GOR

Gesellschaft für Operations Research e.V.

Am Steinknapp 14 b, 44795 Bochum, Tel.: 0234 / 46 22 46, Fax: 0234 / 46 22 45

75. Sitzung der GOR Arbeitsgruppe

Praxis der Mathematischen Optimierung
Optimization Under Uncertainty

Physikzentrum, Bad Honnef,
Oct 20 (14:00) – Oct 21 (17:00) , 2005

Optimization Under Uncertainty

This symposium deals in a unique way with the aspects of optimization under uncertainty. Colleagues working in industry will present their problems and solution approaches to solve their real world problems, researchers from university will focus on modern concepts and methods in that field.

Usually when people talk about optimization they use data treated as without any errors or uncertainty leading to deterministic optimization problems. In contrast to this class, there exists optimization under uncertainty, i.e., optimization problems in which at least some of the input data are subject to errors or uncertainties, or in which even some constraints hold only with some probability or are just soft. Those uncertainties can arise for many reasons:

- Physical or technical parameters which are only known to a certain degree of accuracy. Usually, for such input parameters safe intervals can be specified.
- Process uncertainties, e.g., stochastic fluctuations in a feed stream to a reactor, or processing times subject to uncertainties.
- Demand uncertainties occur in many situations: supply chain planning investment planning, or strategic design optimization problems involving uncertain demand and price over a long planning horizon of 10 to 20 years.

Regarding the conceptual problems involved in optimization under uncertainty it is not a surprise that it took until now that the number of applications using, for instance, stochastic programming is strongly increasing. The first step to model real world problem involving uncertain input data is to analyze carefully the nature of the uncertainty. It is very crucial that the assumptions are checked which are the basis of the various solution approaches. Below we list and comment on some techniques which have been used in real world projects or which one might think of to use.

- Sensitivity analysis is conceptually a difficult problem in the context of MIP, and is, from a mathematical point of view, not a serious approach to solve optimization problems under uncertainty. Nevertheless, it is frequently used by engineers or logistic people to study the role of certain parameters or scenarios.
- Stochastic Programming, in particular *multi-stage stochastic models*, also called *recourse models*, have been used since long. In stochastic programming, the models contain the information on the probability information of the stochastic uncertainty and the distribution does not depend on the decision in most cases. By now, most of the modeling languages used in mathematical optimization use scenario-based stochastic programming for LP problems. While stochastic MILP is an active field of research industrial strength software is still to enter the stage.
- Chance constrained programming has also a long history and dates back to Charnes and Cooper (1959). While usually it is seen as a special approach within stochastic programming, it is here listed separately because it differs significantly from the multi-stage recourse approach. Chance constrained programming deals with probabilistically constrained programming problems, i.e., a constraint holds with a certain probability, and is quite useful to model, for instance, service level features in supply chain optimization problems. As stochastic programming, chance constrained programming also requires probability distributions to be specified. Unfortunately, chance constrained programming is not yet found in commercial software packages.
- Fuzzy set modeling supporting uncertainties which fall into the class of vague information and which are expressible as linguistic expressions. This methodology is much younger than SP and is used when, from the SP point of view, the information is incomplete.
- Robust optimization following the ideas of Ben-Tal is a relatively new approach to deal with optimization under uncertainty in case that the uncertainty does not have a stochastic background and/or that information on the underlying distribution is not or hardly available (which is, unfortunately, often the case in real world optimization problems). While in stochastic programming the number of variables increases drastically, in this robust optimization approach the number of variables approximately only doubles.

- Stochastic decision processes based on *Markov processes* and/or the control of *time-discrete stochastic processes* allow for decision-dependent probability distributions but typically require stronger assumptions on the stochasticity.

Despite the conceptual difficulties, it is strongly recommended that if some data, e.g., demand forecast in planning models, or production data in scheduling are subject to uncertainties, one should consider whether the assumption that planning and modeling is exclusively based on deterministic data can be given up and uncertainty can be modeled.

The following speakers have been accepted for talks.

Optimization Under Uncertainty in Real World - Suppress Uncertainty or Do Not Optimize at All

Dr. Bert Beisiegel, B2 Software-Technik GmbH, Mülheim an der Ruhr, Germany

Robuste nominale Pläne als Grundlage für das Dispatching in einer Halbleiterfertigung mit stochastischen Einflüssen

Dr. Hermann Gold, Infineon Technologies AG, Regensburg, Germany

Optimization problems with linear chance constraints - structure, numerics and applications

Dr. Rene Henrion, WIAS, Inst. f. Mathematik, TU Berlin, Berlin, Germany

Stochastic Fleet Assignment and Disruption Managagement for Airline Planning

Dr. Ulf Lorenz, Paderborn University, Paderborn, Germany

Optimization under Uncertainty using GAMS: Success Stories and some Frustrations

Dr. Franz Nelissen, GAMS Software GmbH

Mixed Complementarity Formulations of Stochastic Equilibrium Models with Recourse

Alexander Meeraus, GAMS Corp., Washington D.C. & Thomas F. Rutherford, Economics Department, University of Colorado, Boulder, USA

Hybrid algorithms for stochastic integer programs in chemical batch scheduling

Guido Sand, Jochen Till, Sebastian Engell, University of Dortmund, Germany

Stochastic Scheduling of Services - the Example of Vehicle Refinishing

Hannes Schollenberger, Jutta Geldermann und Otto Renz, Univ. Karlsruhe, Karlsruhe

Fast Algorithms for Nonlinear Multistage Stochastic Programs

Dr. Marc Steinbach, ZIB, Berlin

By showing the strengths and characteristic features of various methods applied to different real world problems we hope to give novices and practitioners in mathematical optimization, supply chain management, finance industry and other areas of industry a useful overview on optimization under uncertainty and to support decision makers when they have to decide which way to go.

GOR

Gesellschaft für Operations Research e.V.

Am Steinknapp 14 b, 44795 Bochum, Tel.: 0234 / 46 22 46, Fax: 0234 / 46 22 45

75. Sitzung der GOR Arbeitsgruppe

Praxis der Mathematischen Optimierung
Optimization Under Uncertainty

Physikzentrum, Bad Honnef, October 20 & 21, 2005

Thursday, Oct. 21 - 2005 : 14:00 – 18:00

14:00-14:15 **Opening and Welcome Session** (Josef Kallrath & Alexander Lavrov)

14:15-15:05 **Hermann Gold**, Infineon Technologies AG, Regensburg, Germany
Robust Nominal Plans for Dispatching in Semiconductor Front End Manufacturing

15:05-15:55 **Marc Steinbach**, Zuse Institute Berlin, Berlin, Germany
Fast Algorithms for Nonlinear Multistage Stochastic Programs

15:55-16:30 -------------------------- Coffee Break ---------------------------------

16:30-16:45 **Victor Gomer**, Physikzentrum, Bad Honnef, Germany
Information on the Conference Center

16:45-17:20 **Franz Nelissen**, GAMS GmbH, Köln, Germany
Optimization under Uncertainty using GAMS
- Success Stories and some Frustrations

17:20-17:40 **Bert Beisiegel**, B2ST GmbH, Mülheim an der Ruhr, Germany
Optimization Under Uncertainty in Real World
- Suppress Uncertainty or Do Not Optimize at All

17:40-18:00 **Josef Kallrath**, GOR AG, Weisenheim am Berg, Germany
Open Discussion on Bert Beisiegel's Talk
and *Optimization Under Uncertainty in Real World*

18:30- **Conference Dinner** – Buffet; get-together in the wine-cellar
Celebrating the 75th Meeting of our GOR Working Group

Friday, Oct 21 - 2005 : 10:00 – 16:45

10:00-10:50 **Ulf Lorenz**, Paderborn University, Paderborn, Germany
Stochastic Fleet Assignment and Disruption Managagement for Airline Planning

10:50-11:45 **Guido Sand**, Jochen Till, Sebastian Engell, Universität Dortmund, Germany
Hybrid Algorithms for Stochastic Integer Programs in Chemical Batch Scheduling

11:50-13:30 -------------------------- Lunch Break ---------------------------------

13:30-14:20 Thomas R. Rutherford, Boulder, CO & **A. Meeraus,** GAMS, Washington
Mixed Complementarity Formulations of Stochastic Equilibrium Models with Recourse

14:20-14:50 -------------------------- Coffee Break ---------------------------------

14:50-15:40 **Rene Henrion**, Weierstraß Institut Berlin (WIAS), Berlin, Germany
Optimization Problems with Linear Chance Constraints - Structure, Numerics and Applications

15:40-16:30 **Hannes Schollenberger**, Jutta Geldermann & Otto Renz, Universität Karlsruhe, Karlsruhe, Germany
Stochastic Scheduling of Services - the Example of Vehicle Refinishing

16:30-16:45 **Final Discussion – End of the Symposium**

Optimization Under Uncertainty in Real World
- Suppress Uncertainty or Do Not Optimize at All -

Bert Beisiegel
B2 Software-Technik GmbH
Gracht 157
D-45472 Mülheim an der Ruhr
Germany
e-mail: bert.beisiegel@b2st.de

This talk will present two (simplified) examples of optimization problems in the steels and metals industry. These problems affect people preparing the production process and people on the production floor (executing it):

- Select the best mix of raw materials to be melted to 100 tons liquid metal with a given upper limit of its Copper content whilst the Copper content of some raw materials is known as a probability distribution only.
- Select the best mix of raw materials to be purchased for the monthly production in all steel plants of the company, based on forecast data for the planned production.

The users are aware of the uncertainties in their optimization problems, but they either

- suppress the uncertainties and perform a deterministic optimization, or
- give up the optimization at all.

This talk shall stimulate the exchange of ideas how users could be motivated to deal with uncertainties.

Robust Nominal Plans for Dispatching in Semiconductor Front End Manufacturing

Hermann Gold
Infineon Technologies AG
Wernerwerkstrasse 2
D-93049 Regensburg
Germany
e-mail: hermann.gold@infineon.com

August 2005

Semiconductor front end manufacturing facilities are prone to stochastic influences because of randomness in service times and machine availabilities as well as lack of predictiveness of engineering requirements, yield and customer demand. Complex logistic problems brought upun by batch service processes, setup requirements, tool internal buffer limitations and time bound sequences of process steps make it practically impossible to provide full-blown machine schedules without sacrificing a siginificant amount of capacity. More fundamentally, the reentrance of material flow exposes the manufacturing network to deterministic chaos.

We consider a semiconductor manufacturing facility with multiple products and associated routes, single servers and batch servers, and job class dependant service times. The system is modelled as an open queueing network with given external arrival rates for each product type. The aim is to find robust and efficient routing policies so as to remove avoidable idleness from the machines under loading conditions as they are common in semiconductor front end manufacturing. That way cycle time constrained capacity is maximized for each product type.

We use a decomposition approach based on the connected components, also called closed machine sets (CMS), of a properly defined fab graph which involves the relation containing all job class to machine qualification combinations. Taking into consideration arrival rate vectors and service time matrices the routing problem for the network is formulated as a Quadratic Programming Problem (QP) involving averages and variances. Solving this QP yields a robust nominal plan for routing. The strategy for use of the manifold routing options underlying the nominal plan is to distribute load in a way such that each CMS approaches heavy traffic resource pooling behaviour. Our technique to appraoch the ideal system behaviour according to the nominal plan by a dispatching policy is multiple job class multiple server polling.

In the presence of batch servers a new result for the batch service queue $M/D^{[a,b]}/1 - S$ with infinitely many job classes and Round Robin service discipline has been developed and applied along with the QP solver.

Performance analysis of system characteristics which are influenced by effects such as overtaking regarding the whole system is done using simulation.

Optimization problems with linear chance constraints - structure, numerics and applications

René Henrion
Mohrenstr. 39
10117 Berlin
Deutschland
e-mail: henrion@wias-berlin.de

Although optimization problems with linear chance constraints have been introduced quite a while ago, they still offer a lot of challenges both in theory and algorithms. In this class of problems one is faced with many structural differences according to the chosen model (e.g., joint or individual chance constraints, stochastic or deterministic coefficient matrix, continuous or discrete, log-concave or arbitrary probability distributions, number of inequalities smaller or larger than dimension of random vector). All these models have many interesting practical applications in engineering sciences or mathematics of finance. A successful algorithmic treatment of the arising optimization problems requires a good insight into structural and analytical properties (e.g., convexity, differentiability etc.) of the probabilistic functions involved. The talk presents some recent results on the structure and numerics of such problems and provides an illustration by a selection of applications.

Stochastic Fleet Assignment and Disruption Managagement for Airline Planning

Sven Grothklags, Ulf Lorenz, Jan Ehrhoff
Paderborn University
F¨rstenallee 11
D-33102 Paderborn
Germany
e-mail: `flulo@upb.de`

The world around us seems to become more and more dynamic, and past data often loose their predictive power for future planning tasks. Therfore, we are interested in optimization problems with uncertainty, uncertainty modeled with the help of random distributions.

The task of the Repair Game is to generate robust plans and to perform perturbation management for large planning tasks with the help of game tree search, in settings where the deterministic optimization problem is already NP-complete and cannot be approximated. We built a test bed for the example of "stochastic fleet assignment".

Optimization under Uncertainty using GAMS
- Success Stories and Some Frustrations -

Franz Nelissen
GAMS Software GmbH
Cologne, Germany
e-mail: FNelissen@gams.com

The General Algebraic Modeling System (GAMS) is a high-level modeling environment for mathematical programming problems. It consists of a language compiler and a stable of integrated high-performance solvers. GAMS is tailored for complex, large scale modeling applications. We will talk about some typical applications from finance and energy where dealing with uncertainty is essential.

We will show some features of algebraic modeling modeling systems, which support an efficient development of these kind of applications, including some recent developments.

The area of stochastic programming models with recourse is more challenging in various areas. Although algebraic modeling systems also do support these models and do have links to specialized systems for stochastic programming, stochastic programming models require substantial more resources. The concept of having sequences of decisions is natural for a decision maker but is much difficult to implement. Thus there are far less applications of stochastic programming models with recourse than one may expect. We will talk about these difficulties and some of the developments on our side towards a better support of this kind of models.

Mixed Complementarity Formulations of Stochastic Equilibrium Models with Recourse

Thomas F. Rutherford
Economics Department
University of Colorado
Boulder, USA
e-mail: rutherford@colorado.edu

and

Alexander Meeraus
GAMS Development Corp.
Washington D.C., USA
e-mail: alex@gams.com

We demonstrate practical methods for formulating and solving multistage stochastic equilibrium models in a complementarity format. We focus on infinite-horizon economic models with a finite set of stochastic stages and deterministic horizons. We consider both partial and general equilibrium examples. We demonstrate that PATH is capable of efficiently solving large instances of these models.

Hybrid algorithms for stochastic integer programs in chemical batch scheduling

Guido Sand, Jochen Till, Sebastian Engell

Process Control Laboratory, Department of Biochemical and Chemical Engineering,
Universität Dortmund, 44221 Dortmund, Germany

Batch scheduling problems in the chemical industries are usually characterized by the presence of uncertainties in parameters, e.g. the prices of raw materials, the availability of production capacity, or the demand for products. A promising approach to deal with these uncertainties is the use of two-stage stochastic integer programming with a finite number of scenarios.

In a recent paper, Till et. al. [1] proposed the use of a hybrid evolutionary algorithm (EA) to solve stochastic programs with mixed-integer recourse based on stage decomposition. The master algorithm is an EA which performs a search on the first stage variables, and the decoupled second-stage problems represent small MILPs which are solved by mathematical programming and provide a fitness value to the EA. In contrast to stage decomposition methods based on mathematical programming (e.g. the "L-shaped decomposition"), the hybrid EA approach does not suffer from the nonconvexity of the second-stage value function.

In this contribution we present the application of a hybrid EA to a real world example [2], the real-time scheduling of a multi-product batch plant for the production of polymers with uncertainties in the demand and in the operational availability of the processing units. For the search on the constrained first stage variables, an evolution strategy using superiority of feasible solutions and a penalty function is used.

The performance of the EA approach is compared to that of the dual decomposition based algorithm of Carøe and Schultz [3]. Both algorithmic approaches are complementary; the dual decomposition based algorithm provides tight lower bounds while the EA can be seen as a self-adjusting heuristic that generates upper bounds [4].
Several test instances are investigated which differ with respect to the properties of the stochastic program, e.g. the dimension of the first stage, the completeness of the recourse, and the diversity of the stochastic parameters. We apply both decomposition methods and analyze the relation between the model properties and the performance of each algorithmic approach.

References

[1] Till, J., Sand, G., Engell, S., Emmerich, M., Schönemann, L.: A hybrid algorithm for solving stochastic scheduling problems by combining evolutionary and mathematical programming methods. 15th European Symposium on Computer Aided Process Engineering, Elsevier , 2005, 187-192.

[2] Sand, G., Engell, S.: Modelling and solving real-time scheduling problems by stochastic integer programming. Computers and Chemical Engineering 28 (2004), 1087-1103.

[3] Carøe, C.C.; Schultz, R.: Dual decomposition in stochastic integer programming. Operations Research Letters 24 (1999), 37-45.

[4] Till, J., Engell, S., Sand, G.: Rigorous vs. stochastic algorithms for two-stage stochastic integer programming applications. International Journal of Information Technology (2005), to be published.

Stochastic scheduling of services - the example of vehicle refinishing

Hannes Schollenberger, Jutta Geldermann, Otto Rentz
Institute for Industrial Production
University of Karlsruhe
76187 Karlsruhe
Germany
e-mail: hannes.schollenberger@wiwi.uni-karlsruhe.de

For the sector of vehicle refinishing, the application of solvent-reduced paint systems is legally binding due to the new European Product Directive 2004/42/EC (Decopaint-Directive). The use of these new materials influences the work flow to such an extent that adaptation is required.

Extensive time and motion studies, based on REFA methodology, have been carried out in order to analyse the existing processes and their time requirements. The results of these studies are the basis for the scheduling problem presented in this contribution. The objective of the scheduling is the determination of the optimal job sequence. Therein, the consideration of uncertainty is of interest.

A scheduling problem is defined for a reference body shop that fulfils the general conditions of the vehicle refinishing process. The problem is solved using an enumerative approach linked with a Monte-Carlo-Simulation. The results show that time savings can be realized by optimizing the job sequence, however, they are subject to a high degree of uncertainty thus influencing their practical realization.

Fast Algorithms for Nonlinear Multistage Stochastic Programs

Marc Steinbach
Zuse Institut Berlin
Takustr. 7
D-14195 Berlin
Germany
e-mail: steinbach@zib.de

Multistage stochastic programs exhibit hierarchical sparsity patterns determined by the dynamics and information structure (block level) and by model-specific properties (sub-block level). We distinguish three fundamental scenario tree formulations that yield favorable block-level sparsity in the KKT systems of interior methods. Then we present associated generic block-level solution algorithms and techniques to exploit the sub-block sparsity in specific models. Applications to computational finance and engineering demonstrate the performance of the approach.

75th Meeting of the GOR Working Group

„Praxis der Mathematischen Optimierung"

Optimization Under Uncertainty

List of Speakers & Participants[1]

Dipl.-Math. Andreas Bardeck*
B2 Software-Technik GmbH
Gracht 157
45472 Mülheim an der Ruhr
Germany

Phone : 0049 (0)208/629-3410
Fax : 0049 (0)208/629-3420
Mobile: 0049 (0)171/279-5048
e-mail : andreas.bardeck@b2st.de
Web : http://www.b2st.de

Dr. Bert Beisiegel
B2 Software-Technik GmbH
Gracht 157
45472 Mülheim an der Ruhr
Germany

Phone : 0049 (0)208/629-3410 (11)
Fax : 0049 (0)208/629-3420
Mobile: 0049 (0)171/279-5048
e-mail : bert.beisiegel@b2st.de
Web : http://www.b2st.de

Optimization Under Uncertainty in Real World - Suppress Uncertainty or Do Not Optimize at All

PD Dr. Andreas Brieden*
Univ. der Bundeswehr/TU München
Mathematik
Werner-Heisenberg-Weg 39
85577 München

Tel. : 0049 (0)89/6004-4247
Fax :
e-mail : brieden@tum.de

Dr. Michael Bussieck
GAMS Development Corp
1217 Potomac St. N.W.
Washington, DC 20007
USA

Phone : 001 (202) 342-0180
Fax : 001 (202) 342-0181
e-mail : mbussieck@gams.com
Web : http://www.gams.com

[1] * = Non GOR-member, *italic* = speaker (28 participants incl. 9 speakers and 2 CLs, **)

PhD Arne Drud*
Arki Consulting & Devleopment A/S
Bagsvaerdweg 246A
DK-2880 Bagsvaerd
Denmark

Tel. : 0045 4449-0323
Fax : 0045 4449-0333
e-mail : adrud@arki.dk

Dipl.-Math Rafael Fink
TU Clausthal
Abt. für BWL: Produktion & Logistik
Julius-Albert-Str. 2
38678 Clausthal-Zellerfeld

Tel. : 0049 5323/72-7612
Fax : 0049 5323/72-7698
e-mail : rafael.fink@tu-clausthal.de

Dr. Hermann Gold
Infineon Technologies AG
AT PL OPC IEZ, Simulation
Wernerwerkstr. 2
93049 Regensburg

Phone : 0941/202-1466
Fax : 0941/202-2593
e-mail : hermann.gold@infineon.com

Robust Nominal Plans for Dispatching in Semiconductor Front End Manufacturing

Dr. Rene Henrion
Weierstraß Institut Berlin (WIAS)
Nichtlineare Optimierung und inverse Probleme
Mohrenstr. 39
10117 Berlin
Germany

Phone : 0049 (0)30/20372540
Fax : 0049 (0)30/2044975
e-mail : henrion@wias-berlin.de

Optimization Problems with Linear Chance Constraints - Structure, Numerics and Applications

Dipl.-Math Sascha Herrmann
TU Clausthal
Abt. für BWL: Produktion & Logistik
Julius-Albert-Str. 2
38678 Clausthal-Zellerfeld

Tel. : 05323/727614
Fax : 05323/727698
e-mail : sascha.herrmann@tu-clausthal.de

Roland John
Bahnhofstr. 9
86424 Dinkelscherben
Germany

e-mail : roland@rolandjohn.de

Prof. Dr. Josef Kallrath**
Am Mahlstein 8
67273 Weisenheim am Berg
Germany

Phone : 0049 (0)621/60-78297
Fax : 0049 (0)1212/5-197-197-29
Mobil : 0049 (0)172/769-6578
e-mail : josef.kallrath@t-online.de

Prof. Dr. Alexander Lavrov**
Fraunhofer ITWM
Europaallee 10
D-67657 Kaiserslautern
Germany

Phone : 0049 (0)631/303-1884
Fax : 0049 (0)631/303-1811
e-mail : lavrov@itwm.fhg.de

Dr. Ulf Lorenz
Paderborn University
Fürstenallee 11
D-33102 Paderborn
Germany

Phone : 0049 (0)5251/60-6731
Fax : 0049 (0)5251/60-6697
e-mail : flulo@upb.de

Stochastic Fleet Assignment and Disruption Managagement for Airline Planning

Debora Mahlke*
TU Darmstadt
Schloßgartenstr. 7
64289 Darmstadt

Tel. : 0049 (0)6151/164700
Fax : 0049 (0)6151/163954
e-mail : mahlke@mathematik.tu-darmstadt.de

Alexander Meeraus
GAMS Development Corp
1217 Potomac St. N.W.
Washington, DC 20007
USA

Phone : 001 (202) 342-0180
Fax : 001 (202) 342-0181
e-mail : alex@gams.com
Web : http://www.gams.com

Mixed Complementarity Formulations of Stochastic Equilibrium Models with Recourse

Prof. Dr. Thomas Morgenstern
Operations Research, Mathematik, Statistik
Prodekan FB Automatisierung & Informatik
c/o Hochschule Harz
Friedrichstr. 57-59
38855 Wernigerode
Germany

Tel. : 0049 (0)3943/659-337
Fax : 0049 (0)3943/659-399
e-mail : tmorgenstern@hs-harz.de
web : http://www2.fh-harz.de/~tmorgenstern/

Dipl.-Math. Alexey Nagaytsev
Universität Duisburg-Essen
Fachbereich Mathematik
Lotharstr. 65
D-47057 Duisburg
Tel. : 0203/379-1894
Fax : 0203/379-2528
e-mail : alex@math.uni-duisburg.de

Dr. Franz Nelissen
GAMS Software GmbH
Eupener Str. 135-137
50933 Köln
Phone : 0049 (0)221/949-9170
Fax : 0049 (0)221-949-9171
e-mail : FNelissen@gams.com
Web : http://www.gams.de

Optimization under Uncertainty using GAMS: Success Stories and some Frustrations

Dipl.-Math. Sebastian Pokutta
Universität Duisburg-Essen
Fachbereich Mathematik
Lotharstr. 65
D-47057 Duisburg
Tel. : 0203/379-1894
Fax : 0203/379-2528
e-mail : pokutta@math.uni-duisburg.de

Steffen Rebennack
Universität Heidelberg
Diskrete Optimierung (AG Reinelt)
69120 Heidelberg
Germany
Tel. : 0621/896477
e-mail : steffen.rebennack@web.de

Dr.-Ing. Guido Sand
Universität Dortmund
Bio- und Chemieingenieurwesen
Emil-Figge-Str. 70
Dortmund
Germany
Phone : 0049 (0)231/755-5124
Fax : 0049 (0)231/755-5129
e-mail : guido.sand@udo.edu

Hybrid Algorithms for Stochastic Integer Programs in Chemical Batch Scheduling

Dr. Max Scheidt
ProCom GmbH
Geschäftsleitung
Luisenstr. 41
52070 Aachen
Germany
Phone : 0049 (0)241/51804-0
Fax : 0049 (0)241/51804-30
e-mail : ms@procom.de

Sylvia Schimmack*
ProCom GmbH
Abt. ENW
Luisenstr. 41
52070 Aachen
Germany

Phone : 0049 (0)241/51804-0
Fax : 0049 (0)241/51804-30
e-mail : si@procom.de

Dipl.-Geoökol. Hannes Schollenberger
Universität Karlsruhe
Institut für Industriebetriebslehre
Hertzstr. 16
76187 Karlsruhe
Germany

Tel. : 0049 (0)721/6084584
Fax : 0049 (0)721/758909
e-mail : hannes.schollenberger@iip.uka.de

Stochastic Scheduling of Services - the Example of Vehicle Refinishing

Prof. Dr. Christoph Schwindt
TU Clausthal
Abt. für BWL: Produktion & Logistik
Julius-Albert-Str. 2
38678 Clausthal-Zellerfeld

Tel. : 0049 5323/72-7615
Fax : 0049 5323/72-7698
e-mail : christoph.schwindt@tu-clausthal.de

Dr. Marc Steinbach
Zuse Institute Berlin
Takustr. 7
14195 Berlin
Germany

Phone : 0049 (0)30/84185-227
Fax : 0049 (0)30/84185-269
e-mail : steinbach@zib.de

Fast Algorithms for Nonlinear Multistage Stochastic Programs

Dominik Stotko*
Universität Dortmund
Mathematik
Saarbrückener Str. 103
45138 Essen

Tel. : 0049 201/2766-290
Fax : 0049 201/2766-291
e-mail : dominik.stotko@email.de

Andrea Zelmer*
TU Darmstadt
Mathematik
Schloßgartenstr. 7
64289 Darmstadt

Tel. : 0049 (0)6151/164700
Fax : 0049 (0)6151/163954
e-mail : zelmer@mathematik.tu-darmstadt.de