Gesellschaft für Operations Research e.V.

Joseph-Sommer-Straße 34, 41812 Erkelenz, Tel.: 02431 9026710, Fax: 02431 9026711

GOR Annual Meeting

„OR2015 Business Day“

Vienna, September 03, 2015

Organization

Josef Kallrath

BASF SE, Scientific Computing, Ludwigshafen, Germany
&
GOR Working Group „Praxis der mathematischen Optimierung“

Mathematical Optimization in Industry

Operations Research (OR) and especially Mathematical Optimization is becoming an important differentiator in various industries and society. Because companies offer similar products, have comparable technology and compete on a global scale, high performance business processes are among the last differentiators. As UPS mentioned: ”In God we trust, everything else we measure and improve”, underpinning the importance of Operation Research and mathematical optimization as an enabler for creating that competitive edge. In these times of economic downturn Operations Research is even more important. It gives guidance to management on where to invest and where to scale down, making the operation more agile.

This meeting will give an overview about the state-of-the art technologies illustrated by real-world applications. In a 6 talks, each approximately 40 minutes, experts from practice, or solution providers and software companies, will present selected problems and the corresponding solutions and illustrate what has been achieved during the last 40 years, what have been the key factors for success, and what is the vision for the future.

This one-day event attempts to give an overview of the current state of the art of mathematical optimization techniques and OR applied in industry and society.

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Thursday, Sep 03 - 2015: 09:15 – 16:15

09:15-09:25 **Opening and Welcome Session** (J. Kallrath)

09:25-10:15 **Dr. Franz Höfferl** (ÖMV, Vienna, Austria)
LP based OR applications in refinery&marketing business at OMV

10:15-10:45 ---------- Coffee Break ----------

10:45-11:35 **Armin Gauss** (Fichtner IT Consulting AG, Stuttgart, Germany)
LP Energy System Planning - Examples, general approach and aspects related to other industrial OR applications -

11:35-12:25 **Prof. Dr. Josef Kallrath** (BASF SE, Ludwigshafen, Germany)
Mathematical Optimization at BASF – A Quarter Century and more …

12:25-13:05 ---------- Lunch Break ----------

13:05-13:55 **Jawad Elomari** (ORTEC B.V., EA Zoetermeer, The Netherlands)
Supply chain optimization at TNT express

13:55-14:45 **Dipl.-Inf. Robert Krämer** (Mathesis GmbH, Mannheim, Germany)
Work Visually with Complex Data

14:45-15:15 ---------- Coffee Break ----------

15:15-16:05 **Prof. Dr. Daniele Vigo** (Bolognoa University & Optit srl, Bologna, Italy),
Optimization of Staff Management for Desk Customer Relations Services

16:05-16:15 F**inal Discussion – End of the Workshop**

The Speakers

Jawad Elomari he is a lead researcher at ORTEC B.V. on mixed integer nonlinear optimization. He has worked in various industries like supply chain, pharmaceuticals, and engineering design. His research interests include multi-objective optimization, ranking and selection, algorithm tuning, and traffic assignment.

Armin Gauss Armin Gauss obtained his 'Diplomingenieur' in Technical Cybernetics from the University of Stuttgart in 1993 and is currently working as Project Manager and Principal Consultant at Fichtner IT Consulting. He coordinated the development of modular toolboxes for energy system planning and managed numerous projects to train and implement tools for energy system planning in utilities, in the public sector and in industrial enterprises. He has particular experience in energy system planning of large energy systems and concepts for optimizing distributed virtual energy systems.

Interests include robust solutions of practical optimization problems, large scale MIP optimization, decision support based on uncomplete information and uncertainties, multi model approach.

Franz Höfferl received his PhD in physics from university Vienna in 1979. He is a Member of research staff at Austrian Academy of Sciences. In 1980 he began to work in the field of OR at OMV. Since 1995 he is the Department Manager OR at OMV BU Refinery&Marketing.

Josef Kallrath obtained his PhD in astrophysics from Bonn University (Germany) in 1989. He is is with BASF's Scientific Computing group at BASF in Ludwigshafen since 1989, is a professor at the University of (Gainesville, FL, www.astro.ufl.edu/∼kallrath), and solves real-world problems in industry using a broad spectrum of methods in scientific computing, from modeling physical systems to supporting decisions processes by mathematical optimization. He has written review articles on the subject, about 100 research papers in astronomy and applied mathematics, and several books on mixed integer optimization, as well as one on eclipsing binary stars.

He leads the Real World Optimization Working Group of the German Operations Research Society. His current research interests are polylithic modeling and solution approaches to solve large-scale or difficult optimization problems, for instance, by decomposition techniques such as column generation, or hybrid methods.

Robert Krämer studied computer science at the University Kaiserslautern. He has been working in the central computer department of BASF until 1999 und then joined the company MATHESIS in the role of technology advisor for web based developments and interfacing. Currently he is engaged in extending the company's VisPlain product.

Daniele Vigo is Professor of Operations Research at the Department of Electrical, Electronic and Information Engineering of the University of Bologna, Italy, and visiting Professor at the Department of Information, Logistics and Innovation of the Vrije Universiteit Amsterdam, Netherlands. His research interest are in the design of optimization algorithms for hard combinatorial problems. He worked in several applied project in collaboration with research institutions and companies, in which he developed algorithms for vehicle routing, crew scheduling and rostering and industrial cutting and packing. In 2007 he founded Optit, an accredited spin-off company of the University of Bologna that develops decision support sys-

tems for various applications such as logistics, personnel management and energy production successfully used by several companies, particularly in the utility sector.

Supply chain optimization at TNT express

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The application of optimization techniques at TNT Express during the past seven years improved the decision making process, and resulted in savings of millions of Euros. TNT Express delivers today about 4.7 million packages in over 200 countries, using a network of 2,600 facilities, a fleet of 30,000 road vehicles and 50 aircraft, and a workforce of 77,000 people. Designing a supply chain that achieves a high level of customer service, and at the same time, maintaining low operating costs is challenging. Two major challenges are of concern here: first, transportation volumes are usually low, and shipping them directly over long distances is not justified; hence, consolidating packages is necessary to reduce the costs. Second, cutoff times at the pickup and/or delivery depots must be considered when moving packages across the supply chain. To overcome these issues, ORTEC with collaboration with researchers from Tilburg University, worked closely with TNTs Global Optimization division to develop a software solution in the form of three sub-programs: DELTA for supply chain optimization, TRANS for network scheduling, and SHORTREC for pickup and delivery tactical planning. This talk begins with an overview of each of these sub-programs, their implementation challenges, and benefits. It then moves on to describe a specific module designed to determine the optimal paths for each package, given the current setup of depots and hubs, and cutoff time constraints. As a result of these efforts, TNT Express were able to save around 207 million Euros during the period of 2008 2011, 132 of which came from supply chain optimization, 48 from networks scheduling, and 27 from tactical route planning. In addition, the CO2 emissions was reduced by 283 million kilograms from over 1,000 trucks traveling around the world.

Energy System Planning
- Examples, general approach and aspects related to other industrial OR applications -

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Linear and MIP Optimization models are used for energy system planning for more than 40 years. Initially used for large scale models of regions, countries, large utilities and energy intensive industry, similar methods are applied today for energy management and energy optimization of smaller systems, e.g. industrial energy management and energy optimization of facilities. Increasing power generation from fluctuating renewables and fast changing regulation and market conditions cause high uncertainties. Decisions based on uncomplete information require advanced methods for short, medium and long term planning for infrastructure provider and market participants. Industrial companies have to meet increasing energy management requirements.

Three project examples will present a general approach for energy system planning and specific aspects related with practical optimization problems in other application fields.

How to deal with large and complex energy systems, uncertainties, uncomplete data and nonlinear dependencies? Challenging projects like the set up of a power system master plan for Afghanistan will force a kind of puzzling competition. Key elements include preliminary analysis, model simplification, core model optimization and an extensive validation process. Several iterations may use different point of views and different models of the original decision problem. Uncomplete data and high uncertainties are part of the original decision problem and imply multi-stage decision processes for candidate projects. Additional model constraints for the timeline of these candidate projects ensure robust strategies.

Current and future changes of the power market on the one hand and fast integrating IT and automation technologies on the other hand enable new energy and measurement based services for specific infrastructure provider of airports, ports and industrial sites. The SmartEnergyHub research project adresses these opportunities and will use an optimization modul to explore new specific energy and measurement based services. Apart from application fields and market segments cost-benefit analysis is used to define size, details and complexity of underlying optimization models.

How to optimize energy systems having a high share of fluctuating renewables? A small project example illustrates stochastic input data, dependencies and some practical restrictions. Even small and simple optimization model will show important aspects. Very large and complex optimization models are more suitable, but may include some additional minor errors and some people may not be able to explain some impressing results to an astonished audience.

LP based OR Applications in Refinery & Marketing Business at OMV

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I started my work for OMV 35 years ago. At this time OMV ran 1 refinery and the marketing business was mainly Austrian based. OMV was the only one state owned oil company and had to provide the Austrian market with mineral oil products. The status of the LP technology at this time was a mainframe based Linear Programming system to solve a linear, continuous and static refinery optimization problem. Since that time OMV became a listed company at the stock exchange and acquired the majority of PETROM, the Romanian oil company . Now OMV runs 3 refineries (Schwechat near Vienna, Burghausen in Germany and Petrobrazy in Romania) and the marketing regions spread out beyond the Austrian borders. By this also the LP model had to be expanded including the usage of progress in LP based technologies during the last decades.

Mathematical Optimization at BASF
- A Quarter Century and More... -

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Since the advent of computer, and PCs especially, in the 1970 and 1980, there was a positive climate towards mathematical methods at BASF. Mathematics and mathematical tools were used by various individuals or subgroups in departments to support analytics, the evaluation of experiments, or the description of reaction by differential equations – Mathematics was never strictly centralized at BASF.

The chemical industry is full of problems requiring a mathematical modeling *and* optimization background, *e.g.*, modeling of chemical reactions (parameter estimation in systems of stiff nonlinear ordinary or partial differential equations), the analysis of experimental data in pharmacokinetics, simulations on an atomistic or molecular level in material sciences or the optimal control of biotechnological reactors.

In 1990, the group *Systems for Chemistry* was founded focussing on problems as the ones mentioned above and as new fields of activities at BASF mixed integer mixed integer optimization and later on operations research in the more general sense were added, *e.g.*, blending problems, production planning and scheduling problems, supply network problems. These problems lead to linear programs, mixed-integer problems both linear and nonlinear which brings us also into the field of deterministic global optimization.

Nowadays, mathematical optimization is used in the area of supply chain management (SCM) for a wide range of strategic, tactical, and operational topics encountered at BASF, *e.g.*, to design the structure and size of its rail car fleet.

At BASF we have always followed the idea that in-house groups always keep the ability of solving difficult problems on their own although we also collaborate with research institutions where possible, in order to keep up-to-date with leading edge developments in academia. This independence and competence is important a) for keeping in reasonable contact and collaboration with research institutions in the area of mathematical optimization, but also b) to be able to assess the offerings of such institutions. Finally, there are c) also projects which are confidential and which cannot be communicated to the outside world. An additional advantages of this strategy is that the group as an internal unit can perfectly match its methodological knowledge with the specific application experience of our clients.

Consistent with this basic self-understanding of the group I have, for instance, developed polylithic modeling and solution approaches useful to solve very difficult or large scale problems, or to compute optimal breakpoint systems to approximate nonlinear terms with a pre-given tolerance in otherwise mixed integer linear problems. When confidentiality aspects allow this, we also publish our solutions.

Work Visually with Complex Data

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The current hype on big data may overshadow the problems inherent in complex data.

Complex data constellations, which are nothing new to large companies, are gaining importance by:

- more process information getting available to computer systems,
- demand for views of the overall picture require to correlate earlier separate information pools,
- computer power and mathematical progress making optimization computation feasible in instantly computed what if scenarios.

Complexity in above situations shows up in multiple, often not explicitly known relationships between the data items.

The knowledge worker's job is not merely to look at and understand data items in certain locations, but to find out about relationships within those data items.

The end user has to deal efficiently and safely with complexity in his day to day work.

It may be argued, that information presented as lists or common business graphics, is not the optimal solution for above task.

Look at a child given a new toy:

- It will grab it with its hands and turn it to be able to look from all sides on it.
- It will open it to see what's inside; it will twist and press to see what will happen to the toy's structure.
- It will try to combine it with other toys it already has and understands to find out if something bigger can be made out of it.

Shouldn't a knowledge worker be given the same capabilities?

Couldn't current computer assistance be enhanced to better support human brain's capacity to understand and work with complex constellations of information ?

Isn't vision, especially in a short feedback loop of applying change and viewing the result a more human way of understanding the 'whole picture' ?

In this speech we will discuss an approach which works with information based on digraphs consisting of nodes connected by directed edges and a highly interactive handling and viewing layer above it.

Pros and cons will be discussed based on real examples in the food and chemical businesses targeting logistic and production planning.

It will be shown how a complex manual planning situations and the output of a mathematical optimization computation can be examined and composed visually; in scenarios for the end user and the knowledge worker.

Optimization of Staff Management for Desk Customer Relations Services

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We discuss a decision support system for optimizing staff management of desk customer relations services at Hera, a large Italian multiutility company. The system, called SPRINT, which is based on state-of-the-art demand forecasting, implements a novel two-phase optimization procedure based on adaptive staffing. The processes developed proved to be superior to other state-of-the-art approaches. After using the system for more than three years, Hera has considerably improved its planning and management processes, achieved a significant level-of-service improvement of its desk customer services, and substantially increased staff productivity.