"The fire and rescue vehicle location problem"

Henrik Andersson, Norwegian University of Science and Technology
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Efficient utilization of fire and rescue service resources is important in order to reduce the negative consequences of events, i.e. accidents and other emergencies. By locating the resources in an optimal way, the time it takes to properly respond to an event is reduced, and thus also the consequences of the event. Many of the tools today do simple coverage or availability analyses to support these decisions.

Examples include minimizing the time before the first unit is on site, maximizing the number of people reached within a given time limit, and only including one type of rescue units. A problem is that they do not take into account different and new ways of organizing responding units or the gradual build-up of resources on site. Two aspects are important when evaluating a given location, the time it takes for the first resource to reach the event and the time it takes until a sufficient number of resources have reached the event.

The fire and rescue vehicle location problem (FRVLP) is the problem of locating a fleet of response units where the objective is a weighted sum of when the first unit is on site and when a sufficient number of resources have reached the event. The version of the problem presented here includes different types of accidents and a fixed heterogeneous fleet of responding units. Each type of accident is associated with a specific emergency preparedness plan, defining which types and the number of emergency units needed for the accident to be covered.

The geographical area studied is divided into zones and the expected number of accidents of each type is given for each zone. We propose a descriptive formulation of the problem and a reformulation such that it can be solved using dynamic column generation. The reformulated model decomposes into one master problem and one subproblem for each unit. The subproblems generate coverage plans for each unit, and the master problem makes the assignment of plans to units.

We present the formulations and a branch-and-price framework for solving the FRVLP. Cases based on real world data will be analyzed and discussed.

“Discrete optimization support system for the collection grid in large offshore wind parks”

Niels-Christian Fink Bagger and Michael Lindahl, Technical University of Denmark.

Offshore wind parks have in the recent years started to grow significantly in size making the task of deciding on how to build the cable collection grid a lot more complex. Not only to keep the initial construction costs down, but also to make sure it is efficient with minimal loss of power.

The goal is to connect all turbines down to a substation by using different types of cables. The objective is then to minimize the cost by minimizing the amount of cables, connections and loss of power.

The project is made in collaboration with DONG Energy which are market leaders in building offshore wind parks. A mathematical representation of the problem is given which is turned into a MIP model by linear approximations of the quadratic power losses. It is shown how the problem is simplified by using Delaunay triangulation and a k-nearest neighbourhood for the turbines.

In order to solve the problem within a reasonable time the local branching framework is used. At the end different cases with additional constraints and data are explored to show the flexibility of the tool. All of this is done on the Anholt Project which is a large offshore wind park including 111 wind turbines and 1 substation.

The tool is made as a plug-in to Microsoft Office Excel as the employees are familiar with this software. It is shown how this tool can be used, not only to reduce cost, but also to easily explore different scenarios and see how the solution is affected if different constraints are added or other properties are changed. This could for example be if different cable types are used or if the substation is located elsewhere.

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“An nonlinear programming approach to structural estimation of real options”

Knut-Harald Bakke and Jon Ragnar Viggen, NTNU

We analyze the real options to shutdown, startup and abandon gas-fired power plants. The numerical approach is nonlinear programming (Su and Judd, 2012, forthcoming Econometrica), where the value matching and smooth pasting conditions are modeled as constraints, and option value constants, exercise boundaries and structural parameters are variables.

Structural parameters of interest include the cost of switching operating status for the power plant; the plants' status for a given year is either operating, in standby or retired. Their status is further dependent on a stochastic two-factor model for the spark spread process. The analysis is made possible by data on operating status as reported annually to the US Energy Information Administration. The nonlinear program is implemented in AMPL using KNITRO as solver.

"A Stochastic Programming Formulation for the Maritime Fleet Size and Mix Problem"

Rikard Bakkehaug, Eirik Eidem, Kjetil Fagerholt and Lars Magnus Hvattum, Norwegian University of Science and Technology

Capital cost constitutes a major part of the total cost in a shipping company, and thus keeping the best fleet possible is an important task for shipping companies. We propose a new multi-stage stochastic optimization formulation for the maritime fleet size and mix problem. The formulation considers multiple adjustment possibilities and accounts for the uncertainty in the future parameters.

The formulation is tested through Monte Carlo simulations. Results show that accounting for the uncertainty improves the fleet adjustment decisions made. The stochastic programming approaches use a larger vessel fleet than the more traditional deterministic approaches. If the stochastic approaches experience excess capacity it tries to charter out as much as possible to recover the costs. The deterministic approaches have a smaller vessel fleet and experience to a greater extent lack of capacity and thus the need of chartering in expensive vessels to be able to serve their demand.

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Planning vessels air emission regulations compliance under uncertainty

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Abstract

In this paper we consider the reduction of air emissions from vessels when uncertainty is taken into account. Uncertainty in the reduction effects of the different existing air emission controls is currently high and makes their selection for vessels emission regulations compliance a challenging process. We develop a two-stage stochastic optimization model that addresses this uncertainty. The model's objective is to plan the installation of air emission control over a specified time horizon for a vessel to comply in the most cost-efficient way with the air emission regulations. The uncertain reduction effects of the controls are modelled by a set of scenarios. The approach is applied to a case study with real data. The solution exposes the important impact of uncertainty on this problem, especially on the SO_X reduction, while the CO_2 reduction plan seems in this case not affected by uncertainty.

"Decomposition Strategies for Stochastic Mixed-integer Nonlinear Programs with Applications to Energy Systems"

Paul I. Barton, Massachusetts Institute of Technology

We present a recently developed deterministic global optimization approach with running time that scales linearly with the number of scenarios considered. This enables the solution of large-scale instances of problems that arise in the optimization of a variety of energy systems under uncertainty, such as the planning of natural gas production infrastructure, the design of flexible energy polygeneration systems, feedstock selection for oil refineries, etc.

A Dynamic Programming Algorithm for the Space Allocation and Aisle Positioning Problem

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Abstract

The space allocation and aisle positioning problem (SAAPP) in a material handling system with gravity flow racks is defined by Anken et al. (2011) as the problem of maximizing the number of assigned product units subject to practical constraints related to the need for aisles granting safe and easy access to storage locations. The SAAPP considers two interrelated problems and seeks to find an optimal solution for them simultaneously. The first is the determination of the number of units per product assigned to the forward area. The second problem is the storage location assignment problem. Separately, these problems have been extensively investigated. However, previous research in the field of material handling seems to underestimate the effect of interrelations between the managerial decisions on warehouse performance. It is thus of interest to learn how material handling decisions are interconnected, and develop integrated material handling systems. Need for research on integration of problems has been expressed earlier in Matson and White (1982) and de Koster et al. (2007).

The SAAPP is to maximize the number of assigned product units (or, equivalently, minimizing the total number of replenishments) over a period, given a unit-load, gravity flow storage system with n locations, m slots per location, p different products with a periodic demand d_j ($j = 1, \ldots, p$) and the following requirements according to Anken et al. (2011): (1) each product receives at least one slot, (2) each mixed location is adjacent to an empty location (i.e., an empty aisle), (3) all allocated units of a product are located in the minimum number of consecutive locations and (4) all units of a given product are located on only one side of an empty location.

In this paper, we define the SAAPP as a shortest path problem with resource constraints on an appropriately defined graph and introduce a dynamic programming algorithm for its solution. Moreover, we present a heuristic algorithm which is obtained as a simplified version of our exact algorithm. The main contribution of this research is our exact algorithm which is able to optimally solve SAAPP instances of moderate size in reasonable time. Indeed, the instances that we are able to solve to proven optimality are considerably larger than those solved in Anken et al. (2011). In addition, we observe that our heuristic is very efficient in finding optimal solutions, so also with respect to heuristics do our research lead to considerable improvements over the methods introduced in Anken et al. (2011).

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A rolling horizon heuristic for optimal trading in the LNG spot market

Authors: Ruud Egging (NTNU/SINTEF) and Peter Schütz (SINTEF)

We present a stochastic multi-stage mixed integer optimization model for spot trading in the liquefied natural gas supply chain. The model captures order lead times, capacity constraints and other operational characteristics, combined with uncertainty in LNG and local gas spot prices. The decision variables are when to place orders and when to regasify and sell gas. To solve the model, we propose a novel rolling horizon heuristic, which represents the uncertainty in spot prices but stays numerically tractable for practically relevant problems sizes. Based on conditional expectations and probabilities, we construct a series of reduced scenario trees that are solved for each day of the planning horizon.

Keywords: LNG spot trade, rolling horizon heuristic, reduced scenario tree

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Optimizing toll locations and levels in a road congestion pricing scheme by minimizing the deviation from marginal social cost pricing tolls

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Abstract

The problem of designing a congestion pricing system, assuming that the road users are distributed according to a static user equilibrium, is commonly formulated as a bi-level program, with the toll locations and toll levels being the decision variables. The upper level objective is to maximize the social surplus, and on the lower level a convex program is solved to obtain the road users response to the toll level solution. This optimization problem is both non-convex and non-smooth and therefore difficult to solve for a global optimum.

For one special case, when all links are tollable and when there are no restrictions on the toll levels, the bi-level program can be formulated as a convex program which can easily be solved, with one optimal solution, among possibly several ones, equal to marginal cost pricing tolls (MSCP). With MSCP tolls, the road users are charged a toll on each congested road segment equal to the marginal increase in total travel cost incurred by one additional road user on the road segment. Any solution which maximizes the social surplus functions is referred to as a first-best toll level solution (as opposed to second-best when there are restrictions on toll locations and/or toll levels) with system optimal link flows and demands. While there may exist several first-best toll level solutions, they all satisfy the principle of MSCP on a route level, if the demand in the traffic network is elastic. This result has previously in the literature been used to devise a set of feasible toll vectors which all result in system optimal flows and demands.

In this paper the set of feasible first-best toll vectors is relaxed to allow second-best solutions. The relaxation is performed on a route level, and the deviation from first-best route tolls is penalized. The objective then becomes to minimize the penalty, weighted by some factor to reflect each routes importance. The optimization problem either takes the form of a linear program (LP), if the toll locations are fixed, or a mixed integer linear program (MILP), if the toll locations are variable. For solutions with optimal objective function value close to zero, the toll level solution will be close to the global maximizer of the social surplus function. As the number of tollable links is reduced, the true equilibrium demands and link flows may differ from the system optimal ones. Thus, the performance of the approach can be assumed to be dependent of the number of tollable links. Numerical results show that the approach can give valuable information on close to optimal toll locations and toll levels, even when a small subset of the links are tollable.

Some unimportant optimization problems

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In this talk I will present some unimportant optimization problems that I have encountered from time to time. These problems will neither land you an Edelman Award nor a PhD, as they represent problems of little commercial interest and do not present considerable solution challenges. Still, there may be something to learn from these problems in how we as optimizers can contribute to our local community, how we can generate interest in and spread knowledge about what optimization is, and how we can use real life problems to motivate students taking optimization classes.

Among the problems presented are the Social Cooking Problem with Couple Constraints (SCP-CC) and the Friendly Tournament Problem (FTP).

"Day-ahead spot bidding of flexible hydro - *Optimal practice*?"

Erik Alnæs, Roger Grøndahl and Stein-Erik Fleten, NTNU

In deregulated electricity markets, power producers submit daily bids to sell power via power exchanges. We present an empirical analysis of bids submitted to the day-ahead electricity auction Nord Pool Spot by 3 medium-sized Norwegian hydro power producers over four two-week periods in 2011. The producers' main goal is to maximize profits when bidding under price uncertainty given a set of restrictions on their technical and hydrological systems.

We find patterns in the bid matrices and explain why hydro power producers bid the way they do. Suboptimalities and potential irrationalities in the bidding are revealed. We develop a two-stage stochastic mixed-integer linear program that generates optimal bids to assist in the analysis. The hydro power producers bid semi-manually using various models as decision support and their bidding is often close to the output of our model.

“Discretely-Constrained Mathematical Programs with Equilibrium Constraints - Application and Algorithm”

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We describe a model to analyze how the introduction of third party access should affect the long term investment decisions in a natural gas infrastructure. The investment decisions are analyzed from the perspective of a centralized planner maximizing social surplus. Operational production and sales decisions are taken by several independent producers while the routing of gas is taken care of by an independent system operator. The producers compete for capacity in a transportation market.

The model is a discretely-constrained stochastic mathematical program with equilibrium constraints, and the main focus of the talk will be on a branch-and-bound based algorithm to solve this class of problems. The algorithm builds on the work by Gabriel et al. (2010) and uses Benders decomposition to form a master problem and a subproblem. The new dynamic partition scheme that we present ensures that the algorithm converges to the global optimum. Partitioning is done to overcome the non-convexity of the Benders subproblem. In addition Lagrangean relaxation provides bounds that enable fathoming in the branching tree and warm-starting the Benders algorithm, and it supports utilization of the special structure of a stochastic problem. Numerical tests show significantly reduced solution times compared to the original algorithm for general random generated test instances of the problem class. The algorithm is tested on small instances of the presented natural gas problem.

Speciality oils supply chain optimization: from a decoupled to an integrated planning approach

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Abstract

We study an optimization problem of tactical planning in a divergent supply chain. It involves decisions regarding production, inventory, internal transportation, sales and distribution to customers. The problem is motivated by the context of a company in the speciality oils industry. The overall objective at tactical level is to maximize contribution and, in order to achieve this, the planning has been divided into two separate problems. The first problem concerns sales where the final sales and distribution planning is decentralized to individual sellers. The second problem concerns production, transportation and inventory planning through refineries, hubs and depots and is managed centrally with the aim of minimizing costs. Due to this decoupling, the solution of the two problems needs to be coordinated in order to achieve the overall objective. In the company, this is pursued through an internal price system aiming at giving the sellers the incentives needed to align their decisions with the overall objective. We propose and discuss linear programming models for the decoupled and integrated planning problems. We present numerical examples to illustrate potential effects of integration and coordination and discuss the advantages and disadvantages of the integrated over the decoupled approach. While the total contribution is higher in the optimal solution of the integrated model, it has also been found that the sellers' contribution can be considerably lower. Therefore, we also suggest

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contribution sharing rules to achieve that both the company and sellers get a better outcome under the integrated planning.

Key words:
Supply chain management; integrated planning; decoupled planning; linear programming; contribution sharing; OR in the oil industry.

Abstract NOS 2012

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Title: Deployment of Multi-tier Services in Cloud Data Centers confined by Quality of Service (QoS) Requirements

Abstract:

The Software-as-a-Service (SaaS) model of the cloud computing paradigm has changed the way ICT services are being provisioned, as the service providers are given more flexibility in scaling their services according to the demand and requirements of the end-users. In the provisioning, a SaaS provider needs to focus on cost- and energy-efficient operation of its private cloud, and ensure that the services deployed on the nodes in the private cloud, or on the virtual machines in a public cloud, have a QoS satisfying the agreed requirements. In this talk, we mainly focus on decisions of a SaaS provider related to the management of his services and cloud data centers, but also acknowledge decisions related to bursting services into public clouds.

The services are modeled as consisting of multiple tiers, where each of these tiers is distinct software components with different functionality. Increased QoS, measured as service response time and availability, is obtained by adding active or passive copies of the components in the various tiers, thereby providing more resources to the services. Modeling of multi-tier services are generally more complex compared to services of a single tier, since one cannot treat the tiers separately, and thus, there might exist several ways to satisfy the QoS requirements of a service.

We will present (M)IP models of a problem where the goal is to minimize the cost of running services in private and public clouds, while ensuring satisfactory QoS. Firstly a direct formulation is created, and then we reformulate the model, utilizing column generating techniques with pregeneration of node patterns, by which we achieve better results.

Dynamic Planning of Fire and Rescue Services

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The fire and rescue services in Sweden have traditionally been characterized by relatively static planning and resource management. In general, emergency resources are strategically located in populated areas and in relation to the risk factors. The firefighters normally wait at the station until they receive an alarm, and when the work is performed they return back to the station.

Recently, a new way of planning has been adopted. The new approach divides the firefighters into smaller groups. It is then possible to assign different types of tasks to these smaller groups. For example, some can perform different preventive tasks while others are strategically placed to maintain good preparedness levels. When an accident occurs, the resources with the shortest response times are usually dispatched. If a small unit is dispatched, it might be necessary to dispatch additional units to achieve full response. This is an example of when a dynamic planning is desirable.

This work will explore the potential of working more dynamically with planning and management of fire and rescue resources, such as by constantly account for the current situation and use intelligent strategies to locate and allocate resources to support good preparedness

The purpose of the work is to develop tools that can support dynamic planning of fire and rescue services.

Preparedness describes the ability to respond to accidents in the present and in the future. We have defined the factors that directly affect the preparedness. These include the demand for resources, response times for the required resources and the expected number of incidents. With respect to the factors, we developed a quantitative measure for preparedness and use it as a basis for decision support. For example, it should be possible to both ensure an efficient response to an accident site as well as to ensure continuous preparedness for new incidents. The challenge is then to determine which resources to dispatch to a specific incident and determine how the remaining resources should be located and relocated to maintain good preparedness at all locations i.e., determine which resources to move and where to place them. Relevant and adequate decision support tools can help to facilitate such decisions.

The developed tools will be tested using an experimental setup. The results will compare decision making and resource allocation both with and without use of the developed decision support tools. The experiments will be performed in a simulation environment in which 20 different fire and rescue services in Sweden will perform a series of test scenarios. The series of experiment will also give valuable insight into how fire and rescue services can work with dynamic planning and the effect this may have on the operations.

The next step in this work is to validate the preparedness value and complete the development of the decision support tools.

Vessel fleet size and mix analysis for operation and maintenance activities for offshore wind farms

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Offshore wind energy is expected to play an important role in the future energy supply. The operation and maintenance (O&M) activities for an offshore wind farm is expected to account for 25-30% of the total cost of energy from an offshore wind farm, and the vessels supporting these activities will be an expensive resource in the logistic chain. Thus, to keep the cost of energy down it is essential to keep an optimal, or near-optimal, fleet of vessels and helicopters to support O&M activities.

Our research has the primary objective of reducing the cost of energy from offshore wind farms by finding optimal fleet composition to support the offshore O&M activities and analysing the related infrastructure for the transport and logistics system.

In this presentation, we will describe the vessel fleet size and mix problem for the O&M activities for an offshore wind farm. The problem consists of deciding on the combination and number of vessels to invest in, and to analyse the alternatives regarding the location of the corresponding vessel bases, these being either onshore harbours or offshore platforms. Simultaneously, the use of the vessel fleet needs to be analysed to determine the optimal fleet size and mix. Scheduled and unscheduled O&M activities need to be performed in a manner that minimize the downtime of the wind farm and thus increase the produced electricity and profit from the wind farm.

A deterministic optimization model that solves the problem has been developed and will be described and presented. The problem has many uncertain parameters that are highly relevant, for example weather conditions and corrective maintenance tasks due to failures to the system. These uncertainties can be treated by simulation and analysis. The optimization model will be integrated with a simulation model for life cycle cost-benefit analysis for offshore wind farms. This simulation model can then analyse a given vessel fleet size and mix under uncertain weather conditions and unexpected failure paradigm. Some preliminary computational results will illustrate how the optimization model can be used to provide decision support for an offshore wind farm developer and operator.

“Stochastic programming with decision dependent probabilities”

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We propose an investment problem modeled as a stochastic program with decision dependent probabilities. In addition to the available production technologies, we assume there is an activity or technology available that will alter the probabilities of the discrete scenarios occuring. By investing in such technology or activity, it is possible to increase the probability of some scenarios, while reducing the probability of the remaining scenarios, or vice versa.

We also demonstrate the use of a specialized decomposition algorithm for this class of problems, using generalized Benders decomposition and relaxation of algorithms/McCormick relaxations.

We illustrate the potential usefulness and the performance of the decomposition algorithm on this class of problems through an application from the Energy sector.

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Milk Collection in Western Norway Using Trucks and Trailers

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Collection and transportation of milk from farms to production factories is a crucial issue around the world. Geographically, milk farms are mostly located in the rural areas in every country. Due to the spoiling behavior of milk and storage capacities at farms, it must be collected by production factories within a given time limit and cannot be kept longer. Truck and trailers with different capacity/size are used for collection, and they can be hired or leased. In addition to the fleet composition problem, there is also weight and accessibility restrictions that apply to this type of problem and make this problem more difficult. As a result of this added complexity in the problem constraints, the distribution planning decisions are harder to make.

This paper describes the real world problem where a Norwegian dairy firm collects and delivers raw milk from different farms to the production factories. The purpose of this research is to provide an economical solution for this problem within the given scenario(s) while satisfying the constraints. This particular problem considers four major aspects: fleet composition, multiple depot, routing decisions and possible location of parking places for trailers. Routing decisions are concerned with assigning farms to a truck that is able to fulfill the farm's demand and satisfies the road restriction constraints as well. Farms may be serviced by one of three possible depots in this specific problem. Various types of trucks with or without trailers are available on the production factory. The capacity of each truck varies in terms of volume and weight. Due to road limitations, a loaded truck with trailer cannot be driven on some roads and trailer(s) must be temporarily parked in designated parking places.

The well known meta-heuristics tabu search which was proposed by Glover (1986) [1] is used to solve this problem. Tabu search is based on simple greedy local search trying to find improving neighboring solutions and stops in local optima. A basic neighborhood is used. In this neighborhood, two different customers are exchanged between two distinguished routes. The search will also decide on the composition of truck fleet with or without a number of trailers. It will be tested with real world data and computational results will be reported in detail. A variant of this type of problem is often named the *Truck and Trailer Routing Problem* (TTRP) and was presented by Chao [2] and Scheuerer [3].

Keywords: Truck and trailer Routing Problem, Scenarios

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Optimization by Controlling Self-Optimizing Measurements

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The optimization approach presented in this paper is inspired from the idea of feedback control, where a controller manipulates one input in such a way that another variable is kept at its pre-specified setpoint in spite of disturbances.

In an optimization context, this means that we want to find variables, which give optimal operation when kept constant. Thus, instead of focusing on finding the right input variables to a process, we present how to find the right output variables, which guarantee optimal or near-optimal operation.

As an example consider a marathon runner. The objective is to run the marathon in minimum time. A simple strategy would be to run with a constant speed, however this will hardly be optimal. A different strategy would be to use some model to find the optimal speed at each instant of the run. If a good model is available, this will be close to optimal, but relative complicated and little robust in practice. A better strategy which is in the spirit of this work is to run with a constant heart rate. When there are changes in the conditions, such as changing slope or winds, the runner will adjust optimally to the new situation. This strategy is easy to implement, while it is robust with respect to disturbances and will be close to the true optimum.

Thus, one may formulate the goal of our research as to find the "heart rate" of the process. We present some examples from chemical engineering e.g. heat exchanger networks, where this concept is applied successfully to optimize operation.

A batch reactor heat recovery challenge problem

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We present a challenge problem for maximizing the heat recovery in a heat exchanger network connected to a set of batch reactors, which are discharged periodically.

A cold process stream is to be used as a utility, and is split into several parallel branches which each are connected to a heat exchanger. After being heated in the primary sides of the heat exchangers, the streams from the different branches are merged again. The recombined stream is then further heated to a specified target temperature in a fired heater.

During the discharging periods of the batch reactors, the reactor effluents are fed into the secondary sides of the heat exchangers to preheat the branches of the cold process stream.

The optimization objective is to adjust the split of the cold incoming stream such that a maximum amount of heat is recovered from the reactor effluents over a time period of 24h. This is equivalent to minimizing the energy required for the cold stream to reach the target temperature. Due to the batch reactor operation strategy, it is not known a-priori when the batches are emptied. Sometimes only one batch is emptied at a time, at other times several discharges start shortly after each other, such that the discharging processes overlap.

The proposed problem has several interesting and challenging features, the most important ones are:

- Relevant for industrial practice
- Integer character: Either a batch is discharged or not
- Dynamic optimization: A trajectory for a given scenario is to be obtained.
- Nonlinear model equations:
  - Discharge flow rate of the batch reactors depends nonlinearly on the reactor levels
  - Heat transfer depends nonlinearly on the discharge flow rate, which either changes continuously, or is zero.

These features make the proposed problem an interesting benchmark for testing optimization strategies and solution algorithms.

A more detailed problem description can be downloaded at `www.nt.ntnu.no/users/skoge/2012/BatchChallenge`

“Life-cycle asset allocation with focus on retirement savings”.

Agnieszka K. Konicz , Technical University of Denmark

We consider optimal asset allocation of a pension saver with uncertain lifetime. The objective is to maximize the expected utility of the retirement savings. The model accounts for characteristics of a pension saver given by her mortality risk, risk attitude, type of retirement contract, trading costs, taxes, and uncertain labor income.

The problem is solved using a combination of a multi-stage stochastic linear programming (SLP) model and stochastic optimal control, such that the practical application is emphasized. Both solutions are integrated into the SLP formulation.
The decisions for the long period are based on a classical continuous-time optimization based on the closed-form solution obtained by Richard (1975). This model is first simplified by removing the insurance policy, such that the focus is on the pension savings. In particular, fully funded contribution-defined pension schemes are considered with different payout possibilities: lump sum payment at retirement and payment in installments. Richard’s model is extended by introducing deferred labor income linear taxation of contributions to the pension savings.
The first year decisions account moreover for aspects such as the trading costs and uncertain labor income. The market returns uncertainties are modeled by discrete scenario trees, where a joint distribution is consistent with the specified values of the first four marginal moments and correlations, and the arbitrage opportunities are excluded.

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“Solving a real-life waste collection problem using an optimization-based metaheuristic approach”

Kristian Milo Hauge (Department of Transport, Technical University of Denmark),
Jesper Larsen (Department of Management Engineering, Technical University of Denmark, corresponding author).

This presentation will present a problem of collecting industry waste. The task is to construct routes for trucks that delivers empty waste containers to customers and takes full waste containers to dump sites. The containers come in different shapes and sizes and therefore when they are empty more containers can be stacked (up to four). Full containers cannot be stacked. This problem originates from a real case of waste collection.

We will present a solution strategy that is based on a classical column generation framework. The master problem is an LP-relaxation of a generalized set partitioning problem, but the traditional exact solution of the subproblem has been replaced with a metaheuristic. This combined approach generates promising results both with respect to solution quality and solution time.

A Column Generation Approach for Solving the Patient Admission Scheduling Problem

Richard Martin Lusby, Troels Martin Range, Jesper Larsen

The Patient Admission Scheduling Problem (PASP) is the problem of assigning patients to hospital rooms in such a way that the preferences of the patients as well as the effectiveness of the medical treatment are maximized. A set of hard constraints determine whether or not a patient can stay in a room. However, if a patient can stay in a room, then there is a corresponding penalty associated with assigning the patient to the room. This penalty reflects the patient's preferences as well as how equipped the room is to cater for the patient's condition (among other other things).

We present a Dantzig-Wolfe decomposition of PASP into a set partitioning master problem and a set of room scheduling problems for the pricing problems; here each column of the master corresponds to a feasible room schedule over the planning horizon. The master problem ensures that each patient is assigned a room for each night of their stay and that we do not exceed the available number of each room type. The room scheduling sub problem for a specific room has to select a number of patients in each time period such that the number of patients in the room is not greater than the capacity of the room and that the genders of the patients chosen in each time period is the same. We describe an implementation of dynamic constraint aggregation to overcome the degeneracy of the master problem and show how this improves the performance of the column generation significantly.

The method is tested on benchmark instances where we derive tighter lower bounds than those previously reported. The computation time for identifying these lower bounds is, in most cases, significantly faster. A discussion on several branching strategies to integerize the lower bound solution is also provided.

“Bilevel traffic pricing models”

Michael Patriksson, Chalmers University of Technology and Gothenburg University

The talk will give an overview of the field of bilevel traffic design and pricing, as it is usually studied in the OR community. The talk will concentrate mostly on work related to that performed by the speaker and his co-workers. Historical notes will abound, in tracing parts of this development, including discussions on the traffic equilibrium problem, Braess' paradox, and (stochastic) bilevel optimization. A possible pitfall in transportation planning projects will also be illustrated.

“A decision model and case study for a Natural gas-powered Industrial Park”.

Gerardo Alfredo Perez-Valdes, NTNU

In this work, we present a decision-making model for an industrial cluster mainly powered by a natural gas plant. The motivation for this is the Norwegian government’s impulse to the domestic usage of natural gas as fuel and the consequent boost to technology and local industries.

The park modeled relies on a combined-cycle natural gas power plant with a flexible choice of technology. Several other plants are included in the model, including a carbon-capture plant to reduce environmental emissions. Each plant has been modeled according to industrial data and simulations to produce black box-like production functions.

Our model is made using a central-planner approach, which we believe gives an acceptable benchmark to the profitability of the park and its long term return of investment.

A case study of a realistic park is presented to showcase the functionality and results of the model. Furthermore, an extension to a stochastic case is delivered, focusing on how stochasticity affects the solution process and the nature of the solution.

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"Order picking in a multi-parallel-aisle warehouse"

David Pisinger, DTU Management, Technical University of Denmark
Joint work with Katja Prnaver, Maribor University, Slovenia

Given a set of customer orders and storage locations, the order batching problems seeks a grouping of the orders into picking routes, such that the overall length of all picking routes is minimized, while respecting the capacity of the picking vehicles. Order picking is estimated to take up more than half of the operational costs of a warehouse.

We first present an optimal algorithm for finding a single picking route in a warehouse with a fixed number of cross-aisles. The algorithm is based on dynamic programming, but due to the complexity of the problem, transition tables are to be computer generated in advance.

We then study a variation of the order batching problem where a time window (release time and due date) is assigned to every order. This is a very common extra constraint in most real-life order batching problems. The proposed solution is based on a GRASP heuristic, where we try to balance proximity of orders against urgency of orders. Computational experiments are performed on simulated data sets from the literature as well as on the data received from a central supermarket chain warehouse in Slovenia. The results of the random data sets allow us to analyze the impact of the time windows on the number of vehicles and the number of batches, while the results on the real data give a significant reduction (up to 75%) on both the number of vehicles, duration of picking (makespan), and the number of batches.

“Uncertainty quantification using nonparametric estimation and epi-splines”

Johannes O. Royset, Operations Research Department, Naval Postgraduate School
Roger J-B Wets, Department of Mathematics, University of California, Davis

We address uncertainty quantification in complex systems by a flexible, nonparametric framework for estimation of density and performance functions. The framework systematically incorporates hard information derived from
physics-based sensors, field test data, and computer simulations as well as soft information from human sources
and experiences.

The framework is based on epi-splines for consistent approximation of infinite-dimensional optimization problems arising in the estimation process. Preliminary numerical results indicate that the framework is highly promising.

Parameter calibration in public transport models

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When predicting and forecasting current and future use of public transport systems in urban areas, network based public transport models are used. For large scale models, so-called headway based models are used. Several commercial systems are available, and most of the large operators make use of such models. Some of the prediction and forecasting models are formulated as actual mathematical optimization problems and solved by optimization algorithms, while others are heuristics.

Minimizing a generalized travel cost is the basis for predicting the choice of public transport mode and public transport line. The models use of a number of parameters in the computation of this generalized travel cost. The generalized cost typically includes components like walking time from home to a bus stop, and from a bus stop to the destination; waiting times at the stops; the in-vehicle time; switching penalties etc. Each of these components is weighted by a parameter in the generalized travel time. The parameters have to be set by the planner before the model is used and the values of the parameters have an influence on the results from the model. The calibration procedure for these parameters is to find a best fit between the model output and some observed flows or travel times. This requires observed traveler behavior, which normally is found from travel surveys. Travel surveys are expensive, and the quality and the level of detail of the observed flows and times will affect the results.

In order to investigate which type of observations, and the effect of the quality of the observations to the results of the calibration, a framework for optimizing this type of model parameters is set up. The framework is based on derivative free optimization techniques. In the presentation the measures used for the comparisons, and results from a number of measures and data set sizes and quality levels, will be presented.

Abstract

Title:
Risk Modeling in Stochastic Optimization

Speaker:
Rüdiger Schultz, Department of Mathematics, University of Duisburg-Essen, Lotharstr. 65, D-47048 Duisburg, Germany

In this tutorial we discuss possibilities to express risk aversion in the objective or the constraints of optimization problems with uncertain parameters. The classical, risk neutral linear two-stage or recourse model, with its beneficial convexity properties, will be extended in various manners: by introducing integer decision variables, by allowing for risk aversion in the objective by means of risk measures or in the constraints by resorting to stochastic orders. After having formulated the models we study some crucial structural properties, identify numerically tractable deterministic equivalents when the underlying probability spaces are finite, and develop decomposition methods bringing these typically huge, but structured, optimization problems into the reach of practical computation. The latter is illustrated by computational experiments. Time permitting we conclude with an outlook to transferring the modeling concepts of the talk into infinite dimension.

"Shape Optimization with Uncertain Loading from the Stochastic Programming Point-of-View"

Rüdiger Schultz (University of Duisburg-Essen).
The talk is based on joint work with Martin Rumpf and Sergio Conti (both University of Bonn) as well as Harald Held (Siemens Corporate Research Munich) and Martin Pach (University of Duisburg-Essen).

Following paradigms from finite-dimensional stochastic programming shape optimization of elastic bodies under random loading is formulated as a two-stage stochastic program. The shape being selected without
complete information on the loading it is made the first-stage decision.

After observation of the random loading, the elasticity PDE determines the displacement, which is considered the second-stage decision. Conceptually, the second-stage optimization problem is given by the weak (variational) formulationof the PDE.

In the talk we discuss risk neutral and risk averse model formulations, give an idea about the tailored finite-element procedures for solving the omnipresent PDEs, and report computational tests.

"Mathematical Programming for Gas Network Operation and Extension"

Jonas Schweiger, Konrad-Zuse-Zentrum für Informationstechnik Berlin
This is joint work with A. Fügenschuh, B. Hiller, J. Humpola, T. Lehmann,
and R. Schwarz within the “Forschungsverbund Netzoptimierung” (ForNe).

Gas distribution networks are complex structures that consist of passive pipes and active, controllable elements such as valves and compressors. Controlling such a network means to find a suitable setting for all active components such that a nominated amount of gas can be transmitted from entries to exits through the network, without violating physical or operational constraints. The control of a large-scale gas network is a challenging task from a practical point of view. In most companies the actual controlling process is supported by means of computer software that is able to simulate the flow of the gas. However, the active settings have to be set manually within such simulation software.

Our approach, in contrast, is capable of considering continuous (like pressure and flow) and discrete decisions (like the configuration of active devices) in an integrated, fully automatic manner based on the rigorous application of mathematical optimization techniques. To capture the physical and operational side-constraints, we formulate a mixed-integer nonlinear optimization model. A solution of such a model provides either a feasible network configuration or a certificate that such a configuration does not exist.

If the nominated amounts of gas can not be transported through the network, the network operator might desire to extend the network. Based on the above model, we propose a workflow for the extension of the network topology. In a first step, slack models are used to determine bottlenecks in the network. The solutions of the slack models are used to generate reasonable extension candidates in the second step. In a last step, a cost-optimal subset of all extension candidates is selected which allows to transport the nominated amounts of gas in the extended network.

Finally, we present real-world instances which we use to perform computational experiments. The data is provided by Open Grid Europe GmbH (OGE), which operates the former E.on / Ruhrgas network.

Optimization of forest harvesting in Norway

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Abstract

Optimization in forestry dates back to the introduction of computers in the 60's and 70's, with most of the research taking place abroad. Technical developments since then, and the topography of Norway, makes it worthwhile to review the field.

The large part of harvesting in Norway is done with wheel based harvesters and forwarders. The harvester is driving from the roadside to the harvesting site, where it starts to fell, cross cut and delimb the trees. Timber is placed in piles of different assortments, and is picked up by the forwarder and transported to the roadside. Both the harvester and the forwarder are equipped with cranes, typically with a reach of 5–10 meters.

The amount of maturing forest in the western parts of Norway imply that harvesting using cable yarding systems will increase. The cable yarding system consist of a tower, cables and a tree used as a tail spar, typically covering some $300m \times 50m$.

For wheel based harvesting, the optimization problem is to locate the paths in the grid that minimize cost of the operation. In general, this is a facility location problem, where the paths are connected through neighboring vertices.

The time used for driving the harvester is small compared to the processing time, reducing the significance of the trail layout. However, some trail layouts may reduce idle driving (e.g. with loops). To find such solutions, we have to combine the facility location problem with the Chinese postman problem.

The cost of forwarding rely more heavily on the design of the trails, as the forwarder is driving back and forth between the harvesting site and roadside. If we assume that the trails are given, together with different timber assortments and the location of corresponding timber piles, the forwarding is a vehicle routing problem (VRP). On the other hand, if the trails are not given, the trail location problem is a combination of a facility location problem, a Chinese postman problem and a VRP, all NP-hard problems.

Optimization of cable yarding is also a facility location problem. Each cableway is serving an area close to the cableway. There seems to be two traditions in the layout of the cable yarding patterns. One prefers radial layout (e.g. USA), where the cableways are fanned from one landing, and one a parallel layout (e.g. Europe), where the cableways are located more or less parallel perpendicular to the road. An optimization approach should ideally consider both cases and select the better one, or possibly a mix.

Cable yarding is relying on roads, and the two traditions give different road location problems. If we have some selected landings (with

a radial cableway pattern), these landings have to be connected to the existing road network. This is a Steiner tree problem (NP-hard). However, if the better solution is a parallel pattern, the location of new roads is also a facility location problem.

In our presentation we give an overview of these problems, and look at methods for solving them.

“Long term expansion of the European power system”

A. Tomasgard, C. Skar, G. Doorman, NTNU

This paper will present an analysis of optimal expansion of generation and transmission capacity for a country-level power system model of Europe, based on emission mitigation strategies resulting from a scenario analysis done with an IAM, the Global Change Assessment Model (GCAM).

Important driving factors for investments in new infrastructure, such as increase in annual demand for electricity, fuel prices and prices for CO2 emissions, are taken directly from GCAM and used as parameters for the expansion model. As electricity demand in GCAM is only calculated for two regions, Western Europe and Eastern Europe, a disaggregation based on statistical data is used to get country-wise demand. The approach used is two-stage stochastic programming.

Understanding stochastic (mixed) integer programs

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On one hand, most cases of industrial-sized stochastic (mixed) integer programs are numerically unsolvable. On the other hand, the problems exist and deserve our attention. This talk focuses on a series of papers investigating different network design problems.

We investigate the relationship between the stochastic and deterministic versions of the design problems, and in particular ask if the deterministic solutions can be useful even if the Value of the Stochastic Solution is high. The goal is to understand what stochastics does to these problems and how it affects the optimal solutions. By better understanding what stochastics does we are in a position to develop better heuristics and also to communicate better with users, even when we do not solve the relevant models.

The vale of energy storage in domestic homes: A smart grid perspective

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About 7% of the energy consumption in the UK presently comes from wind, but this is expected to grow to well over 20%. This causes serious concerns about the ability of the energy system to balance supply and demand, as it is already very inflexible. Though each household is very small, in total they contribute substantially to the energy demand, and in particular to the peak demand.

In this paper, we develop a bottom-up approach, focusing on the value of energy storage and renewable micro-generation in domestic homes. Specifically, we consider a connection to the grid, a boiler, a solar collector, a small wind turbine, a water tank, and a battery. We use the wholesale spot prices as proxies for the provision costs of gas and electricity. We focus on the predictable inter-temporal variations of energy demand, wind speed, and spot prices, and thus assume that these parameters, though deterministic, are time varying.

The objective of the model is to minimize the total energy consumption cost, as seen from the grid, throughout a finite horizon. We conduct a numerical case study using a sample of real-life demand and weather data for some typical houses in the UK and recent spot price data. Our results show that a battery might have a significant contribution to energy cost savings, and shed new light on the design of distributed energy systems for a smart grid, especially when coupled with a wind turbine. The benefits do not depend on behavioural changes in the households.