
KTH Mathematics

# 3rd Nordic Optimization Symposium

March 13–14, 2009

## Program

Division of Optimization and Systems Theory
Department of Mathematics
Royal Institute of Technology
Stockholm, Sweden
http://www.math.kth.se/optsyst/




# 3rd Nordic Optimization Symposium

Stockholm, Sweden, March 13–14, 2009

**Symposium Site.** The symposium will be held at the Royal Institute of Technology (KTH), which is situated in the northern part of the inner city of Stockholm. It is easy to reach it by subway—take the red line towards Mörby Centrum and get off at station Tekniska Högskolan. From the subway platform, follow the signs to Tekniska Högskolan. Once you reach the main entrance of KTH, signs will show you the way to the symposium site. The plenary talks will be held in room D2, Lindstedtsvägen 5. The parallel sessions will be held in rooms 3721 (session A) and 3733 (session B) at the Department of Mathematics, Lindstedtsvägen 15. Lunch and coffee will be provided at the Department of Mathematics, Lindstedtsvägen 15.

**Reception.** On Thursday March 12, 20.00-21.00, a reception will be held at the Department of Mathematics, Lindstedtsvägen 15.

**Registration.** Attendees may pick up programs and name tags either at the reception on Thursday night, or in the the morning of Friday, March 13, prior to the first talk. Anyone is welcome to attend the seminars for free. Only preregistered attendees can take part in the full symposium (including seminars, coffee, lunch, reception and banquet). There is a registration fee of SEK 2000 for preregistered attendees.

**Banquet.** On Friday March 13, at 19.00, a banquet will be held at Restaurant Syster o Bror, Drottning Kristinas väg 24.

**Plenary Speakers.** Plenary talks will be given by

- Edwin Romeijn, University of Michigan
- Melvyn Sim, National University of Singapore

**Organizing Committee.** Rasmus Bokrantz, Mikael Fallgren, Anders Forsgren (chair), Albin Fredriksson and Krister Svanberg.

**Sponsors.** The symposium is financially supported by the following companies:

- Jeppesen
- MOSEK
- Optimization Partner
- RaySearch Laboratories

# List of Abstracts, Friday March 13, 2009, 9.00–15.00

**Edwin Romeijn**

University of Michigan, Ann Arbor, Michigan, USA

**Friday**
**9.00–9.50**

### Optimization problems for radiation therapy treatment planning

In this talk we will discuss the state-of-the-art of optimization models for static radiation therapy treatment planning for cancer paatients, focusing in particular on intensity modulated radiation therapy (IMRT). In particular, we will focus on (i) the fluence-map optimization problem, in which the goal is to design high-quality fluence profiles for the radiation beams, and (ii) the leaf-sequencing problem, in which the goal is to enable the efficient delivery of these optimal fluence profiles. In the first part of the talk we will discuss the issue of assessing the quality of a treatment plan and establish a connection with (financial) risk management. In the second part of the talk we will study a new optimization approach to the problem of decomposing a fluence profile into a collection of so-called apertures. Mathematically, a fluence profile can be represented as a nonnegative integer matrix, while an aperture can be represented as a binary matrix whose ones appear consecutively in each row. A feasible decomposition is one in which the original desired fluence profile is equal to the sum of a number of feasible binary matrices multiplied by corresponding intensity values. In order to most efficiently treat a patient, we wish to minimize a measure of total treatment time, which is given as a weighted sum of the number of apertures and the sum of the aperture intensities used in the decomposition. We develop an exact algorithm capable of solving real-world problem instances to optimality within practicable computational time limits, using a combination of integer programming decomposition and combinatorial search techniques. We demonstrate the efficacy of our approach on a set of 25 test instances derived from actual clinical data.

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**Rasmus Bokrantz**

Royal Institute of Technology (KTH) and RaySearch Laboratories AB, Stockholm, Sweden

**Friday**
**10.20–10.40**
**Session A**

### Second-order dose estimates for radiotherapy treatment planning

Intensity modulated radiation therapy (IMRT) is a technique for cancer treatment where the patient is irradiated with high-energy photon beams with modulated fluence. The fluence profiles are computed by solving an inverse problem, with the goal of conforming the radiation dose to the tumor volume. We consider a problem formulation where a weighted sum of quadratic terms is minimized. Here, each term penalizes deviation from a dose objective prescribed to a specified anatomical region, and the relative importance of these objectives is reflected in the choice of weights. Due to differences between each patient case, it is in general not possible to assign a set of weights that constitute a suitable trade-off between high tumor dose and sparing of healthy organs prior to optimization. Instead, the objective weights must be assigned in a time-consuming trial-and-error process involving repeated re-optimization. In our research, we address this problem by considering a change of the objective weights as a perturbation of the initial problem, and compute first and second-order sensitivity estimates of the perturbed solution. Such estimates have the potential of providing the radiation oncologist with information on which changes to the objective weights that may improve the dose plan.

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**Friday**
**10.40–11.00**
**Session A**

**Albin Fredriksson**
Royal Institute of Technology (KTH) and RaySearch Laboratories AB, Stockholm, Sweden

**Geometrical uncertainties in radiation therapy**

When treating cancer patients with radiation, the objective is to deliver a prescribed dose of radiation to the tumor while sparing healthy tissue. An advanced technique that is used to achieve this is intensity modulated radiation therapy (IMRT), in which the intensity of the radiation is modulated not only between but also within the beams. This makes it possible to deliver a dose that conforms closely to the shape of the tumor, which can reduce damage to the surrounding tissue. We consider stochastic programming and robust optimization in order to achieve a safe treatment, in which uncertainties in the geometry of the patient, e.g. due to measurement and alignment errors as well as changes in the patient's constitution, are taken into account. Currently, the most widely used method to do this is by using margins. For instance, the tumor region is expanded into a planning target volume (PTV). The drawback is that organs intersecting the PTV will also receive high doses. Consequently, we want to avoid margins while keeping the plans robust to geometrical uncertainties.

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**Friday**
**11.00–11.20**
**Session A**

**Mikael Rönnqvist**
Norwegian Institute of Economics and Business Administration, Bergen, Norway

**Robust optimization for rolling horizon planning**

In this paper we describe a new method to solve Linear Programming (LP) problems with uncertain parameters. We apply this to planning problems where a rolling planning horizon is used. The method is based on a decomposition scheme where we iteratively solve an upper level problem for the first time period where the parameters are assumed to be known. The lower level problem use the upper level solution and computes a worst case scenario for an anticipation period with uncertain parameters. Information in how the worst case scenario is affected by the upper level decisions is given back as a valid inequality. This process is repeated until the upper level solution satisfy the last generated valid inequality. We test the proposed method on a integrated production, transportation and inventory planning problem coupled to planning annual planning for heating plants. We also compare our approach with a deterministic approach with and without safety stocks. The result shows that the method works well and perform better than the deterministic approach with safety stock.

This is joint work with **David Bredström**.

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**Yousaf Shad Muhammad**

NTNU, Trondheim, Norway

**Friday**
**11.20–11.40**
**Session A**

**Seafood value chain stochastic optimization model**

We are presenting a seafood value chain model for multi-facility and multi-location business management organization. Farming seafood follows cycle of reproduction, growth and maturation which takes place in the wild. A single management decides about optimal use of logistics and installed facilities on multiple locations. The complex processing of seafood from slaughtering to sale and its distribution with limited resources of inventories storage as well as limited durability of seafood make its operations specialized. This is a problem of multi-product, multi-facility locations, multi-period and a supply chain design. The objective of this study is to develop tools for producing economically sound management guidelines by structuring an economic optimization model that accommodates the operational complexity of the economical modeling of resources, logistics, and yield management and market demand under uncertainty.

This is joint work with **Asgeir Tomasgard**, **Peter Schütz** and **Kristin Tolstad Uggen**.

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**Oleg Burdakov**

Linköping University, Linköping, Sweden

**Friday**
**11.40–12.00**
**Session A**

**A novel approach in multilinear least-squares with application to design of filter networks**

Filter networks is a rapidly developing area due to their ability to significantly lower the computation time in multidimensional signal processing, especially in medical imaging. The design is based on solving a multilinear least-squares (MLLS) problem where the use of conventional methods is often practically impossible, because it is a non-convex large-scale optimization problem with a lot of local minimizers. The existing approaches are characterized by a lack of robustness - a very slow convergence with no guarantee of success. They are typically based on generating random initial points for further refinement with the use of local search methods.

So far, successful network designs have been restricted to special types of filters, e.g. those used for analyzing local signal structures. The lack of efficient methods for solving MLLS is however a bottleneck for further progress in filter network design.

Our approach is based on a reformulation of the MLLS problem in the form of a new optimization problem which allows us to deal with the multi-extremal nature of the original problem. Its solution is used then as an initial point in the original MLLS problem for further refinement.

We present results of numerical experiments which testify to the efficiency and robustness of our approach. Comparing to the standard approach, it demonstrated a speedup factor of several hundred in designing sub-filter sequences for 2D low-pass, band-pass and high-pass filters.

This is joint work with **Mats Andersson**, **Hans Knutsson** and **Björn Svensson**.

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**Friday**
**10.20–10.40**
**Session B**

**Jens Lysgaard**
Aarhus School of Business, Aarhus, Denmark

### The pyramidal capacitated vehicle routing problem

This paper introduces the Pyramidal Capacitated Vehicle Routing Problem (PCVRP) as a restricted version of the Capacitated Vehicle Routing Problem (CVRP). In the PCVRP each route is required to be pyramidal in a sense generalized from the Pyramidal Traveling Salesman Problem. A pyramidal route is defined as a route on which the vehicle first visits customers in increasing order of customer index, and on the remaining part of the route visits customers in decreasing order of customer index.

Moreover, this paper develops an exact branch-and-cut-and-price algorithm for the PCVRP. A main feature of the algorithm is that exact pricing over elementary routes are done in pseudo-polynomial time.

Computational results suggest that PCVRP solutions are highly useful for obtaining near-optimal solutions to the CVRP. Furthermore, pricing of pyramidal routes may prove to be very useful in column generation for the CVRP.

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**Friday**
**10.40–11.00**
**Session B**

**Clas Rydergren**
Linköping University, Norrköping, Sweden

### A heuristic method for finding congestion pricing schemes in urban traffic networks

We present a heuristic procedure for solving the congestion pricing problem of simultaneously finding the optimal number of toll facilities, their corresponding location and toll levels. The efficiency of the pricing scheme is evaluated by the net social surplus, which is the social surplus minus the cost of collecting the tolls. The congestion pricing model incorporates a discrete choice model to accommodate modal choice between two travel modes. The heuristic is based on a continuous approximation of an objective function with discrete variables, and repeated solutions of a toll level adjustment problem. The heuristic procedure is demonstrated and results from a Stockholm network model are presented.

This is joint work with **Joakim Ekström** and **Leonid Engelson**.

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**Jesper Larsen**

Technical University of Denmark (DTU), Lyngby, Denmark

**Friday**
**11.00–11.20**
**Session B**

**The vehicle routing problem with time windows and temporal dependencies**

In this presentation, we will formulate the vehicle routing problem with time windows and temporal dependencies. The problem is an extension of the well studied vehicle routing problem with time windows. In addition to the usual constraints, a scheduled time of one visit may restrain the scheduling options of other visits. Special cases of temporal dependencies are synchronization and precedence constraints. Two different models are proposed and the Dantzig-Wolfe decompositions of these models are presented to allow for a column generation based solution approach. Temporal dependencies are modeled by generalized precedence constraints. A total of four different master problem formulations are proposed and it is shown that the formulations can be ranked according to the tightness with which they describe the solution space. A tailored time window branching is used to enforce feasibility on the relaxed master problems. Finally, a com- putational study is carried out to quantitatively uncover strengths and weaknesses of the proposed formulations. It is concluded that, depending on the problem at hand, the best performance is achieved from either a relaxation of the generalized precedence constraints in the master problem, or using a time-indexed model, where generalized precedence constraints are added as cuts when they become severely violated.

This is joint work work **Anders Dohn** and **Matias Sevel Rasmussen**.

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**Min Wen**

Technical University of Denmark, Lyngby, Denmark

**Friday**
**11.20–11.40**
**Session B**

**Dynamic multi-period vehicle routing problem**

We will present the Dynamic Multi-Period Vehicle Routing problem (DMPVRP), encountered by a large distribution company in real-life. The problem considers the distribution of orders from a depot to a set of customers over a planning horizon of multiple periods. Customers with specific demands and specific feasible service periods are revealed incrementally over time. Multiple objectives are considered, including minimizing the total traveling time over the planning horizon, minimizing the customer waiting time and balancing the daily workload.

A tabu heuristic is developed to solve the problem. Computational experiments on real-life data involving up to 1100 orders over a planning of 15 periods are carried out. Results will be presented.

This is joint work with **Jean-Francois Cordeau**, **Gilbert Laporte** and **Jesper Larsen**.

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**Friday**
**11.40–12.00**
**Session B**

**Tobias Andersson Granberg**
Linköping University, Norrköping, Sweden

### Locating fire and rescue service resources through variable neighborhood search

The traditional way of designing a fire and rescue services system has been to find suitable locations for a number of fire stations, and then supply these stations with resources. This is a suitable way of designing the system if it can be assumed that the resources most of the time can be found at the station, an assumption that traditionally has been valid. However, attempting to increase the resource utilization of the fire and rescue services, managers now tend to look at the possibility of using resources for preventive work outside the station, e.g. education and supervision. A new challenge for location modelling is thus to locate the specific resources instead of the stations. Here, a model for locating rescue service resources is presented. The model considers multiple units types, and matches these to predetermined requirements for a number of different events, including building fires and traffic accidents. The gradual build-up of resources up to this requirement is taken into account in the objective, and the units do not have to be located at a fire station. The model is solved using the Variable Neighborhood Search heuristic. Computational results are presented for two Swedish fire and rescue services organisations.

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**Friday**
**13.20–13.40**
**Session A**

**Mikael Fallgren**
Royal Institute of Technology (KTH), Stockholm, Sweden

### On transmit power allocation in wireless networks

In this talk we consider a radio cellular system in which each cell manages the radio resources for its own users and services. The radio resources are orthogonal within each cell, e.g. Orthogonal Frequency Division Multiple Access (OFDMA). However, inter-cell interference is an issue if nearby cells use the same resorce simultaneously. The scheduling problem of the system is posed as a mathematical optimization problem, with the distribution of radio resources and transmission powers as variables. Various problem formulations and different solution methods will be discussed.

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**Kaj Holmberg**

Linköping University, Linköping, Sweden

**Friday**
**13.40–14.00**
**Session A**

### Valid inequalities from valid cycles

In IP networks using the routing protocol OSPF, the routing patterns are given by the shortest paths, based on link weights specified by the network operator. Designing such a network does not only concern choice of links and capacities, but also choice of weights.

For a given desired routing pattern, there might not exist weights (called compatible weights) that yield the pattern as shortest paths. Such unobtainable routing patterns can not be used, and should be removed from consideration. If the routing patterns are modeled with the help of binary variables, one might construct linear constraints, valid inequalities, that forbid unobtainable routing patterns.

We have previously identified a fairly strong substructure, called valid cycles, that prohibits the existence of compatible weights, and have efficient polynomial methods for finding such cycles. We will here present how valid inequalities for the set of all obtainable routing patterns can be constructed from valid cycles. We give a couple of sets of inequalities, prove that they are valid, and compare their strength.

This is joint work with **Mikael Call**.

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**Björn Johansson**

Royal Institute of Technology (KTH), Stockholm, Sweden

**Friday**
**14.00–14.20**
**Session A**

### Distributed non-smooth resource allocation over a network

Networked systems are common and crucial. One of the canonical problems in such systems is distributed resource allocation. From this rather broad class of problems, we consider a convex non-smooth resource allocation problem with a global resource constraint. More specifically, the objective function is separable and consists of a sum of convex functions with a local variable each, where each function corresponds to a node in a given network; the sum of the local variables across the network is constrained to be constant. For scalability, we consider an algorithm where only neighboring nodes need to communicate with each other. The resulting optimization algorithm is a combination of a subgradient method and distributed averaging. The algorithm starts from a feasible point, and then the nodes iteratively exchange resources with their neighbors to get close to the optimal set and to keep the resource allocation feasible at all times. We show that under mild technical assumptions, the algorithm converges in an epsilon-sense as long as the stepsize is chosen sufficiently small and the distributed averaging process is sufficiently accurate, which can be guaranteed by sufficiently many iterations.

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**Friday**
**14.20–14.40**
**Session A**

**Arne Løkketangen**
Høgskolen i Molde, Molde, Norway

### Generating metaheuristic optimization code using ADATE

Local Search based heuristic methods for finding good solutions to hard combinatorial optimization problems have attained a lot of success, and a plethora of methods exist, each with its own claim to fame, and associated quirks and parameter settings. At the same time, experience is needed to implement highly competitive code, and some of the experience applied is not easy to quantify.

ADATE is a system to automatically generate code based on a set of input-output specifications, and can work in vastly different domains. It generates code in a subset of ML and works by functional transformations of the program code.

We look at how code automatically generated by the ADATE system compares with state-of-the-art handcrafted metaheuristic optimization code. In particular, we compare the programs generated by ADATE on the move selection part of BOOP - Boolean Optimization Problems. Our baseline is a highly successful Tabu Search implementation. Our comparisons are when running a limited number of iterations, suitable for applications needing a short response time. Our computational tests show that the ADATE system is able to generate highly competitive code, executing at competitive speeds. The generated code also gives new insights on how to implement metaheuristic mechanisms.

This is joint work with **Roland Olsson**.

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**Friday**
**14.40–15.00**
**Session A**

**Di Yuan**
Linköping University, Norrköping, Sweden

### Performance optimization in beyond-3G cellular networks: A comeback of frequency assignment?

Beyond-3G cellular networks, in particular those based on the 4th generation Long Term Evolution (LTE) radio technology, form the access infrastructure of future broadband wireless Internet. Design and resource management of LTE give rise to a number of research challenges from a mathematical optimization viewpoint. In this talk we discuss capacity optimization of LTE and relate it to previous research on resource optimization in cellular systems. To this end, we review the well-known frequency assignment problem (FAP) in 2G networks, and discuss interference considerations and the resulting planning problem in 3G networks. We then introduce the concept of fractional frequency reuse (FFR) in LTE, and examine FFR vis-à-vis the classical frequency assignment problem. Some preliminary results of optimizing FFR for a realistic planning scenario are presented and analyzed.

This is joint work with **Lei Chen**.

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**Ann-Brith Strömberg**

Chalmers University of Technology, Göteborg, Sweden

**Friday 13.20–13.40 Session B**

### A cardinality constrained quadratic program with application to index tracking

We aim at constructing a portfolio that tracks a target portfolio using only a subset of the stocks and such that the total weight in each of the categories of several partitionings of the stocks is preserved. Further, the average grade of the stocks in the tracking portfolio should be maximized or constrained.

The problem is modelled as a mixed binary quadratic program. A direct application of branch-and-bound on a personal compoúter for a reasonable number of stocks in the portfolio yields a huge gap between the upper and lower bounds on the optimal objective value. Therefore, we employ a Lagrangian relaxation based solution method. Preliminary results are presented.

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**Adela Pagès-Bernau**

Norwegian University of Science and Technology (NTNU), Trondheim, Norway

**Friday 13.40–14.00 Session B**

### Model and analysis of a $CO_2$ value chain in Norway

Among the actions contemplated for carbon abatement we find the Carbon Capture and Storage (CCS). It consists on separating the $CO_2$ from exhaust fumes of large emitting industries, and transport it to suitable storage locations.

The storage of $CO_2$ can be done in geological formations (such as aquifers) for a long-term isolation. $CO_2$ can also be injected into mature oil fields for Enhanced Oil Recovery (EOR). This gives extra value to the $CO_2$ since additional barrels of oil are recovered due to the action of the $CO_2$.

The economical incentive for $CO_2$ storage is then to avoid paying the $CO_2$ quotas. In addition if $CO_2$ is used for EOR there is the income from the extra oil recovered. The use of $CO_2$ for EOR has a high potential but with large financial risk.

In order to analyse how a $CO_2$-EOR value chain can be realized in Norway we use a investment model that optimizes the Net Present Value by deciding the network structure, the best suited injection points and the investment timing. The model developed will be presented together with a base case. Analysis of the results will be discussed.

This is joint work with **Asgeir Tomasgard**.

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**Friday**
**14.00–14.20**
**Session B**

**Mikael Call**
Linköping University, Linköping, Sweden

### A cycle basis model of an inverse shortest path problem

In the OSPF inverse shortest path problem the metric must not imply that some undesired path is a shorthest path. The Farkas system of the original formulation of this problem is a special circulation multicommodity system. We derive a new equivalent model of this system based on fundamental cycle bases that is closly related to the working basis in the basis partitioning method of the multicommodity problem.

Implications of this new model are considered. It is shown that the Farkas system is feasible if and only if all inequality constraints can be satisfied with equality. Hence, some capacity constraints associated with a spanning tree are "redundant". In the original model this means that part of the metric can be fixed a priori. We discuss how this may be used in solution methods.

This is joint work with **Kaj Holmberg**.

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**Friday**
**14.20–14.40**
**Session B**

**Mohammed Alfaki**
University of Bergen, Bergen, Norway

### A path formulation for the generalized pooling problem

The pooling problem is an extension of the minimum cost network flow problem where the composition of the flow depends on the sources from which it originates. At each source, the composition is known, whereas in all other nodes the relative content of any component is given as a weighted average of the relative contents of it in entering flow streams. The weights in this average are simply the arc flow. At the sinks of the network, there are bounds on the relative content of the various components. Such problems have strong relevance in e.g. planning models for oil refining, and in gas transportation models with quality constraints at he reception side.

Although the pooling problem has bilinear side constraints, much progress in solving a class of instances to global optimality has recently been made. Most of the approaches are however restricted to networks where all directed paths have length at most three, which means that there is only one layer of nodes (pools) between the sources and the sinks. In this work, we generalize one of the most successful formulations of the pooling problem, and propose a path-oriented model that makes no assumptions on the network topology. We also discuss how this model can be solved by column generation.

This is joint work with **Dag Haugland**.

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**Richard Lusby**

Technical University of Denmark, Lyngby, Denmark

**Friday**
**14.40–15.00**
**Session B**

**An exact method for the double travelling salesman problem with multiple stacks**

The double travelling salesman problem with multiple stacks (DTSPMS) is a pickup and delivery problem in which all pickups must be completed before any deliveries can be made. The problem originates from a real-life example where a 40 foot container (configured as 3 columns of 11 rows) is used to transport up to 33 pallets from a set of pickup customers to a set of delivery customers. The pickups and deliveries are performed in two separate locations, where each location has a depot and a number of customers. The aim of the problem is to produce a stacking plan for the pallets that minimizes the total transportation cost (ignoring the cost of transporting the container between the two locations) given that the container cannot be repacked at any stage. In this talk we present an exact solution method based on matching k-best TSP solutions for each of the separate pickup and delivery TSP problems and show that previously unsolved instances can be solved within seconds using this approach.

This is joint work with **Jesper Larsen**, **Matthias Ehrgott** and **David Ryan**.

## Schedule, Friday March 13, 2009, 8.30-15.30

| | | |
|---|---|---|
| 8.30– 8.50 | Registration | |
| 8.50– 9.00 | Opening Remarks | |
| 9.00– 9.50 | **Edwin Romeijn**, *Optimization problems for radiation therapy treatment planning* | |
| 9.50–10.20 | Coffee Break | |
| | **Session A** | **Session B** |
| 10.20–10.40 | **Rasmus Bokrantz**, *Second-order dose estimates for radiotherapy treatment planning* | **Jens Lysgaard**, *The pyramidal capacitated vehicle routing problem* |
| 10.40–11.00 | **Albin Fredriksson**, *Geometrical uncertainties in radiation therapy* | **Clas Rydergren**, *A heuristic method for finding congestion pricing schemes in urban traffic networks* |
| 11.00–11.20 | **Mikael Rönnqvist**, *Robust optimization for rolling horizon planning* | **Jesper Larsen**, *The vehicle routing problem with time windows and temporal dependencies* |
| 11.20–11.40 | **Yousaf Shad Muhammad**, *Seafood value chain stochastic optimization model* | **Min Wen**, *Dynamic multi-period vehicle routing problem* |
| 11.40–12.00 | **Oleg Burdakov**, *A novel approach in multilinear least-squares with application to design of filter networks* | **Tobias Andersson Granberg**, *Locating fire and rescue service resources through variable neighborhood search* |
| 12.00–13.20 | Lunch Break | |
| | **Session A** | **Session B** |
| 13.20–13.40 | **Mikael Fallgren**, *On transmit power allocation in wireless networks* | **Ann-Brith Strömberg**, *A cardinality constrained quadratic program with application to index tracking* |
| 13.40–14.00 | **Kaj Holmberg**, *Valid inequalities from valid cycles* | **Adela Pagès-Bernau**, *Model and analysis of a $CO_2$ value chain in Norway* |
| 14.00–14.20 | **Björn Johansson**, *Distributed non-smooth resource allocation over a network* | **Mikael Call**, *A cycle basis model of an inverse shortest path problem* |
| 14.20–14.40 | **Arne Løkketangen**, *Generating metaheuristic optimization code using ADATE* | **Mohammed Alfaki**, *A path formulation for the generalized pooling problem* |
| 14.40–15.00 | **Di Yuan**, *Performance optimization in beyond-3G cellular networks: A comeback of frequency assignment?* | **Richard Lusby**, *An exact method for the double travelling salesman problem with multiple stacks* |
| 15.00–15.30 | Coffee Break | |

## Schedule, Friday March 13, 2009, 15.30–

| | Session A | Session B |
|---|---|---|
| 15.30–15.50 | **Bjørn Nygreen**, *Real time production optimization in upstream petroleum production — Applied to the Troll West oil rim* | **Anders Forsgren**, *An elementary proof of optimality conditions for linear programming* |
| 15.50–16.10 | **Henrik Andersson**, *The liquefied natural gas inventory routing problem* | **Erling D. Andersen**, *On the linear optimizers in MOSEK* |
| 16.10–16.30 | **Conrado Borraz-Sanchez**, *A tree decomposition algorithm for minimizing fuel cost in gas transmission networks* | **Michal Kaut**, *Solution methods for a multi-item newsvendor problem with substitution* |
| 16.30–16.50 | **Peter Schütz**, *Parallelizing the GassOpt-model* | **Trond Steihaug**, *When Halley and Newton are one step apart* |
| 16.50–17.10 | **Lennart Frimannslund**, *Scientific computing on the Sony Playstation 3 — The case of the pooling problem* | **Nils-Hassan Quttineh**, *Implementation of a one-stage efficient global optimization (EGO) algorithm* |
| 19.00– | B a n q u e t | |

## Schedule, Saturday March 14, 2009

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|---|---|
| 9.00– 9.50 | **Melvyn Sim**, *Distributionally robust optimization: A marriage of robust optimization and stochastic programming* |
| 9.50–10.20 | C o f f e e B r e a k |

| | Session A | Session B |
|---|---|---|
| 10.20–10.40 | **Tommy Clausen**, *Shift design for airport ground handling operations* | **Anders Hansson**, *A tailored inexact interior-point method for systems analysis* |
| 10.40–11.00 | **Henrik Delin**, *Extending the crew pairing problem using retiming of flights* | **Mohamed El Ghami**, *Primal-dual interior-point methods for linear optimization based on a kernel function with trigonometric barrier term* |
| 11.00–11.20 | **Matias Sevel Rasmussen**, *The home care crew scheduling problem* | **Elina Rönnberg**, *An all-integer column generation methodology for set partitioning problems* |
| 11.20–11.40 | **Geir Dahl**, *Disjoint congruence classes and an optimization problem* | **Matthias Nowak**, *Two modifications of the subgradient method* |
| 11.40–12.00 | **Stein-Erik Fleten**, *Optimal day-ahead bidding for a Norwegian hydropower producer* | **Kim Allan Andersen**, *The bicriterion multi modal assignment problem* |
| 12.00–13.20 | L u n c h B r e a k | |
| 13.20–14.00 | Business Meeting, Nordic Section of the Mathematical Programming Society | |

# List of Abstracts, Friday March 13, 2009, 15.30–17.10

**Bjørn Nygreen**

Norwegian University of Science and Technology (NTNU), Trondheim, Norway

**Friday 15.30–15.50 Session A**

### Real time production optimization in upstream petroleum production — Applied to the Troll West oil rim

Upstream petroleum production systems are usually quite complex consisting of many wells, pipelines and processing units. Optimization is performed on the life-time horizon of the hydrocarbon reservoir, typically many years, as well as on shorter time horizons. In this study we focus on short term optimization in the range of days and weeks. This requires models of each well and the pipeline system. Downstream processing equipment is not included in the present study.

First the Troll West oil field at the Norwegian continental shelf will be used discuss appropriate well models and pressure drop models for pipe flows. Then, alternative formulations of the optimization problem will be discussed and assessed. These include a nonlinear programming problem and a mixed integer formulation. At the end, alternative solutions methods are discussed with emphasis on the Dantzig Wolfe decomposition before some computational results are given.

This is joint work with **Vidar Gunnerud**, **Nina Walberg**, **Randi Vestbø** and **Bjarne A. Foss**.

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**Henrik Andersson**

Norwegian University of Science and Technology (NTNU), Trondheim, Norway

**Friday 15.50–16.10 Session A**

### The liquefied natural gas inventory routing problem

The Liquefied Natural Gas Inventory Routing Problem (LNG-IRP) is a complex combined inventory management and routing problem dealing with the distribution of LNG from liquefaction plants to regasification terminals using special purpose ships. In our setting, both liquefaction plants and regasification terminals have upper and lower inventory limits and variable production/consumption rates. A heterogeneous fleet of ships is given and the main question is how to route and schedule these ships so that the inventory limits are never broken. A ship schedule consists of a sequence of port calls and corresponding times. The ship loads at one liquefaction plant and then unload at one or two different regasification terminals before returning to a liquefaction plant to reload. Two models for the problem will be discussed. Both models are path-based, but differ in the way paths are represented. In the first model, each path covers a schedule for the whole planning horizon, while in the second, a path is a duty which only covers a loading operation and the subsequent unloading operations. Hence, an entire schedule for a ship is composed of a sequence of duties. A priori generation of all feasible schedules and duties as well as dynamic column generation have been implemented and tested. Preliminary results together with future plans are presented.

This is joint work with **Marielle Christiansen** and **Guy Desaulniers**.

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**Friday**
**16.10–16.30**
**Session A**

**Conrado Borraz-Sanchez**
University of Bergen, Bergen, Norway

### A tree decomposition algorithm for minimizing fuel cost in gas transmission networks

In this work, we address the problem of computing optimal transportation plans of natural gas by means of compressor stations in pipeline networks. This non-linear (non-convex) problem takes into account two types of continuous decision variables: mass flow rate through each arc, and gas pressure level at each node. Compressors consume fuel at rates depending on flow and pressure, and the problem is to assign values to these variables such that the total fuel cost is minimized. We propose a dynamic programming algorithm based on tree decomposition, which applies to a broader class of instances than currently available techniques can solve. Through computational experiments, we demonstrate that our algorithm is capable to solve several instances where previously suggested methods and commercially available solvers for non-linear optimization fail.

This is joint work with **Dag Haugland**.

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**Friday**
**16.30–16.50**
**Session A**

**Peter Schütz**
SINTEF Technology and Society, Trondheim, Norway

### Parallelizing the GassOpt-model

The GassOpt-model is a mixed-integer program intended to maximize the flow of natural gas from the gas fields in the North Sea to the European customers. The problem is formulated as a multi-commodity network flow problem with pooling constraints in some of the nodes. These pooling constraints increase the complexity, and thus the solution time, of the problem considerably. In order to speed up the solution, we decompose the model and implement a solution procedure for parallel processing.

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**Lennart Frimannslund**

University of Bergen, Bergen, Norway

**Friday**
**16.50–17.10**
**Session A**

**Scientific computing on the Sony Playstation 3 — The case of the pooling problem**

In the world of oil and gas production, it is common to model pipeline networks in order to determine their expected performance and their vulnerabilities. One way to do this is through Monte-Carlo simulation, where one simulates many life spans of a network subject to randomly generated events such as pipeline breakdown and varying demand. This way one can compute means and variances of quantities of interest, and measure to what extent the networks can be used to satisfy customers.

At the heart of this simulation lies a hard non-convex optimization problem, the pooling problem. For arbitrary pipeline networks it is hard to find an efficient solution algorithm that gives the global optimum. For Monte-Carlo simulations one therefore accepts local solutions, which are cheaply obtained with Linear Programming (LP) relaxations to the original problem. Accordingly, one has to solve many LP problems in such a simulation, which calls for fast algorithms and computers.

The Sony Playstation 3 gaming console is a computer which can give very impressive performance in flops compared to its cost in money. However, due to its low internal transfer speed, maximum performance is only achieved on problems where one, simply put, has to do a lot of work on little data. We show that our problem is of this type, and give some preliminary results.

This is joint work with **Dag Haugland**.

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**Anders Forsgren**

Royal Institute of Technology (KTH), Stockholm, Sweden

**Friday**
**15.30–15.50**
**Session B**

**An elementary proof of optimality conditions for linear programming**

Proving optimality conditions for linear programming is straightforward, if one assumes that the problem is primal nondegenerate. The general case, covering degeneracy, is less straightforward. Traditionally, one makes use of either Farkas' lemma or of the simplex method with some anticycling scheme. In this talk, we give an elementary proof of optimality conditions for linear programming, built on a straightforward classical perturbation of the constraints. The proof does not require either the use of Farkas' lemma or the use of the simplex method. As a by-product, we also obtain a proof of Farkas' lemma.

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**Friday**
**15.50–16.10**
**Session B**

**Erling D. Andersen**
MOSEK ApS, Copenhagen, Denmark

### On the linear optimizers in MOSEK

The software package MOSEK is capable of solving large-scale sparse linear optimization problems using either an interior-point, a primal simplex or a dual simplex algorithm. The aim of this talk is to present the optimizers and the recent advances in their implementation. Moreover, we will present numerical results demonstrating the optimizers performance.

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**Friday**
**16.10–16.30**
**Session B**

**Michal Kaut**
Høgskolen i Molde, Molde, Norway

### Solution methods for a multi-item newsvendor problem with substitution

We have a stochastic multi-item newsboy model with the following modification: if a customer who wants to buy an item arrives and the item is not available, there is some (specified) probability that he or she will be willing to buy another item instead.

It turns out that a straightforward LP implementation does not work, as it assumes that we can optimize customers' behaviour. This issue can be remedied by introducing extra binary variables, but such a model is solvable only for very small examples.

Instead, we show that the problem can be solved using a derivative-free solver (in our case Ganso), using the second stage of the stochastic pro- gram as a simulator. This approach allows us to solve significantly larger models than the stochastic-MIP formulation. In addition, the running time can be expected to be approximately linear in the number of scenarios. Could it be that the derivative-free (or simulation-based) optimization deserves more attention also in the LP/MIP world?

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**Trond Steihaug**

University of Bergen, Bergen, Norway

**Friday**
**16.30–16.50**
**Session B**

### When Halley and Newton are one step apart

Consider numerical solution of a nonlinear system of equations $F(x) = 0$ where the function is sufficiently smooth. While Newton's method which has second order rate of convergence method, is usually used for solving such systems, third order methods will in general use fewer iterations than a second order method to reach the same accuracy. However, the number of arithmetic operations per iteration is higher for third order methods than second order methods. We will show that for a large class of problems the ratio of the number of arithmetic operations of a third order method and Newton's method is constant per iteration using a direct method to solve the linear systems including the cost of computing the function and the derivatives. We also discuss an inexact method.

This is joint work with **Geir Gundersen**, **Torbjørn Lium** and **Sara Suleiman**.

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**Nils-Hassan Quttineh**

Mälardalen University, Västerås, Sweden

**Friday**
**16.50–17.10**
**Session B**

### Implementation of a one-stage efficient global optimization (EGO) algorithm

Almost every Costly Global Optimization (CGO) solver utilizes a surrogate model, or response surface, to approximate the true (costly) function. The EGO algorithm introduced by Jones et al. utilizes the DACE framework to build an approximating surrogate model. By optimizing a less costly utility function, the algorithm determines a new point where the original objective function is evaluated. This is repeated until some convergence criteria is fulfilled.

The original EGO algorithm finds the new point to sample in a two-stage process. In its first stage, the estimates of the interpolation parameters are optimized with respect to already sampled points. In the second stage, these estimated values are considered true in order to optimize the location of the new point. The use of estimate values as correct introduces a source of error.

Instead, in the One-stage EGO algorithm, both parameter values and the location of a new point are optimized at the same time, removing the source of error. This new subproblem becomes more difficult, but eliminates the need of solving two subproblems.

Difficulties in implementing a fast and robust One-Stage EGO algorithm in TOMLAB are discussed, especially the solution of the new subproblem.

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## List of Abstracts, Saturday March 14, 2009

**Saturday**
**9.00–9.50**

**Melvyn Sim**
National University of Singapore, Singapore

### Distributionally robust optimization: A marriage of robust optimization and stochastic programming

Stochastic Programming (SP) and Robust Optimization (RO) are often viewed as two extreme approaches of addressing optimization problems under uncertainties. In SP, uncertain data is represented as a random variable based on an assumed probability distribution. However, from practical perspective, it is impossible to elicit the exact distribution of the uncertain data. Besides, a SP model is generally computationally intractable. In RO, data uncertainty is represented by an uncertainty set. Although some RO models are computationally amiable, their solutions can be rather conservative. In this talk, we look at Distributionally Robust Optimization (DRO), which integrates SO and RO models. A DRO model allows the modeler to consider uncertain parameters whose distributions is unknown but with the same descriptive statistics on the data such as known means, variances and directional deviations among others. We will discuss the techniques for formulation computationally tractable DRO models for multistage modeling with recourse and for safeguarding constraints against infeasibility analogous to joint chance constrained problems.

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**Saturday**
**10.20–10.40**
**Session A**

**Tommy Clausen**
Technical University of Denmark (DTU), Lyngby, Denmark

### Shift design for airport ground handling operations

We consider the shift design problem in which work shifts must be created in order to cover a given workload as good as possible while minimizing cost. The workload is given as a number of demand graphs that each specifies a required combination of skills per time period. Each shift is created with qualifications that may cover workload for one or more skill combination.

We focus mainly on applications within airport ground handling where the workload is usually highly irregular. Furthermore the rules and preferences used in ground handling operations can be numerous and vary significantly between different operations, as different labor regulations or organizational rules apply. Therefore, a large degree of flexibility is required to model different ground handling operations.

We present a Simulated Annealing metaheuristic with adaptive neighborhood selection and a loosely coupled rule engine for solving the Shift Design Problem. Computational results are presented based on scenarios from different real-life ground handling operations.

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**Henrik Delin**

Jeppesen Technology Services, Göteborg, Sweden

**Saturday**
**10.40–11.00**
**Session A**

**Extending the crew pairing problem using retiming of flights**

Airline schedule planning is traditionally done in a sequential manner, starting with creating the time table for the flights. Subsequently, the planning of aircraft schedules and the crew schedules follows. Crew pairing, the first step of crew scheduling and which builds anonymous trips, is a well known problem usually solved using column generation. One way to improve the crew planning is to allow the pairing solution to suggest some changes in the time table, retimings. We will present how this can be done in crew pairing optimization, considering the aspects of not breaking other parts of the planning, e.g. aircraft schedules. The potential savings can be several percent of the crew cost. Since the cost of crew is a large proportion of the operational costs for an airline, the savings can be substantial.

This is joint work with **Fredrik Altenstedt**, **Lennart Bengtsson** and **Johan Ivarsson**.

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**Matias Sevel Rasmussen**

Technical University of Denmark (DTU), Lyngby, Denmark

**Saturday**
**11.00–11.20**
**Session A**

**The home care crew scheduling problem**

In the Home Care Crew Scheduling Problem (HCCSP) a staff of caretakers has to be assigned a number of visits, such that the total number of assigned visits is maximised. The visits have different locations and positions in time, and travelling time and time windows must be respected. The challenge when assigning visits to caretakers lies in the existence of soft constraints and indeed also in temporal dependencies between the starting times of visits.

Most former approaches to solving the HCCSP involve the use of heuristic methods. Here we develop an exact branch-and-price algorithm that uses clustering of the visits based on the problem structure. The algorithm is tested on real-life problem instances and we obtain solutions that are better than current practice in all cases.

This is joint work with **Tor Justesen**, **Anders Dohn** and **Jesper Larsen**.

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**Geir Dahl**

University of Oslo, Oslo, Norway

**Saturday**
**11.20–11.40**
**Session A**

**Disjoint congruence classes and an optimization problem**

We consider a combinatorial problem motivated by a special simplified timetabling problem for subway networks. Mathematically the problem is to find (pairwise) disjoint congruence classes modulo certain given integers; each such class corresponds to the arrival times of a subway line of a given frequency. For a large class of instances we characterize when such disjoint congruence classes exist and how they may be determined. We also briefly mention a generalization involving a minimum distance requirement between congruence classes, and a comparison of different frequency families in terms of their "efficiency". Finally, a general method based on integer programming is also discussed.

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**Saturday**
**11.40–12.00**
**Session A**

**Stein-Erik Fleten**
Norwegian University of Science and Technology (NTNU), Trondheim, Norway

### Optimal day-ahead bidding for a Norwegian hydropower producer

This paper presents a multistage stochastic MIP-model developed for day-ahead market bidding and short term scheduling of a Norwegian hydro power generator. In order to capture the long-term aspects of depleting reservoirs the model uses an hourly resolution the first day, and a gradually coarser resolution toward the end of the planning horizon, which stretches about six months ahead. Electricity prices are stochastic, whereas inflow is deterministic as the model is intended for use in the winter season. The model is tested on a power plant in Southern Norway and is found to give reasonable results and to be able to mimic the real world bidding strategy of the plant owner fairly well.

This is joint work work **Jens Arne Steinsbø**.

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**Saturday**
**10.20–10.40**
**Session B**

**Anders Hansson**
Linköping University, Linköping, Sweden

### A tailored inexact interior-point method for systems analysis

Within the are of systems analysis there are several problem formulations that can be rewritten as semidefinite programs. Increasing demand on computational efficiency and ability so solve large scale problems make the available generic solvers inadequate. In this presentation structure knowledge is utilized to derive tailored calculations and to incorporate adaptation to the different properties that appear in a proposed inexact interior-point method.

This is joint work with **Janne Harju Johansson**.

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**Saturday**
**10.40–11.00**
**Session B**

**Mohamed El Ghami**
University of Bergen, Bergen, Norway

### Primal-dual interior-point methods for linear optimization based on a kernel function with trigonometric barrier term

In this paper we present a new barrier function for primal-dual interior point methods (IPMs) in linear optimization. The proposed function has a trigonometric barrier term. We prove that large-update method for linear optimization based on the new search direction improve the classical iteration bound namely $O(n \log \frac{n}{\epsilon})$. For small-update interior point methods the iteration bound is $O(\sqrt{n} \log \frac{n}{\epsilon})$, which is currently the best-known bound for primal-dual IPMs.

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**Elina Rönnberg**
Linköping University, Linköping, Sweden

**Saturday**
**11.00–11.20**
**Session B**

**An all-integer column generation methodology for set partitioning problems**

The set partitioning polytope has the quasi-integrality property that enables the use of simplex pivot based methods for finding an improved integer solution, which thereby is associated with a linear programming basis and a corresponding dual solution. I will present a framework for an all-integer column generation methodology for set partitioning problems that utilises the quasi-integrality property of the feasible polytope.

In the presented methodology, each successively found solution to a restricted master problem is feasible, integer and associated with a corresponding dual solution, which is then used in the column generation step. The column generation problem is tailored to produce columns that maintain integrality when pivoted into the basis. Furthermore, criteria for verifying optimality are presented.

This is joint work work **Torbjörn Larsson**.

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**Matthias Nowak**
MARINTEK, Trondheim, Norway

**Saturday**
**11.20–11.40**
**Session B**

**Two modifications of the subgradient method**

Subgradient methods are known to be very easily implemented, but also for their bad performance. The first modification deals with smooth problems and changes the method into a predictor-corrector method by exchanging the stopping criterion for some steps. The second part of the talk deals with non-linear problems. Using subgradients forbids line-searches, because they lead to early stops at non-optimal points. The usual step-length rule avoids this pitfall but might take to much time. The presented rule avoids this and leads to an efficient method for some types of problems.

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**Kim Allan Andersen**
Aarhus School of Business, Aarhus, Denmark

**Saturday**
**11.40–12.00**
**Session B**

**The bicriterion multi modal assignment problem**

We consider the bicriterion multi modal assignment problem which is a new generalization of the classical linear assignment problem. A two-phase solution method using an effective ranking scheme is presented. The algorithm is valid for generating all nondominated criterion points or an approximation. Extensive computational results are conducted on a large library of test instances to test the performance of the algorithm and to identify hard test instances. Also, test results of the algorithm applied to the bicriterion assignment problem is provided.

This is joint work with **Christian Roed Pedersen** and **Lars Relund Nielsen**.

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## List of Speakers

### Plenary talks

- **Edwin Romeijn**, (romeijn@umich.edu), University of Michigan, Ann Arbor, Michigan, USA. *Optimization problems for radiation therapy treatment planning.* (Friday, 9.00–9.50, Abstract on p. 5).
- **Melvyn Sim**, (melvynsim@nus.edu.sg), National University of Singapore, Singapore. *Distributionally robust optimization: A marriage of robust optimization and stochastic programming.* (Saturday, 9.00–9.50, Abstract on p. 24).

### Contributed talks

- **Mohammed Alfaki**, (mohammed.alfaki@ii.uib.no), University of Bergen, Bergen, Norway. *A path formulation for the generalized pooling problem.* (Friday, 14.20–14.40, Session B, Abstract on p. 14).
- **Erling D. Andersen**, (e.d.andersen@mosek.com), MOSEK ApS, Copenhagen, Denmark. *On the linear optimizers in MOSEK.* (Friday, 15.50–16.10, Session B, Abstract on p. 22).
- **Kim Allan Andersen**, (kia@asb.dk), Aarhus School of Business, Aarhus, Denmark. *The bicriterion multi modal assignment problem.* (Saturday, 11.40–12.00, Session B, Abstract on p. 27).
- **Henrik Andersson**, (henrik.andersson@iot.ntnu.no), Norwegian University of Science and Technology (NTNU), Trondheim, Norway. *The liquefied natural gas inventory routing problem.* (Friday, 15.50–16.10, Session A, Abstract on p. 19).
- **Tobias Andersson Granberg**, (tobias.andersson.granberg@itn.liu.se), Linköping University, Norrköping, Sweden. *Locating fire and rescue service resources through variable neighborhood search.* (Friday, 11.40–12.00, Session B, Abstract on p. 10).
- **Rasmus Bokrantz**, (bokrantz@kth.se), Royal Institute of Technology (KTH) and RaySearch Laboratories AB, Stockholm, Sweden. *Second-order dose estimates for radiotherapy treatment planning.* (Friday, 10.20–10.40, Session A, Abstract on p. 5).
- **Conrado Borraz-Sanchez**, (conrado.borraz-sanchez@ii.uib.no), University of Bergen, Bergen, Norway. *A tree decomposition algorithm for minimizing fuel cost in gas transmission networks.* (Friday, 16.10–16.30, Session A, Abstract on p. 20).
- **Oleg Burdakov**, (olbur@mai.liu.se), Linköping University, Linköping, Sweden. *A novel approach in multilinear least-squares with application to design of filter networks.* (Friday, 11.40–12.00, Session A, Abstract on p. 7).
- **Mikael Call**, (mical@mai.liu.se), Linköping University, Linköping, Sweden. *A cycle basis model of an inverse shortest path problem.* (Friday, 14.00–14.20, Session B, Abstract on p. 14).
- **Tommy Clausen**, (tommy.clausen@gmail.com), Technical University of Denmark (DTU), Lyngby, Denmark. *Shift design for airport ground handling operations.* (Saturday, 10.20–10.40, Session A, Abstract on p. 24).
- **Geir Dahl**, (geird@ifi.uio.no), University of Oslo, Oslo, Norway. *Disjoint congruence classes and an optimization problem.* (Saturday, 11.20–11.40, Session A, Abstract on p. 25).
- **Henrik Delin**, (henrik.delin@jeppesen.com), Jeppesen Technology Services, Göteborg, Sweden. *Extending the crew pairing problem using retiming of flights.* (Saturday, 10.40–11.00, Session A, Abstract on p. 25).
- **Mohamed El Ghami**, (mohamed.ghami@ii.uib.no), University of Bergen, Bergen, Norway. *Primal-dual interior-point methods for linear optimization based on a kernel function with trigonometric barrier term.* (Saturday, 10.40–11.00, Session B, Abstract on p. 26).

- **Mikael Fallgren**, (werty@kth.se), Royal Institute of Technology (KTH), Stockholm, Sweden. *On transmit power allocation in wireless networks.* (Friday, 13.20–13.40, Session A, Abstract on p. 10).
- **Stein-Erik Fleten**, (stein-erik.fleten@iot.ntnu.no), Norwegian University of Science and Technology (NTNU), Trondheim, Norway. *Optimal day-ahead bidding for a Norwegian hydropower producer.* (Saturday, 11.40–12.00, Session A, Abstract on p. 26).
- **Anders Forsgren**, (andersf@kth.se), Royal Institute of Technology (KTH), Stockholm, Sweden. *An elementary proof of optimality conditions for linear programming.* (Friday, 15.30–15.50, Session B, Abstract on p. 21).
- **Albin Fredriksson**, (albfre@kth.se), Royal Institute of Technology (KTH) and RaySearch Laboratories AB, Stockholm, Sweden. *Geometrical uncertainties in radiation therapy.* (Friday, 10.40–11.00, Session A, Abstract on p. 6).
- **Lennart Frimannslund**, (lennart.frimannslund@ii.uib.no), University of Bergen, Bergen, Norway. *Scientific computing on the Sony Playstation 3 — The case of the pooling problem.* (Friday, 16.50–17.10, Session A, Abstract on p. 21).
- **Anders Hansson**, (hansson@isy.liu.se), Linköping University, Linköping, Sweden. *A tailored inexact interior-point method for systems analysis.* (Saturday, 10.20–10.40, Session B, Abstract on p. 26).
- **Kaj Holmberg**, (kahol@mai.liu.se), Linköping University, Linköping, Sweden. *Valid inequalities from valid cycles.* (Friday, 13.40–14.00, Session A, Abstract on p. 11).
- **Björn Johansson**, (bjorn.johansson@ee.kth.se), Royal Institute of Technology (KTH), Stockholm, Sweden. *Distributed non-smooth resource allocation over a network.* (Friday, 14.00–14.20, Session A, Abstract on p. 11).
- **Michal Kaut**, (michal.kaut@himolde.no), Høgskolen i Molde, Molde, Norway. *Solution methods for a multi-item newsvendor problem with substitution.* (Friday, 16.10–16.30, Session B, Abstract on p. 22).
- **Jesper Larsen**, (jla@imm.dtu.dk), Technical University of Denmark (DTU), Lyngby, Denmark. *The vehicle routing problem with time windows and temporal dependencies.* (Friday, 11.00–11.20, Session B, Abstract on p. 9).
- **Richard Lusby**, (rmlu@man.dtu.dk), Technical University of Denmark, Lyngby, Denmark. *An exact method for the double travelling salesman problem with multiple stacks.* (Friday, 14.40–15.00, Session B, Abstract on p. 15).
- **Jens Lysgaard**, (lys@asb.dk), Aarhus School of Business, Aarhus, Denmark. *The pyramidal capacitated vehicle routing problem.* (Friday, 10.20–10.40, Session B, Abstract on p. 8).
- **Arne Løkketangen**, (arne.lokketangen@himolde.no), Høgskolen i Molde, Molde, Norway. *Generating metaheuristic optimization code using ADATE.* (Friday, 14.20–14.40, Session A, Abstract on p. 12).
- **Matthias Nowak**, (matthiaspeter.nowak@marintek.sintef.no), MARINTEK, Trondheim, Norway. *Two modifications of the subgradient method.* (Saturday, 11.20–11.40, Session B, Abstract on p. 27).
- **Bjørn Nygreen**, (bjorn.nygreen@iot.ntnu.no), Norwegian University of Science and Technology (NTNU), Trondheim, Norway. *Real time production optimization in upstream petroleum production — Applied to the Troll West oil rim.* (Friday, 15.30–15.50, Session A, Abstract on p. 19).
- **Adela Pagès-Bernau**, (adela.pages@iot.ntnu.no), Norwegian University of Science and Technology (NTNU), Trondheim, Norway. *Model and analysis of a $CO_2$ value chain in Norway.* (Friday, 13.40–14.00, Session B, Abstract on p. 13).

- **Nils-Hassan Quttineh**, (nisse.quttineh@mdh.se), Mälardalen University, Västerås, Sweden. *Implementation of a one-stage efficient global optimization (EGO) algorithm.* (Friday, 16.50–17.10, Session B, Abstract on p. 23).
- **Clas Rydergren**, (clas.rydergren@itn.liu.se), Linköping University, Norrköping, Sweden. *A heuristic method for finding congestion pricing schemes in urban traffic networks.* (Friday, 10.40–11.00, Session B, Abstract on p. 8).
- **Elina Rönnberg**, (elron@mai.liu.se), Linköping University, Linköping, Sweden. *An all-integer column generation methodology for set partitioning problems.* (Saturday, 11.00–11.20, Session B, Abstract on p. 27).
- **Mikael Rönnqvist**, (mikael.ronnqvist@nhh.no), Norwegian Institute of Economics and Business Administration, Bergen, Norway. *Robust optimization for rolling horizon planning.* (Friday, 11.00–11.20, Session A, Abstract on p. 6).
- **Peter Schütz**, (Peter.Schuetz@sintef.no), SINTEF Technology and Society, Trondheim, Norway. *Parallelizing the GassOpt-model.* (Friday, 16.30–16.50, Session A, Abstract on p. 20).
- **Matias Sevel Rasmussen**, (masra@imm.dtu.dk), Technical University of Denmark (DTU), Lyngby, Denmark. *The home care crew scheduling problem.* (Saturday, 11.00–11.20, Session A, Abstract on p. 25).
- **Yousaf Shad Muhammad**, (yousaf@iot.ntnu.no), NTNU, Trondheim, Norway. *Seafood value chain stochastic optimization model.* (Friday, 11.20–11.40, Session A, Abstract on p. 7).
- **Trond Steihaug**, (trond.steihaug@ii.uib.no), University of Bergen, Bergen, Norway. *When Halley and Newton are one step apart.* (Friday, 16.30–16.50, Session B, Abstract on p. 23).
- **Ann-Brith Strömberg**, (anstr@chalmers.se), Chalmers University of Technology, Göteborg, Sweden. *A cardinality constrained quadratic program with application to index tracking.* (Friday, 13.20–13.40, Session B, Abstract on p. 13).
- **Min Wen**, (miwe@man.dtu.dk), Technical University of Denmark, Lyngby, Denmark. *Dynamic multi-period vehicle routing problem.* (Friday, 11.20–11.40, Session B, Abstract on p. 9).
- **Di Yuan**, (diyua@itn.liu.se), Linköping University, Norrköping, Sweden. *Performance optimization in beyond-3G cellular networks: A comeback of frequency assignment?.* (Friday, 14.40–15.00, Session A, Abstract on p. 12).

**3rd Nordic Optimization Symposium, March 13–14, 2009**

## Map of KTH campus

Banquet at Restaurant SysteroBror
Drottning Kristinas väg 24

Reception, Lunch, Coffee
Parallel Sessions in Rooms 3721 and 3733
Lindstedtsvägen 15–19

Plenary talks in Room D2
Lindstedtsvägen 5