problem relaxation to improve the simplex algorithm

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Nowadays there exist robust algorithms to solve large-scale linear optimization problems. Even though obstacles like degeneracy and numerical instability can be handled efficiently these issues make the duration of the solution process a major issue. There are several preprocessing methods based on logical correlations to reduce the size of the mathematical model but these techniques cannot use information gathered during the solution process.

In our work we developed a new method to enhance the simplex algorithm by relaxing the feasible domain while granting optimality of the solution using solution time information. This method is based on the two-phase simplex algorithm and elimination of such hyperplanes that have been visited in the second phase of the algorithm. By relaxing the feasible domain the algorithm is likely to find the neighbourhood of the optimal solution faster from which the exact optimum can be found quickly using the original polyhedron.

We implemented this method in the Pannon Optimizer, which is an open-source large-scale linear optimization solver developed at the University of Pannonia. We have evaluated our method and investigated its efficiency during the solution of different classes of problems. In the talk we present our results and point out further research directions.

"Supported by the New National Excellence Program of the Ministry of Human Capacities"

Towards the inclusion of artificial intelligence in the simplex method

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Both linear optimization (LO) and artificial intelligence (AI) are interesting and novel research areas, however combined applications can rarely be found. The Operations Research Laboratory of the University of Pannonia is developing an LO solver for research purposes called Pannon Optimizer. This modular software is a novel tool for implementing and testing new ideas related to the simplex algorithm. Thus it is a suitable candidate for investigating the question of including artificial intelligence in the solution process.

Various heuristic methods contribute to determining the series of basis changes. The operation of these procedures often relies on algorithmic and numeric parameters, so the solution procedure can be customized greatly. In most cases the default parameterization of an LO solver is constructed in such a way that it is efficient for many cases. It often happens, however, that for the solution of a given family of problems fine-tuning of parameterization can result in a great performance improvement. Finding a good combination of the different techniques is not a trivial task. It seems to be worth developing adaptive procedures for changing the parameters of the solver. This way the computational potential of an LO system can be exploited more effectively while supporting the user of the software.

In this research we investigated those parts of the revised simplex method where AI can be included to enhance the solution procedure. Several adaptive procedures were constructed based on our ideas, and some of them were implemented in Pannon Optimizer. The impact on the solution process was analysed using the well-known "LP netlib" problems.

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Allocation of resources to time constrained jobs with S-graph

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The orders of a service provider company usually have to be performed in different locations and they have time constraints like deadlines and strict starting times. If a time constraints of an order is not satisfied, it implies liquidated damages. In the examined problem, the company has orders and teams to perform them. The limited number of teams and their capabilities increase the difficulty of the problem. Each order consists of operations with completion times and costs. The sequence of the operations of each order is given but not necessary sequential, i.e., there may be parallel operations in one order. An order can be assigned to multiple teams but one operation can be performed by only one team. The aim is to assign teams to operations to get the minimal cost which consists of travel costs, operation costs and liquidated damages. The number of orders can be higher than the capacity of the teams. In this case lost orders imply liquidated damages.

The proposed approach relies on the combinatorial algorithms of the S-graph framework, which has been successfully applied to various production scheduling problems in the literature. The original framework is developed to minimize makespan, therefore it has to be extended to handle cost minimization and different time constraints.

Mobile Workforce Assignment and Scheduling Optimization

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Mobile workforce scheduling is a theoretically complex problem. Numerous tasks at various locations need to be assigned to crews. Skills, capabilities, and the level of local knowledge have to be considered to estimate the time required to complete a task by a selected crew. Multiple objectives involves cost, task priorities, and consumer satisfaction. The cost involves the salary of crew members for a whole route from departing to returning to the base location.The cost also depends on the proper routing of the crews and effective collection of closely located tasks into a single route. Priorities of tasks are defined by a function of their deadlines. Consumer satisfaction is proportional to the number of missed appointments. Software frameworks and analysis of MILP models by applying them to infrastructure managements case studies are to be presented.

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S-graph based reactive scheduling

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Uncertainties are natural in the real-life execution of planned schedules: market demand may change, processing units get delayed or break down, etc. Broadly speaking, a production planner may consider some uncertainties with preventive scheduling, and tackle others via reactive scheduling after the events occur. Reactive approaches aim to alter the remaining part of the schedule while considering the issues that already happened, as sticking to the original schedule may result in a sub-optimal, or worse, infeasible plan.

In this work, the S-graph framework is extended to tackle uncertainties in a reactive way. The presented approach provides the schedule with minimal makespan, after one or several uncertain events occur. The new algorithm considers unit breakdowns, delayed productions and infrastructure changes, and can easily be extended to further types of issues. The applicability and efficiency of the developed method is presented via an exhaustive empirical analysis. Iterative testing on the same schedule can also reveal its critical parts, which have the highest influence on the makespan if an uncertain event occurs.

A novel combinatorial approach for the resource-constrained scheduling problem

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In resource-constrained scheduling problems tasks require different quantities from multiple renewable resources at the same time. The goal of the optimization is to obtain a schedule with minimal makespan, where the limits on resource availability are never violated. Recent literature approaches use mixed-integer linear programming, constraint programming and hybrid methods to solve the problem.

This work presents a combinatorial approach based on the S-graph framework. The S-graph algorithms were originally developed for the scheduling of chemical batch processes. Later, the framework was extended to a wider range of scheduling problems, and proven to be a reliable and efficient tool. To address constraints on multiple resources, a new branch-and-bound algorithm was developed. The method relies on the resolution of minimal resource incompatible sets. The construction of these sets is a complex combinatorial problem in itself, for which an efficient algorithm is presented. The new approach was tested through empirical analysis, and compared with literature approaches.

Heuristics for creating vehicle schedules in practice

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The vehicle scheduling problem (VSP) considers the daily trips of a transportation company, and creates a schedule where all trips are serviced exactly once. Such a schedule assigns every trip to the vehicles of the company, minimizing the arising traveling and operational costs. While the solution of the VSP gives an optimal schedule for a single day, its solution usually cannot be used directly by transportation companies. The main difference between the VSP and real-life planning is that companies design their schedules over a planning period. Because of this, the daily schedules cannot be considered as separate problems, and have to be created to show some form of regularity. Moreover, the structure of a daily schedule created by the classic VSP does not consider any vehicle or driver requirements. To our knowledge, only a handful of papers considered such issues with the VSP, see [1,2,3] for some examples. In our presentation, we give heuristic methods that aid the solution of the mathematical model of the VSP, speeding up the solution process significantly, while providing good quality results that can also be used in practice. These methods deal with the similarity and regularity of schedules created for similar days, and also take vehicle specific requirements (eg. time for parking, refueling) into consideration. Our heuristics are tested both on real-lifen and randomly generated instances.

The ABFC defuzzification method in Critical Path Method models and its application

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In this paper we apply the ABFC(Arithmetic Based Fuzzy Control) defuzzification method. We use the special new parametrization in this method for aggregation of the left hand side and the right hand side linear function of fuzzy numbers. We use weighted aggregation form of the fuzzy activity times in this method to calculate the critical path. We give a base of the activity times from which the activity times can be compute with linear combination. In this method the activity times are the coefficients of the linear combination and the weights of the aggregation method.

Integrating combinatorial algorithms into an LP-solver

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While there are numerous linear (and nonlinear) solvers, as well as specialized algorithms for combinatorial problems, they are rarely used together. We wrote a new module for the XPRESS optimizer that lets us call the objects and functions of the LEMON C++ library.

We used this module to compare two versions of the Dual Ascent Procedure (DAP) (Adams and Johnson, 1993). The DAP is an iterative algorithm, it produces lower bounds for the quadratic assignment problem (QAP).

The DAP is based on the level-1 RLT-relaxation (reformulation linearization technique) of the QAP. This formulation is significantly larger than the original QAP, but if we construct its Lagrangian dual, we can decompose the new relaxation to smaller linear assignment problems for a fixed Lagrange multiplier. The algorithm determines a better Lagrange multiplier in every iteration.

We implemented the DAP two different ways. In the first model we solved the smaller linear assignment problems with the linear programming methods of XPRESS, while in the second model we solved them by using the graph algorithms of the LEMON library via the new module.

Using the instances of QAPLIB, the new module produced signicantly better running times, which suggests that this direction of research might yield further results in the future.

Numerical analysis of parallel implementation of the reorthogonalized ABS methods

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Solving systems of equations is a critical step in various computational tasks. We recently published a novel ABS-based reorthogonalization algorithm to compute the QR factorization. Experimental analysis on the Matlab 2015 platform revealed that this new ABS-based algorithm was able to more accurately calculate the rank of the coefficient matrix, the determination of the orthogonal bases and the QR factorization than the built-in rank or qr MATLAB functions. However, the reorthogonalization process significantly increased the computation cost. Therefore, we tested a new approach to accelerate this algorithm by implementing it on different parallel platforms.

The above mentioned ABS-based reorthogonalization algorithm was implemented using Matlab's parallel Toolbox. We have tested various matrices including Pascal, Vandermonde and randomly generated dense matrices. The performance of the parallel algorithm was determined by calculating the speed-up factor defined as the fold reduction of execution time compared to the sequential algorithm. For comparison, we also tested the effect of parallel implementation of the CGS (Classical Gram-Schmidt) algorithm incorporating a reorthogonalization step.

The results show that the achieved speed-up is significant, and also the performance of this practical parallel algorithm increases as the number of equations grows. The results reveal that the reorthogonalized ABS algorithm is practical and efficient. This fact expands the practical usefulness of our algorithms.

Secure Distributed Maximum and Maximal Clique Algorithms

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Problems of secure multi-party computation have been studied by many authors and the popularity of the subject is known to be rising in recent years. The original two-party setting has been extended to arbitrary numbers of participants, and some varieties also exist in the underlying model. This paper presents two secure, distributed algorithms: (1) a maximum clique and (2) a maximal clique enumeration. Both algorithms are based on secure multi-party computation primitives, i.e., none of the participants are allowed to learn the input of any other party participating in the computation. "Honest-but-curious" parties are able to infer information from the output, but gain no additional information besides that. We also consider two additional adversarial settings including malicious parties and eavesdroppers. The paper applies the graph model as we have seen it in distributed computing: (a) nodes of the graph correspond to independent processors (parties), (b) nodes are able to do any local computation, (c) nodes communicate only with their neighbors represented by adjacent nodes in the graph, and (d) nodes know the identity of their neighbors, and have no further information about the global graph. Furthermore, we show how the original algorithm can be altered in order to gain more information regarding the participants in one particular maximal clique. The first, more secure algorithm excludes the possibility for one particular node of knowing the identity of its neighbors who are in the same maximal clique as itself, i.e., during one local computation in the first algorithm one node shall learn only the size of the maximal clique it is part of. With minor modifications, our algorithm solves two other problems of interest, at the expense of weakening security guarantees. In these variants, however, the number of the overall rounds can be substantially reduced. During the development of our algorithms, applicability was among the most important requirements, therefore no garbled circuits were applied in any part of this paper due to their problematic usability. The methods introduced here can be applied for secure and efficient information collection in mesh networks and sensor networks.

High Level Interface for Turing Machine Simulation

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A Mixed-Integer Linear Programming model was developed to address mobile workforce management with schedules prepared for unexpected delays. The main problem involves the allocation of resources over geographically distributed demands. The typical scenario is when a company owns a depot, which acts as a home base for maintenance teams. Each time a demand rises, a single team needs to be dispatched to the destination and execute some jobs termed as tasks. The teams return to the depot at the end of the working day. Finding an optimal schedule for the teams in terms of costs or robustness is very difficult, as mobile workforce management generalizes already computationally costly subproblems like scheduling, traveling salesman, and resource allocation problems.

The proposed model is capable of modeling mobile workforce management in a general manner. The goal was to provide an efficient embeddable tool for optimization software in the future. A wide range of parameters is supported, for example traveling, idle, job execution, packing, unpacking, waiting times, and costs, deadlines for beginnings and endings of tasks, mandatory precedence relations between multiple tasks, and consumable and renewable resource management. For the purpose of obtaining robust schedules, a new notion, the "delay measure" is introduced, which is an informal value showing the expected delays at all points of the working plan, and can make the teams' schedules considerably less vulnerable to unexpected delays. The model is demonstrated on a small benchmark example.

Semidefinite Relaxations for some Graph Problems based on the Exact Subgraph Idea

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It is well known that Semidefinite Relaxations provide a strong machinery for a variety of NP-hard optimization problems on graphs. It has been proposed recently to tighten these relaxations by asking that the restriction of the relaxation to small subgraphs is exact. We will first recall the key ideas underlying this approach. It involves identifying subgraphs which are forced to be exact (separation problem). We discuss several fast heuristics for this separation problem. It turns out that on the computational side, these models provide strong bounds but it is nontrivial to actually solve the resulting semidefinite programs (SDP) using standard approaches.

The main part of the presentation focusses on various computational alternatives to solve these SDP. It turns out that a partial Lagrangian Dual provides an efficient solution approach. It combines the bundle method from convex optimization as the working horse for the outer iterations with the interior-point machinery inside the bundle oracle.

We show the efficiency of this approach for Max-Cut, Stable-Set and Coloring. (this is joint work with my doctoral students Malwina Duda and Elisabeth Gaar)

Support theorems in an abstract setting

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In the theory of convex functions a basic result asserts that every convex function admits an affine support function at each interior point of the domain. Analogously, the existence of a linear support function can be proved for sublinear functions. Motivated by these two results, we define the notions of generalized convexity and affinity for functions mapping an algebraic structure (which is equipped with a family of operations) into an ordered structure (which is also equipped with a family of algebraic operations). We define the relevant notion of interior point and obtain generalizations of the classical support theorems.

On computing the principal eigenvector of nonnegative matrices by the method of cyclic coordinates

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We are proposing a simple method to calculate the principal eigenvalue of positive matrices based on the Perron-Frobenius theorem. The minimax property of the principal eigenvalue makes it possible to formulate a multivariate optimization problem where the elements of the principal eigenvector are variables. This problem can be solved in an iterative way with the cyclic coordinate method.

An extension of this method deals with missing elements in the matrix. In this case the missing elements are additional variables. An application of this method is computing the principal eigenvalue and optimal completion of incomplete pairwise comparison matrices. Computation experiment will be reported.

On the additivity of ranking in generalized tournaments

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Ranking in generalized tournaments with possible missing and multiple comparisons poses serious challenges. An axiomatic approach for the problem is considered. According to the natural additivity property, if object A is preferred over object B in two (sub)tournaments, then this relation should hold on the basis of the entire tournament. Our main result reveals the unfavourable consequences of additivity and two basic axioms. In order to avoid impossibility, a possible solution can be to preserve the relative ranking of two objects only when the subtournaments have the same comparison structure. It is shown that some known ranking methods satisfy this new property.

Strengthening the Lovász theta number towards the chromatic number of a (small) graph

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Consider a simple graph G, its coloring f and the canonical representation of this coloring as a binary matrix C where $c_{ij} = 1$ when the two vertices i and j bear the same color, i.e. $f(i) = f(j)$. Such matrices motivate a copositive representation of the chromatic number whose obvious semidefinite relaxation is the celebrated Lovász theta number.

Likewise given a clique K we introduce similar binary matrix C' where $c'_{ij} = 1$ only when the two vertices are of the same color and additionally this color does not appear on the vertices of the clique K, i.e. $f(i) = f(j) \notin f(K)$. Again defining a copositive representation of the chromatic number and relaxing it in the same obvious way leads to the recently introduced impressive semidefinite strengthening of the Lovász theta number $\Psi_K(G)$. In fact Ψ_K is the only known semidefinite lower bound of the chromatic number which impressively strengthens the Lovász theta number even on random graphs.

As Ψ_K is interesting in the context of branch and bound exact coloring algorithms we study efficient application of the interior point methods to compute $\Psi_K(G)$ on a small graph G.

Pairwise comparison matrices and efficient weight vectors

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Pairwise comparison matrices play a key role in multi-attribute decision making. A weight vector is called efficient (Pareto optimal) if no other weight vector is at least as good in approximating the elements of the pairwise comparison matrix, and strictly better in at least one position. Efficiency can be tested by graph theoretical tools as well as by linear programming, the latter finds a dominating efficient weight vector, too, in case of inefficiency. An open problem of finding a necessary and sufficient condition for the efficiency of the principal right eigenvector is also presented. Lecture slides can be downloaded at http://www.sztaki.mta.hu/ bozoki/slides

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Recent developments in Optimization Services (OS)

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Optimization Services (OS) is an open-source project under COIN-OR and provides infrastructure for the solution of optimization problems over the internet. This includes a number of XML schemas for the transmission of problem instances, options and solutions as well as related information; and interfaces to a number of open-source and commercial solvers. This talk presents recent developments, such as schema elements to describe real-time data, problem modifications, disjunctions, and stochastic information.

Scenario Min-Max Optimization and the Risk of Empirical Costs

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Many decision problems can be formulated as the problem of minimising a convex cost function that also depends on an uncertain variable. A possible way to deal with uncertainty is taking a worst-case approach and minimising the maximum of the cost functions corresponding to various scenarios, i.e., to various instances of the uncertain variable. In this talk, we assume that some previously observed instances of the uncertain variable are available, and we take a data-based approach where *scenarios* are these previously collected observations.

The solution to the resulting optimisation problem is called the *scenario solution*. We define the *empirical costs* as the cost values that the scenario solution incurs for the various scenarios that have been used in optimisation. The *risk* of an empirical cost is defined as the probability that the empirical cost will be exceeded "tomorrow", i.e., when a new instance of the uncertain variable will be experienced.

Traditionally, the risks can be evaluated by resorting to the a-priori knowledge of the distribution of the uncertain variable, which is often unavailable in applications, or by a-posteriori estimation procedures that use new observations that have not been used in optimisation, and this is problematic when observations represent a costly and limited resource. In this talk, we show that a third option is available. In fact, we have proved that the vector of the risks of the empirical costs has an ordered Dirichlet distribution independently of the unknown distribution of the uncertain variable. We argue that based on this result one can construct a probability box for the distribution of tomorrow's cost, without making any assumption on the specific distribution of the uncertainty and without resorting to new observations.

Reliability Analysis of Production Systems

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The complexity of engineering systems have been drastically increased during the last decades. It is, therefore, a key issue how to provide the continuous functionality of a complex system. For this reason, reliability analysis of engineering systems has become a major topic of research. Numerous methods have been developed and published to determine the reliability of various types of systems, e.g., transmission networks, multi-state systems, and communication networks. Even though, these methods are useful for these specific cases, general method that is capable of algorithmically generating the reliability of any system is yet to be developed.

The reliability of an engineering system primarily depends on its structure and the reliabilities of its elements. In the present work, a new method has been developed to determine the reliability of engineering systems with any types of structures. The P-graph framework provides the tool for representing the structure of the system. The fundamental algorithms of the framework, including algorithms MSG and SSG, are also considered in setting up the method. The method is illustrated with solving hypothetical and industrial problems including a gas transmission network.

A note on computational experience with modified L-shaped decomposition for convex stochastic programs

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Brno University of Technology, Czech Republic

During the thirty years, various decomposition techniques related to Benders decomposition ideas have been successfully applied to linear and quadratic stochastic programs.

Specificaly, models of real world engineering problems often involve nonlinear terms in the objective function and/or constraints. In our work, we focus on suggested algorithm's modifications and a computational comparison between different cutting plane methods for convex stochastic programs. These methods are based on the Generalized Benders Decomposition and its different efficient implementations such as bunching and multicut reformulations.

A Waste Management System Modelled by Stochastic Programming

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The purpose of the paper is to discuss the role and importance of stochastic programming approach applied to a general waste management system. Waste management systems in Central European countries will need important changes in the near future. Specifically, they will involve various and well balanced waste treatment options. Among them, we have to deal with the waste recycling and waste use for energy production. Therefore, the whole waste management system composed of particular connected decision making problems must be modelled, transformed, and solved. These problems include a local waste collection, regional transport organization, allocation of specific waste processing units (e.g., landfilling sites, mechanical biological treatment places, and waste-to-energy facilities), and designing and operating decisions about waste-to-energy plants. So, these problems and processes create a complex waste management system involving elements with network-like structure, linear and nonlinear terms, and both continuous and integer variables. In addition, there are uncertain parameters (see, e.g., waste heating values, gate fees, heat demands, heat prices, and electricity prices) dynamically changing within a considered time period. Therefore, stochastic programming has been studied as a possible modelling tool allowing to use suitable computational

techniques. To achieve solvability for real-world data, problems can be modelled separately and satisfiable suboptimal solutions are obtained. Hence, scenario-based programs are used to model waste transportation, wait-and-see models serve to facility operation planning, and here-and-now models help in waste-to-energy facility planning and allocation problems. The principle ideas about the model building are introduced and selected details are precised and discussed. Implementation in GAMS is described and obtained results are analysed for the explanatory and real-world data. At the end, the final conclusions are followed by further research ideas.

A Polynomial Time Theory of Integer Programming

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I will overview our theory that enables to solve broad natural universal classes of linear and nonlinear integer programs in variable dimension in polynomial time, and discuss a recent drastic improvement to fixed-parameter tractable cubic time.

I will describe some of the many applications of this theory, to multi-dimensional table problems and multi-commodity flows, and recent progress on these problems.

Mathematical models from sports rating to portfolio optimization

András London
University of Szeged, Hungary

Making predictions for future events is one of the most interesting research topic in many areas of social-and natural sciences as well. The aim of this talk is to present some of the author's work and results in that direction by applying several techniques of mathematical modelling and optimization.

First we present a model for probabilistic forecasting in sports. By using different linear algebraic rating methods to evaluate the relative performance of sport teams round by round we assign probabilities for the possible outcomes of the upcoming matches. We empirically estimate the predictive power of the method comparing it to the widely-used Bradley-Terry model and also to the forecasts of experts using bookmaker's betting odds data.

Then, we investigate the portfolio selection problem, which is one of the most important problem in asset management, aims at reducing the risk of an investment by diversifying it into independently fluctuating assets. We apply different filtering procedures (Random Matrix Theory, Clustering) to the correlation matrices obtained by Budapest Stock Exchange data. Our results show that estimated risk is much closer to the realized risk of a portfolio using filtering methods. Bootstrap analysis shows that ratio between the realized return and the estimated risk (Sharpe ratio) is also improved by filtering.

Enhanced cutting-plane methods for two-stage stochastic programming problems

Csaba I. Fábián
Pallasz Athéné University, Hungary

Functions involving expectations, probabilities and risk measures typically occur in stochastic programming problems. This means large amounts of data to be organized, and inaccuracy in function evaluations. In this talk we discuss computational issues of decomposing two-stage problems, and of handling probabilistic constraints in static problems.

Third-order stochastic dominance in portfolio optimization

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Thierry Post
Nazarbayev University, Kazakhstan

We develop an optimization method for constructing investment portfolios that dominate a given benchmark portfolio in terms of third-degree stochastic dominance. Our approach relies on the properties of the semivariance function, a refinement of an existing "superconvex" dominance condition, and quadratic constrained programming. We apply our method to historical stock market data using an industry momentum strategy. Our enhanced portfolio generates important performance improvements compared with alternatives based on mean-variance dominance and second-degree stochastic dominance. Relative to the Center for Research in Security Prices all-share index, our portfolio increases average out-of-sample return by almost seven percentage points per annum without incurring more downside risk, using quarterly rebalancing and without short selling.

A financial systemic risk analysis using copula orderings

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University of Vienna, Austria

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University of Vienna, Austria

In the recent years the interest in financial systemic risk research has been growing enormously due to the financial crisis in 2007-08. Practitioners and researchers aim to have a deeper understanding in the operation of financial systems. The first phase of such an analysis is to discover and model the dependency structure between the entities (banks, insurance companies, countries) of a system and then to examine how these interdependencies are changing over time. Most studies also contain an empirical data analysis which can serve as an illustration of the approach and it can also verify the validity of the suggested model.

In our definition systemic risk is the additional risk in the system which arises from the interdependencies of the entities. The abstract notion of the risk can be quantified by risk functionals, i.e. mappings to the real line, which might be also interpreted as the (sometimes hypothetical) price of the risk. Our approach also incorporates the general observation that during 'bad times' the asset prices and other financial indicators are more dependent than during 'good times'. The dependency structure can be described by the copula of the underlying multivariate distribution. Therefore the strength of dependency can be related to certain copula orderings (supermodular, hypermodular, convex, etc). As an alternative, one can investigate the dependency structure with a multivariate life-time based approach, namely in the sense of Marshall-Olkin type models, which naturally lead to the family of Marshall-Olkin copulas. We examine and compare the copula orderings for different orders and different family of copulas, especially in the light of our dataset, which consists of daily CDS spreads of 77 major banks from all over the world on the time horizon 2007-2015.

Stress-testing of pension fund ALM models with stochastic dominance constraints

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Miklós Kopa
Charles University in Prague, Czech Republic

Vittorio Moriggia
University of Bergamo, Italia

The main goal of a pension fund manager is sustainability. We propose an Asset and Liability Management (ALM) model structured as a multi-stage stochastic programming problem adopting a discrete scenario tree and a multi-objective function. Among other constraints, we consider the second order stochastic dominance with respect to a market portfolio. To protect the pension fund from shocks we test the inclusion of hedge financial contracts in the form of put options. Numerical results show that we can efficiently manage the pension fund satisfying liquidity, return, sponsor's extraordinary contribution and funding gap targets. We test sensitivity to put option strikes and to stochastic dominance constraints inclusion.

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Evaluation of the energy options of a manufacturing firm by the P-graph methodology

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A wide range of energy-efficiency and energy production investments were evaluated for a large manufacturing company using the P-graph methodology. The P-graph framework is an effective tool for Process Network Synthesis. The need for multi-period P-graph models arise when production demands or supplies vary significantly along the term of the optimization, and the caused peaks might violate capacity or storage limitations if the design considers average in- and outflows. For that reason, the time frame is divided into multiple periods with their own specific lengths, demands, and supplies.

In the present work, three models are proposed to investigate the renewable energy production potential of a manufacturing company. First, an ordinary (single period) P-graph based model was developed including new energy sources like solar cells and biomass combustion facilities. The second model also takes into account possibilities for energy-efficiency upgrades like insulation, energy-saving light bulbs and upgraded equipment. The third model is expanded into multi-periodic model to address the design of effective heat, electricity and water supply of a large-scale production environment. The model results are analyzed using multiple scenarios.

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General Mixed-Integer Linear Programming model for mobile workforce management with handling of unexpected delays

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A Mixed-Integer Linear Programming model was developed to address mobile workforce management with schedules prepared for unexpected delays. The main problem involves the allocation of resources over geographically distributed demands. The typical scenario is when a company owns a depot, which acts as a home base for maintenance teams. Each time a demand rises, a single team needs to be dispatched to the destination and execute some jobs termed as tasks. The teams return to the depot at the end of the working day. Finding an optimal schedule for the teams in terms of costs or robustness is very difficult, as mobile workforce management generalizes already computationally costly subproblems like scheduling, traveling salesman, and resource allocation problems.

The proposed model is capable of modeling mobile workforce management in a general manner. The goal was to provide an efficient embeddable tool for optimization software in the future. A wide range of parameters is supported, for example traveling, idle, job execution, packing, unpacking, waiting times, and costs, deadlines for beginnings and endings of tasks, mandatory precedence relations between multiple tasks, and consumable and renewable resource management. For the purpose of obtaining robust schedules, a new notion, the "delay measure" is introduced, which is an informal value showing the expected delays at all points of the working plan, and can make the teams' schedules considerably less vulnerable to unexpected delays. The model is demonstrated on a small benchmark example.

Optimal Line Balamncing and Production Scheduling for Computer Assembly Lines

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Integrated method is proposed for line balancing and production scheduling. Line balancing determines the optimal task distribution among the work stations depending on the process structure as well as the number of operators available in the shift. The takt time depends on the line balance and helps predicting the changeover times. Production scheduling considers the calculated changeover times. The method is to be illustrated by optimizing computer assembly.

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Optimal scheduling of examination appointments focusing on oncology protocol

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It is a common social problem that waiting queues are long and chaotic in hospitals and medical centers. In Hungary, a process has been started recently to determine a general medical protocol on the field of oncology. A process that is based on precisely defined rules can be optimized by applying mathematical formalism. In this research, an LP model has been constructed that is capable of providing the optimal schedule of the required examinations to each of the patients. The model and the software were tested on real life cases to ensure the possibility of developing a marketable application.

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A Two-Step Approach for Planning Building-Evacuation Routes via the P-graph Methodology

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In this work, the planning of building-evacuation routes (BERs) inside buildings of small and medium complexity (i.e., total number of floors) has been conducted by adopting the P-graph methodology in light of a two-step approach. As a result, the routing and scheduling of individuals facing a life-threatening situation in such buildings have been optimized. The planning of BERs can be formulated as a process-network synthesis (PNS) problem; in this regard, the P-graph methodology has proven to be highly effective in solving PNS problems. In the approach's first step, the building-floor map is represented by means of a P-graph model, which serves as the input for the algorithm SSG, thereby identifying all feasible BERs. In the approach's second step, each BER is transformed into a time-expanded, process-network synthesis problem (PNST) and optimized algorithmically with the aid of the algorithmic ABB. In the proposed approach, each location in the building and their passages are given by a set of attributes (i.e., room capacity, room's initial occupancy, flow rate and travel time between rooms) to be taken into account in optimizing the BERs. In addition to the globally optimal BER, the P-graph methodology yields the n-best suboptimal BERs that can be ranked according to multiple criteria when computational possible. The viability and effectiveness of the proposed approach are illustrated by resorting to a couple of examples.

Parallel Implementation of GLOBAL with Applications to Nanophotonical Detector Development

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We present a new, Java based implementation of the GLOBAL algorithm to enable it to run more efficiently in multicore computers. The direct motivation for this step were two applications requiring massive amounts of computation from the fields of nanophotonical detector development and surgical operation design.We shall report computational results on the plasmonic problem and also on the speed up achieved.

Interior point algorithm for sufficient LCPs using Darvay's directions

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Linear complementarity problems (LCP) are usually NP-hard problems. The largest matrix class where the interior point algorithms (IPA) are polynomial is the class of P*(κ)-matrices, for given nonnegative real parameter κ. The union for all possible κ parameters of P*(κ)-matrices forms the class of P*-matrices. This class of matrices has been introduced by Kojima et al. in 1991. Cottle et al. (1989) defined the class of sufficient matrices (SU). It has been proved that several variants of the criss-cross algorithm are finite for LCPs with sufficient matrices.

After all of these, it is a natural question: What is the relation between the sufficient and P*-matrices? Väliaho (1996) proved that the P*-matrices are exactly those which are sufficient.

IPAs for LCPs are closely related to the primal-dual IPAs developed for linear programming problems (LPP). Many primal-dual IPAs that solves LPPs efficiently can be generalized for LCPs with P*(κ)-matrices in a way that most of the good characteristics are kept for the larger class of problems.

In 2002 Darvay offered a new technique for finding search directions for LPPs. He introduced a general transformation of the equation defining the centrality path of the LPP. Depending on the real, differentiable and invertible function, φ, applied in the transformation, different search directions can be obtained for the LPP problem. Darvay, in his paper from 2002, used the square root function to transform the equation defining the centrality path. Although, he obtained a different, nonlinear system defining the central path, the Newton-method could be applied to this modified system, as well. The approach of Darvay, led to a new search direction, but the variants of IPAs built on this new search direction possessed the same properties as the IPAs built on the original Newton-directions.

In 2012 Darvay et al. using the real, differentiable and invertible function $\varphi(t) = t - t1/2$, discussed another transformation of the

equation defining the centrality path. Based on this transformation an IPA using the new search direction depending on real function φ was developed.

In this talk we show that transformations developed by Darvay et al. are applicable for LCPs with P*(κ)-matrices and the IPA for this larger problem class keeps the good properties the IPA developed by Darvay et al. for LPPs. The complexity result related to our full step interior point algorithm that uses directions introduced by Darvay et al. coincides with the best known iteration bound for LCPs with P*(κ)-matrices.

An Optimization-based Reconstruction Algorithm for Multivalued Discrete Tomography

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We present several aspects of using Euclidean Jordan algebras for solving linear complementarity problems (LCPs) over symmetric cones. Many optimization problems, such as linear, semidefinite and second order cone programming problems can be formulated as LCPs. The interior-point methods proved to be efficient tools for solving these kind of problems. In this talk we propose a new interior-point algorithm which is suitable for solving the above mentioned problems and we analyse the complexity of this method.

Multi- Objective Time-Cost- Reliability Optimization in Supply Chain Network by a Novel Hybrid Meta-Heuristic Algorithm

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Supply chains are highly complex, dynamic and in many cases globally distributed systems. The inability to deliver a supply part due to unexpected events in a complex supply chain can have a significant impact on the performance of a supply chain. Supply chains, particularly global supply chains, are exposed to a large variety of risks, which compromise the performance of suppliers and the supply chain as a whole. These risks include, for example, natural disasters, strikes and terrorism. A failure of a supplier or a subsystem results in a loss of supply or in the worst case in a total disruption of the supply chain. We focus on the design of inbound supply chains that incorporate reliability. It is necessary to introduce a new objective function to clearly capture the notion of risk. This objective function is the maximization of the reliability. In this Paper, a new approach based on imperialist competitive and genetic algorithm is introduced. The related results of purposed algorithm are analysed by the analysis of variance (ANOVA) method.

In this paper, we presented mixed-integer non-linear programming model for multi-objective optimization of SCN and a novel hybrid imperialist competitive and genetic algorithm to solve the problem which was met on a producer of the plastic products in Iran. Three objectives were considered: (1) minimization of total supply chain cost (2) minimization of total transportation time (3) maximization of total supply chain reliability. A problem solving algorithm finding an optimal solution considers the time, cost and reliability of the supply chain network in term of the planner-specified weights. These weights represent the priority of supply chain objectives that should be selected by the managers. Other optimal solutions have been obtained by changing these weights. Having these optimal solutions on hand and analyzing the environmental conditions, supply chain managers can make effectively decisions.

The managers have been asked to prioritize the objectives of the supply chain, and then we have applied the proposed NICGA for solving the presented model. The high speed of the proposed algorithm and its quick convergence makes it desirable for large supply chain network with a large number of activities. Furthermore, we have used the weight relative deviation (WRD) measure to compare the performance of the NICGA, GA and ICA by the ANOVA method. By considering uncertainty in time, cost and reliability factors, this model can be extended to the cases which can be more realistic.

Process Network Synthesis for Steady State and Dynamic Behavior by P-graphs and Petri Nets

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The P-graph framework involves highly effective computational methods to synthesize the optimal process network constructed from a subset of potential building blocks leading from the available resources or preconditions to the desired products or targets. The networks' requirements are defined for the steady state of continuous operation, e.g., hourly or annual flow rates of the resources and products, as well as, hourly or annual costs and capacities of the building blocks, which are called operating units. The Process Network Synthesis involves computation of both the optimal structure of the process and the optimal volumes or capacities of the operating units, however, does not provide any information on the dynamics of the system synthesized.

In contrast Petri nets are tools for simulation and analysis of complex systems' dynamic behavior. They can compute any potential state of a system or network achievable from an initial configuration through a series of discrete time steps. Petri nets can be set up to simulate the startup, operation, and shutdown of an already well defined process network, but they are inappropriate for process synthesis and determination of optimal solution.

The present work combines algorithmic process synthesis and analysis techniques to effectively synthesize a set of alternative process structures with effortless startup. The proposed method will be illustrated by applying it to reaction pathway identification.

Effective algorithm for synthesizing optimal multiperiod production processes by P-graphs

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Production processes often follows the discrete rhythm of life according to daily, weekly, and monthly contracts for labor, storage capacity, and suppliers. The availability and price of resources may change periodically as well as the demands to be satisfied. The periods are interconnected through the storages levels of desired products and resources, thus multiperiod models incorporating the requirements of each period have to be considered to minimize the overall cost. There exists fast algorithms for calculating the optimal multiperiod production plan, where the storage and production facilities are assumed to be available and their costs are proportional to their load.

Process synthesis aims at determining the optimal process structure constituted by any combination of potential building blocks. The P-graph framework provides not only the optimal but the n-best alternative suboptimal process structures for a synthesis problem. In the recent paper a novel algorithm is proposed for multiperiod production optimization in polynomial time while taking into account alternative production processes.

Parameter tuning for a cooperative parallel implementation of process-network synthesis algorithms

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Process synthesis is the determination of the optimal structure of a process system with optimal configuration and capacities of the operating units building up the system. The P-graph methodology are developed not only to visualize but to optimize structures of process systems. Its power is the capability to provide n-best solutions due to the exploitation of combinatorial characteristics of candidate solution structures. The aim of developing more and more sophisticated solver algorithms is to find the optimum as fast as possible and increase the circle of practically solvable process synthesis problems. A cooperative parallel implementation of process-network synthesis algorithms have been presented in the 2014 ASCONIKK-VOCAL conference. The parallelization increases performance significantly but this can be further improved by fine tuning the parameters of the parallel algorithm. Outcomes of experiments on parameter optimization are to be presented.

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