Gesellschaft für Operations Research e.V.

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73. Sitzung der GOR Arbeitsgruppe

Praxis der Mathematischen Optimierung
Optimization Services in Europe

Physikzentrum, Bad Honnef, 14.-15. Oktober 2004

Mathematical Optimization Services in Europe
- European Networking in Mathematical Optimization -

This symposium brings together solution providers, consultants and practitioners from industry seeking optimization support to solve their real world problems.

The idea is that small companies (approx. less than 10 employees) or individuals who have developed optimization software or operate as consultants

a) offer their spectrum of software and services to an industrial community (the attendees of this GOR meeting),

b) get to know each other,

c) share ideas on how to run small optimization companies or consultant businesses; it might be interesting to see which marketing activities the various companies/consultants have,

d) establish a network among them (although the focus is rather on Europe, it is not strictly limited to Europe), and

e) get together with problem owners from German industries.

Speakers from Belgium, England, Germany, Japan, The Netherlands, Sweden, Switzerland, and the USA have already submitted their talks.

Attendees will benefit from this symposium by getting to know solution providers offering or developing individual solutions to real world optimization problems. The providers cover different application areas (such as supply chain optimization, cutting stock problems, production planning, logistic problems) in various industries (process industry, metal industry, parcel service providers) as well as a broad spectrum of solution approaches reaching from linear over mixed integer linear to nonlinear and differential-equation based optimization.

The broad spectra of offered optimization solutions demonstrates that expensive standard solution from large companies are not always the best choice. Tailor-made, individual solutions are often by far more appropriate and have a much more reasonable pricing structure.

Bad Honnef, Oct 14 – 2004 Josef Kallrath & Alexander Lavrov

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Physikzentrum, Bad Honnef, 14.-15. Oktober 2004

Thursday, Oct. 14, 2004 : 14:00 – 18:45

14:00-14:10 Opening and Welcome Session (Kallrath & Lavrov)

14:10-14:50 **Michael Bussieck & Franz Nelissen**, GAMS Development Corp. , USA
A Model is not just a Model - Models and their Roles

14:50-15:30 **Robert Fourer**, AMPL Optimization LLC, Evanston, IL, USA,
AMPL: New Features for Formulating and Embedding AMPL Models

15:30-16:10 **Robert Simons**, Euxodos Systems, Leigthon Buzzar, England
Practical Experiences of Applying XPRESS-MP and AspenTech MIMI in the Oil and Paper Industries

16:10-16:30 ---------- Coffeebreak ----------

16:30-16:45 Information about the Conference Center **(Dr. Victor Gomer)**

16:45-17:25 **Tony Hürlimann**, Virtual Optima, Fribourg, Switzerland
Model Documentation

17:25-18:05 **Bert Beisiegel**, B2 Software-Technik GmbH, Mülheim/Ruhr, Germany
Black Box Optimization in the Steel Industry

18:05-18:45 **Susumu Ikenouye**, Ike-Ltd., Tokyo, Japan
Efficient Optimization Tools for End-Users in the Process Industries – Deriving Realistic and Acceptable Solutions

18:45- Conference Dinner – Buffet; get-together in the wine-cellar

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Friday, Oct 15, 2004 : 9:00 – 18:00

09:00-09:40 **Sandip Pindoria**, Maximal Software Ltd., Uxbridge, England
Using the MPL and the OptiMax 2000 to Create Embedded Optimization Applications

09:40-10:20 **Max Wagner**, Mathesis GmbH, Mannheim, Germany
Very Different Problems Have the Same Solution

10:20-10:40 ---------- Coffeebreak ----------

10:40-11:20 **Hans Georg Bock & Stefan Körkel**, Steinbeis Technolgy Transfer Center „Simulation & Optimization“ , Germany
Reliable, Robust and Efficient Optimization Methods for Real World Problems

11:20-12:00 **Klaus Schittkowski**, University of Bayreuth, Germany
SQP/SCP-Methods for Nonlinear Programming: Algorithms, Software, and Applications

12:00-12:40 **Robert Fourer**, Ziena Optimization Inc., Evanston, IL, USA
Solving Large-Scale Nonlinear Optimization Problems

12:45-13:55 ---------- Lunchbreak ----------

14:00-14:40 **Kenneth Holmstrom**, Tomlab Optimization AB, Vasteras, Sweden
TOMLAB - Unique Features for Optimization in MATLAB

14:40-15:20 **W.H.M. Baltussen, Wierse Dol & F. Bouma**, NacquIT BV, The Netherlands
Tools to Support Good Model Building and Model Use

15:20-16:00 **Nico DiDomenica**, Optirisk-Systems Ltd., Uxbridge UB9 4DA, UK
Stochastic Programming and Scenario Generation within a Simulation Framework : An Information Systems Perspective

16:00-16:20 ---------- Coffeebreak ----------

16:20-17:00 **Luc VanHamme**, OM Partners NV, Brasschaat, Belgium
Application of Optimization Methods at OM Partners

17:00-17:40 **Jörg Grüner**, Prologos, Hamburg, Germany
Network Design and Optimization of Complex many-to-many Logistical Networks for Express and Parcel Service Providers

17:40-18:00 **Final Discussion – End of the Symposium**

A Model is not just a Model - Models and their Roles

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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 demonstrate that a model can take more than its obvious cost saving role in a modeling application project. Two other roles, at least as important as the apparent role, can be quite valuable in such a project: the model as a communication vehicle and the model as an analytic framework. We will give examples from some past projects including a recent one with a large automotive company. Each role has its own particular requirements and we will demonstrate what the modeling system GAMS offers for models in these roles.

Communication Vehicle: In the project with a large automotive company a simply organized spreadsheet with the basic data of the problem was exchanged. It had all the info needed for defining an initial optimization problem. Everyone in the project team could send the spreadsheet to an optimization server and see if the system/model reacted in the way he/she expected from what was discussed in emails and other communication media. The spreadsheet served as a standard user interface understood by IT, analysts and managers. GAMS supports that by allowing for rapid prototyping, remote model execution (Who wants to install sophisticated licensed software on his/her PC?), and reliable interaction with Office products.

Analytic Framework: This role of a model is often underestimated. After a coarse outline of the project (during this a model could be used as a communication vehicle) usually detailed specifications are written and IT implements according to these specs. The implementation of an optimization model often discovers discrepancies, inaccuracy, and things plainly forgotten in such specs since an optimization model (especially deterministic mathematical programming (MP) models) does not allow for this kind of vagueness. Furthermore, the model will react extremely sensitive to data problems: compilation errors (none unique keys), infeasible or unbounded MP models. The model can even help analyzing complex data problems by solving small MP models. Finally, an analytic model can help to define a metric that helps comparing the results from a previous planning system and the new model. These metrics represent an important tool for managers to demonstrate the success of a project. GAMS, with its sophisticated execution system, is well suited for this role. Multiple MP models can

be defined and solved in one GAMS model. Large amounts of structured data can be processed and analyzed using algebraic statements. GAMS is connected to a couple of "result analyzers" (e.g. VEDA, MATLAB, MapInfo, etc) that make the analysis of model results easily available to non model experts.

Cost Saver: The last and most obvious role of an optimization model is the cost saver, quality improver, or whatever the objective of the optimization model is. The success of an optimization model measured in these terms is often exaggerated, or at least difficult to estimate. In any case, a "successful" optimization model will usually be in use for 10 to 15 years. During this time, the model core will be modified and extended as well as the interface (data and user) will change frequently. Improved hard- and software (including faster MP solvers) will develop during the life cycle of a model and making these improvements available to the model will be in demand. GAMS, dedicated to backward compatibility of models, has a QA program that tests client models when new releases of the modeling software come out. It provides tools (e.g. Bench/Paver) to benchmark new solvers and has plenty of build-in features to successfully develop and maintain a lively model over a long time.

AMPL: New Features for Formulating and Embedding AMPL Models

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AMPL is a comprehensive and powerful algebraic modeling language for linear and nonlinear optimization problems, in discrete or continuous variables. AMPL's design stresses naturalness of expressions, and its syntax permits conventional mathematical notation to be transcribed in a straightforward way to the forms of AMPL statements. Since models of practical interest almost always define indexed collections of constraints, expressions, and other entities, AMPL offers particularly general set expressions and allows model entities to be indexed over sets in a broad variety of contexts, with individual components selected by a conventional subscript notation.

AMPL encourages separation of model and data. An AMPL model represents a class of optimization problems described in terms of fundamental sets and parameters. Other sets and parameters may be computed from the fundamental ones – AMPL makes it easy to say how. Once particular data values are supplied for the fundamental sets and parameters, AMPL can instantiate a problem instance in a form suitable for optimization by various algorithmic techniques.

AMPL itself does not solve optimization problems (except in rare cases where its presolver completely determines the values of all variables). Rather, it passes problem instances to a separate solver, which seeks a solution and returns it to AMPL for further processing. AMPL's publicly available solver interface library permits both academic researchers and commercial vendors to make their solvers work with AMPL. Thus it is easy to benchmark varied solvers on the same difficult problem.

AMPL has a comprehensive command language that allows for iteratively solving and modifying problems and examining solution results. To support the implementation of decompositions and other iterative schemes, AMPL provides for several ways in which data values can be updated. When updating changes fundamental values of the model, AMPL automatically recomputes derived sets and parameters as needed.

AMPL's design principles have guided various additions, including database access and modeling of complementarity conditions. Ongoing projects are adding features for better expressing stochastic programs and combinatorial optimization problems. Callable interfaces are under development to facilitate the building of graphical and specialized front ends for applications.

Practical Experiences of Applying XPRESS-MP and AspenTech MIMI in the Oil and Paper Industries

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Modelling software is now so good that it is straightforward to build optimization-based applications. That does not mean that it is easy; but the effort can be concentrated on understanding the client's problem and modelling it faithfully rather than struggling to get the component pieces of software to work together.

The single greatest advance has been the integration of a general-purpose language with LP modelling facilities. This allows arbitrarily-complex calculations to be made when setting up an LP matrix, such as reflect the intricacies of real-life problems. It also facilitates hybrid approaches to tackling problems, rather than simply setting up a matrix, optimizing it and presenting the solution.

There remain difficulties in using optimization, but they are intrinsic to the technique rather than reflecting inadequacies in the software. The need to support clients and be able to debug reported problems has led the author to eschew direct interfaces to databases in favour of indirect interfaces via formatted ASCII files. Output reports are migrating to .html and .xml/.xslt, where the ability to hyperlink tables together is invaluable.

Despite substantial advances in integer programming, the commercial imperative to work within a fixed price for a client still leads the author to use heuristic methods for combinatorial problems.

Model Documentation

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Documenting a model is extremely important. However, this feature is still badly neglected by the model language designers as well as by the users. By the example of LPL, a powerful modeling system (see www.virtual-optima.com), we show how documentation can be seamlessly integrated into the formal mathematical code of a modeling language and how a well formatted text can be generated automatically from these specifications. We present several case studies.

Black Box Optimizations in the Steel Industry

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Black Box Optimizations (BBO) are completely embedded in application software, for example in an Alloy Addition Calculation in a steel mill, done by the First Melter in the pulpit of a Ladle Furnace in the steel mills melting shop. Here a few characteristics of a BBO:

- A BBO is completely hidden from its users: the users are not aware that they actually benefit from an optimization algorithm.
- A BBO does not talk to the users; it rather receives all input data from other application software and returns its results to other application software.
- A BBO has to return a result under all circumstances, even when
  - the optimization model does not have a solution,
  - the input data is faulty,
  - the BBO's environment doesn't function properly.
- The BBO's code shall be readable by the end users technical management.

This talk addresses some challenges of Black Box Optimizations and uses real-world-examples from the steel industry in order to do that. The talk assumes the reader to have some knowledge of optimization methods.

Efficient Optimization Tools for End-Users in the Process Industries - Deriving Realistic and Acceptable Solutions

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In real world, top-managements and engineers want to know quickly the profit of the company in unstable conditions. To cope with this requirement, many things have to be improved from the points of view, such as, work process, IT systems and simulation methods.

For simulation of enterprise-wide profit in process industry, Linear Programming is one of the best methods to represent real world activities. Standard LP models are certainly a core in the simulation function of enterprise-wide profit. But, until now, there is no good graphical user interface (GUI) for persons who have no mathematical background but have responsible for production management on practical everyday work in collaboration work process of SCM.

We developed a new GUI for the process industry from the point of view of a 'flow chart'. The purpose of the 'Flow chart' is to illustrate the real production process in the process industry. It is the most common representation of these processes for management works. Using this functionality, planners are easily to make mathematical model without mathematical feeling to achieve their duty.

Using the MPL and the OptiMax 2000 to Create Embedded Optimization Applications

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In today's global economy, organizations are being pushed to work smarter and faster. MPL (Mathematical Programming Language) is an advanced modeling system that allows the model developer to efficiently formulate complicated optimization models that are both fast and scalable. We will demonstrate how models written in MPL can easily be embedded into end-user applications using the innovative OptiMax 2000 Component Library. We will further demonstrate how to build customized end-user applications, seamlessly integrating with common programming languages, such as VBA for Excel/Access, Visual Basic, Visual C/C++, Java, Delphi, and web scripting languages, to solve real-world optimization problems.

Very Different Problems Have the Same Solution

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Solving an optimization problem in a business environment requires several different capabilities

- understanding the business problem and translating it into a mathematical model
- building a data structure that can store the required information
- building an user interface
- creating reports that translate the optimization results into information that can be understood from a business perspective

For those different tasks you need people with different skills : business understanding, mathematical capabilities, database and user interface design.

This translates very often into costly and lengthy projects that exceed budgets and require the involvement of a significant number of people, who normally are limited in their available time.

We will show a different approach.

Using abstract and very generic structures like resources, locations and operations we are able to develop a mathematical model that can be applied to a variety of problems. Additionally we can utilize for all those problems one data base structure and one user interface. Therefore we are able to reduce the length and the cost of business optimization problems significantly.

Reliable, Robust and Efficient Optimization Methods for Real World Problems

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SQP/SCP-Methods for Nonlinear Programming: Algorithms, Software, and Applications

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Sequential quadratic programming (SQP) methods for nonlinear programming are very well known since many years. They have been extensively investigated in the past both from the theoretical and the numerical point of view. One of the interesting features is that they are easily adapted to solve also least squares problems.

We will present a summary of software that has been developed by the author during the last two decades. All codes are more or less based on the SQP code NLPQL. Industrial applications are discussed and three typical case studies are outlined,

1. the design of horn radiators for satellite communication (Astrium),

2. the design of surface acoustic wave filters (Epcos),

3. the optimal control of a cracker (BASF).

However, SQP codes are sometimes less efficient than others in special situations, for example when compared to so-called sequential convex programming (SCP) methods in structural mechanical engineering. We outline the basic ideas behind SCP methods and show a typical application, the weight minimization of a cruise ship (Meyer Werft).

A particular advantage of SCP methods is that they are able to solve very large scale optimization (VLSO) problems with 10^5 to 10^6 variables and constraints without exploiting sparsity patterns. SCP methods are often implemented to solve large topology optimization problems, where new materials and designs are to be computed proceeding from uniform initial mass distributions.

Solving Large-Scale Nonlinear Optimization Problems

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KNITRO is a software package for finding local solutions of continuous, smooth optimization problems, with or without constraints. Although KNITRO has been designed as a large-scale solver for general nonlinear problems, it is efficient for many specific problem categories, including unconstrained, bound constrained, and equality constrained problems, systems of nonlinear equations, least squares problems, and linear and quadratic programming problems.

KNITRO offers the broad range of options necessary to reliably carry out nonlinear optimization in varied circumstances. Among its most notable features are:

- Interior and active-set alternatives.
- Derivative-free, 1st derivative and 2nd derivative options.
- Feasible and infeasible versions.
- Iterative and direct approaches for computing steps.

KNITRO's interior (or barrier) method replaces the nonlinear programming problem by a series of barrier sub-problems controlled by a parameter. It performs one or more minimization steps on each barrier problem, then decreases the barrier parameter and repeats the process until the original problem has been solved to the desired accuracy. The method uses trust regions and a merit function to promote convergence.

Complementing the interior method, KNITRO's active-set method is a Sequential Linear-Quadratic Programming algorithm similar to Sequential Quadratic Programming in nature, but designed for solving larger problems than can be solved by traditional SQP methods. This approach has the advantage of allowing for "warm starts" if a good initial solution can be provided.

KNITRO offers callable interfaces from C/C++, Fortran, MATLAB, and Visual Basic, and modeling interfaces for AMPL, GAMS, and Microsoft Excel.

TOMLAB - Unique Features for Optimization in MATLAB

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An overview of the TOMLAB Optimization Environment, http://tomlab.biz, is presented. TOMLAB includes a complete integration of all well-known commercial and academic solvers (e.g CPLEX, XPRESS-MP, SNOPT, KNITRO). The problem formulation is the same for all solvers and completely standardized. This makes it very easy to compare and test a variety of solutions and eventually find the best customer options. The functionality extends far beyond solver integration and options by the inclusion of a multitude of interfaces and specialized tools for numerical- and automatic differentiation, plotting and analysis. Also, there is a number of features in TOMLAB that are unique - costly black-box global optimization, semi-definite programming with a general objective function to name a few. The developments of the former will be further discussed.

Tools to Support Good Model Building and Model Use

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Modeling and simulation are frequently used to get insight in today's real world problems. However, it is an ill-defined methodology, which can end up in irreproducible model based studies of unknown quality. In this paper a set of tools is presented that can overcome some of the problems associated with modeling and simulation. It consists of a handbook for good modeling practice, a handbook for conceptualizing and a software tool for scenario and version management especially for GAMS models. The results of applications of these tools will be discussed.

Stochastic Programming and Scenario Generation within a Simulation Framework: An Information Systems Perspective

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Stochastic Programming brings together models of optimum resource allocation and models of randomness to create a robust decision making framework. The models of randomness with their finite, discrete realisations are called Scenario Generators. In a compendium report we have considered the modelling perspective of Scenario Generation and its integration within Stochastic Programming. In this paper we investigate the role of such a tool within the context of a combined information and decision support system. We analyse the roles of decision models and descriptive models, and also examine how these can be integrated with data marts of analytic organisational data and decision data. Recent developments in On-Line Analytical Processing (OLAP) tools and multidimensional data viewing are taken into consideration. We finally introduce illustrative examples of optimisation, simulation models and results analysis to explain our multifaceted view of modelling.

Keywords : Scenario Generation, Stochastic Programming, DSS , OLAP.

Application of Optimization Methods at OM Partners

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OM Partners n.v. has a long lasting experience in successfully applying optimization methods in the industry. In this talk, a selection of practical optimization problems is presented. We discuss the type of models that have been used. We also provide an insight into the various optimization techniques that were applied, and how these techniques provide a solution to the users's need.

Network Design and Optimization of Complex many-to-many Logistical Networks for Express and Parcel Service Providers

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The presentation describes some characteristics of logistical networks for express and parcel service providers: transportation costs derived from freight tariffs (economies of scale and distance), different types of products (associated to service), some constraints, the objective function and effects of different types of network structure (web-, hub- and mixed structure). In the presentation the scope of the optimization software PRODISI SCO (PROLOGOS Planung und Beratung Dr. Gietz, Henneberg, Kindt OHG, Hamburg) is pointed out and an overview of the steps in the optimization algorithm is given. The software which is based on a network flow algorithm is compared with MIP-based systems. To reduce problem complexity by separation, the tour model used in PRODISI SCO is described in detail. The results of PRODISI SCO using the tour model are discussed.

73rd Meeting of the GOR Working Group

„Praxis der Mathematischen Optimierung“

Optimization Services in Europes

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Tools to Support Good Model Building and Model Use

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Black Box Optimization in the Steel Industry

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Reliable, Robust and Efficient Optimization Methods for Real World Problems

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A Model is not just a Model - Models and their Roles

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Stochastic Programming and Scenario Generation within a Simulation Framework: An Information Systems Perspective

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AMPL: New Features for Formulating and Embedding AMPL Models

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Network Design and Optimization of Complex many-to-many Logistical Networks for Express and Parcel Service Providers

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TOMLAB - Unique Features for Optimization in MATLAB

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Very Different Problems Have the Same Solution

* = Non GOR-member, *italic* = speaker (34 participants incl. 15 speakers and 2 CLs, x*)