APMOD 2014

International Conference on Applied Mathematical Optimization and Modelling

PROGRAM

The University of Warwick

April 09– 11, 2014

wbs
WARWICK BUSINESS SCHOOL

Table of Contents

Dear participant of APMOD 2014,

Welcome to the 11th International Conference on Applied Mathematical Optimization and Modelling, – APMOD 2014. The conference is organised by Operational Research & Management Sciences Group in Warwick Business School, The University of Warwick.

APMOD 2014 aims to bring together distinguished researchers and practitioners from academia and industry to exchange knowledge, ideas and results in a broad range of topics relevant to mathematical optimization, modelling languages and software, theory and practice of computational methods and solution algorithms. The conference also covers various application areas such as healthcare, transportation, logistics, engineering, finance, supply chain management, statistics, scheduling, and energy.

The APMOD 2014 programme consists of one hundred and nine presentations in 37 sessions and three plenary talks to be given by internationally renowned experts in mathematical programming. We have 126 registered participants from more than 15 countries worldwide.

The organising committee would like to take this opportunity to thank all conference participants, plenary speakers, sponsors, and members of the program committee for their valuable support and contribution in preparing APMOD 2014.

We wish you a productive, stimulating conference and a pleasant stay in Warwick.

Nalan GULPINAR (chair), Xuan Vinh DOAN, and Arne K. STRAUSS

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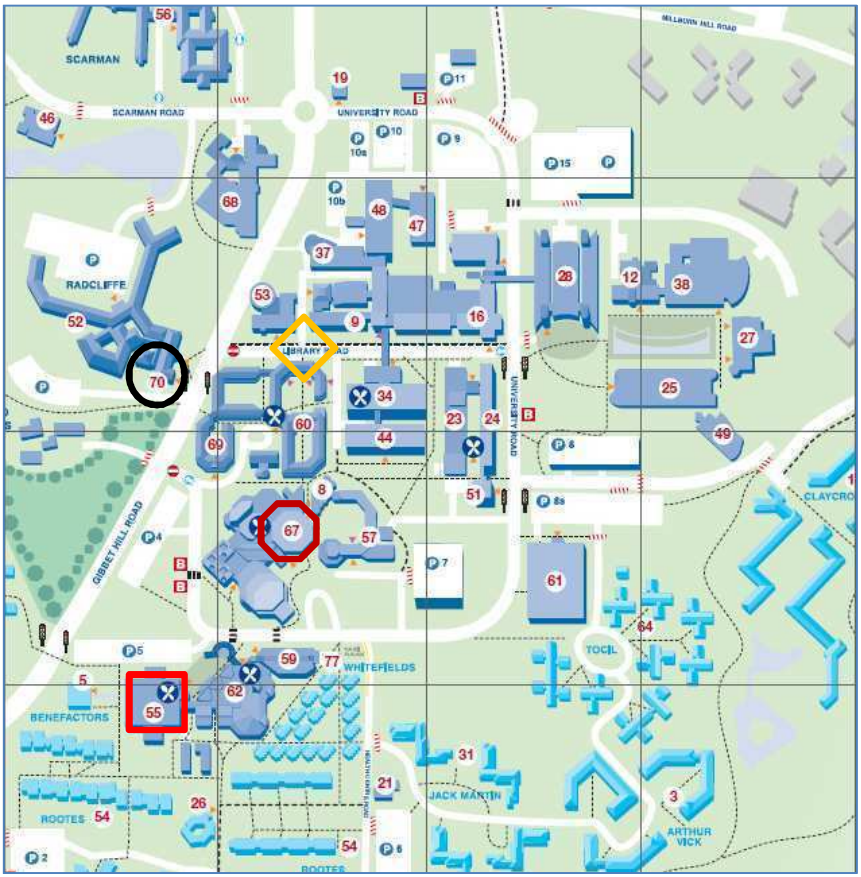
General Information



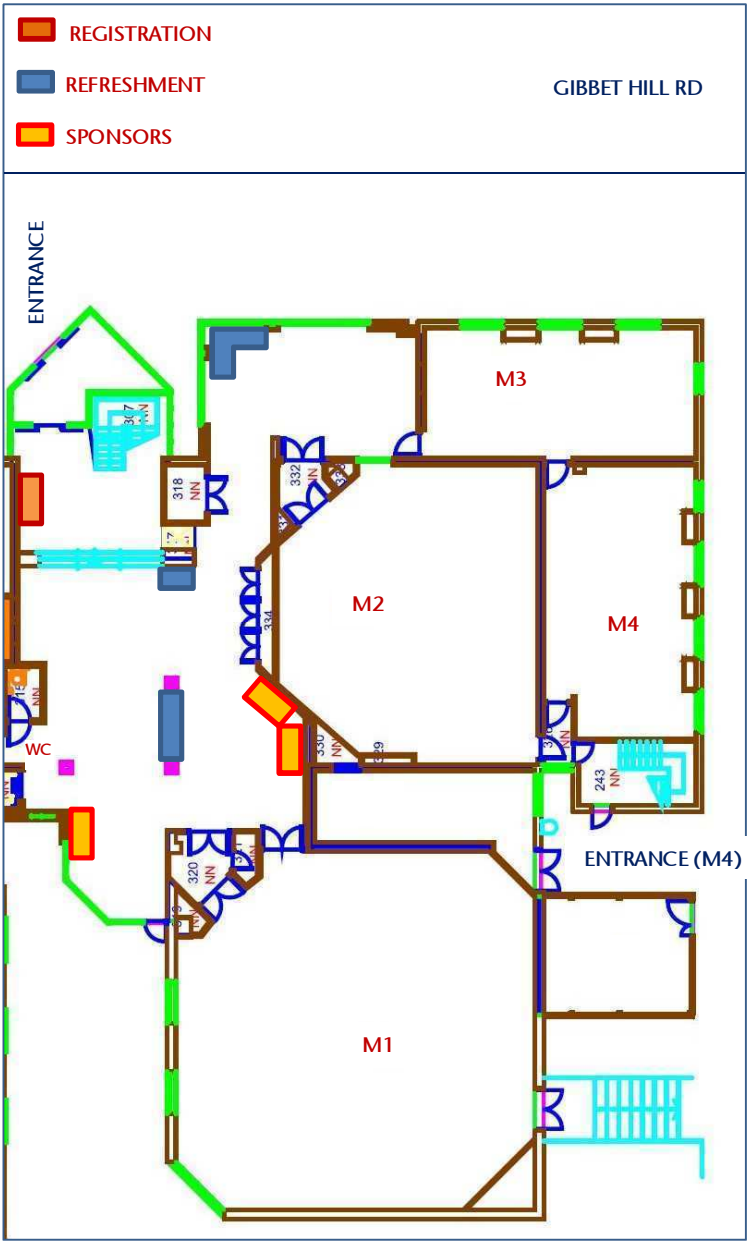
WBS Teaching Centre - Conference Venue

Rootes Building – Conference Luncheon

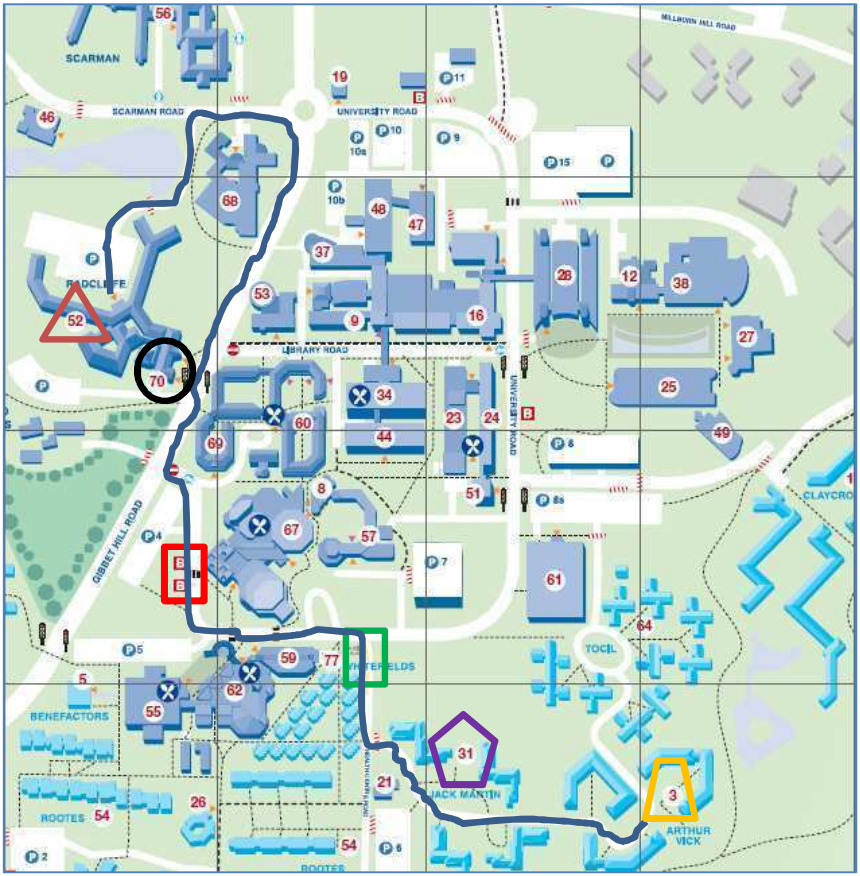
Warwick Arts Centre - Welcome Reception

Coaches for St. Mary's Guildhall and Warwick Castle

WBS Teaching Centre –Conference Venue



On-Campus Accommodation and Transportation



Radcliffe

Arthur Vick

Jack Martin

Bus #11 and #12 to Coventry and Leamington Spa (via Kenilworth)

Taxi rank

Social Program – Map of Locations

Warwick Arts Centre – Welcome Reception

St.Mary's Guildhall – Conference Dinner

Bayley Lane, Coventry, CV1 5RN

Warwick Castle – Conference Tour

Warwick CV34 4QU

General Program

Registration and Conference Venue

APMOD 2014 mainly takes place in the WBS Teaching Centre. Registration will open on Tuesday April 08, 2014 between 14:00-16:30 and then throughout the three days of the conference.

Talks are presented in four lecture theatres: M1, M2, M3, and M4. Coffee and tea are served in the foyer during morning and afternoon breaks. Our sponsors' tables are set out in the foyer and you are welcome to check out their products and offers.

Conference Luncheon

Lunches are served daily in the Rootes Restaurant located in Rootes Social Building from 13:00 – 14:00 (finishing 15 minutes early on Friday for the Warwick Castle trip).

The Rootes Social Building is a short distance from the WBS Teaching Centre in the centre of campus, which is part of the Piazza.

Please ensure you bring your name badge as it is required for entry into the Rootes Restaurant.

Welcome Reception

Where: Warwick Arts Centre, University of Warwick

When: 18:00 – 20:00, Wednesday, April 09, 2014

Warwick Arts Centre is one of the largest performing and visual art complexes in the UK outside London, situated in the very centre of the campus (http://warwickartscentre.co.uk).

The Welcome Reception takes place in the Theatre Foyer with hot canapés. Drink vouchers will be issued for use at the Theatre Bar and additional drinks may be purchased.

Conference Dinner

Where: St. Mary's Guildhall, Bayley Ln, Coventry, CV1 5RN

When: 19:00 – 23:00, Thursday, April 10, 2014

Transportation (name badge required):

18:30, coaches depart from Library Road (close to the WBS Teaching Centre) to Coventry

23:00, coaches depart from St. Mary's Guildhall back to Library Road on campus

Located in the historic Cathedral Quarter of Coventry, St. Mary's Guildhall (http://www.stmarysguildall.co.uk) is one of the finest medieval guildhalls in the UK.

Our conference dinner will be featured with historical talks and medieval music from Blast from the Past (http://www.blastfromthepast.org.uk).

The Best Student Paper Prize will be announced during the conference dinner.

Conference Trip

Where: Warwick Castle, Warwick CV34 4QU

When: 14:30 – 16:30, Friday, April 11, 2014

Transportation (name badge required):

14:00, coaches depart from Library Road (close to the WBS Teaching Centre) to Warwick

16:30, coaches depart from Warwick Castle back to Library Road on campus

Warwick Castle (http://www.warwick-castle.com) is a medieval castle originally built by William the Conqueror in 1068 in the town of Warwick, situated on a bend of the River Avon. During the visit, you will be able to see great halls, high towers, and beautiful landscapes.

Technical Program

Speaker and Session Chair Information

Four lecture theatres M1, M2, M3, and M4, are equipped with Windows PCs and projection screens. Laptops can be used for presentations. Please make sure to arrive at least five minutes before the session starts and check with the session chair about any arrangement for the session.

There are four tracks in each regular session, Track A in M1, Track B in M2, Track C in M3, and Track D in M4. Each talk is scheduled for 25 minutes (20 minutes for presentation, and 5 minutes for Q&A).

The session chair should check with all speakers before the session to make sure there are no technical problems. If there are any technical issues, please contact the conference helpers, who will be wearing blue name badges. There will be a designated conference helper in each lecture theatre.

The session chair should start the session on time, keep talks in order and within scheduled time slots. For each talk, the session chair should introduce the speaker and the title of the talk at the beginning and handle Q&A at the end.

Plenary Talks

Wednesday, April 09, 2014, 08:40 – 09:40 (S2 – M1)

Professor Berç Rustem, Imperial College London

Title: Robust Optimization and its Guarantees

Abstract: Robust optimization provides solutions to decision making under uncertainty. We introduce the problem by considering the formulation of robust policy in the presence of rival models purporting to represent the underlying economic system. We then discuss a collection of models for robust decision making in finance, starting with the robust portfolio optimization problem with uncertain return mean and second moments. We review the robust equal risk contribution and the robust omega ratio problems. Further performance guarantees can be injected by integrating options within a robust framework. This can also be applied to currency portfolios, employing additional constraints to safeguard against arbitrage. We also discuss extensions to multi-stage decision models. The basic paradigm that ensures robustness is minimax: the determination of the optimal decision in view of the worst-case scenario. Most models can be solved as straightforward mathematical programming problems and by dualising the inner optimization problem. Finally, we consider robust option portfolios, for minimizing the maximum hedge error, that require specialized minimax algorithms.

Thursday, April 10, 2014, 08:40 – 09:40 (S7 – M1)

Professor Warren B. Powell, Princeton University

Title: Clearing the Jungle of Stochastic Optimization

Abstract: Mathematical programming has given us a widely used canonical framework for modeling deterministic optimization problems. However, if we introduce a random variable, the field fragments into a number of competing communities with names such as stochastic programming, dynamic programming, stochastic search, simulation optimization, and optimal control. Differences between these fields are magnified by notation and terminology, which hide subtle but more important differences in problem characteristics. Complicating matters further is a misunderstanding of basic terms such as dynamic program, policy, and state variable. While deterministic optimization problems are defined by solving for decisions, sequential stochastic optimization problems are characterized by finding functions known as policies. I will identify four fundamental classes of policies which unify the competing communities into a common framework I call computational stochastic optimization. These ideas will be illustrated using applications drawn from energy, health, freight transportation, and vehicle navigation.

Friday, April 11, 2014, 08:30 – 09:30 (S12 – M1)

Professor Stein W. Wallace, Norwegian School of Economics

Title: Structured Stochastic Integer Programs: Understanding the Effects of Uncertainty

Abstract: Stochastic integer programs of industrial size are almost always unsolvable to optimality. One possible path to better understand and solve such models is to investigate how uncertainty affects optimal solutions to such programs; What characterizes optimal solutions – are there structures that emerge? This can be done by studying small scale problems that are solvable by off-the-shelf software. Inevitably we are led into the area of options theory to understand what is happening. This talk will report on such structural analyses for several classes of network design problems, and also show how the structures can be used to develop good (constructive) heuristics.

Regular Sessions

	M1	M2	M3	M4
Wednesday, April 09, 2014				
09:45 - 11:00	Handling Uncertain Data in Decision Support (S3A)	Search Games (S3B)	Combinatorial Optimization (S3C)	Supporting Advanced Modeling Constructs in AMLs (S3D)
11:30 - 12:45	Uncertainty in Logistics and Transportation (S4A)	Portfolio Management (S4B)	Game Theory (S4C)	Numerical Algorithms I (S4D)
14:15 - 15:30	Optimization in Industry (S5A)	Combinatorial Optimization II (S5B)	Student Best Paper Competition (S5C)	Developments in Modeling Languages and Platforms (S5D)
16:00 - 17:15	Stochastic Programming & Applications (S6A)	Algorithms for Integer Programming (S6B)	Applications in Healthcare (S6C)	Metaheuristics (S6D)
Thursday, April 10, 2014				
09:45 - 11:00	Applied Dynamic Stochastic Optimization (S8A)	Optimization in the Energy Sector (S8B)	Social Networks (S8C)	Heuristics (S8D)
11:30 - 12:45	Stochastic Programming & Energy (S9A)	Financial Optimization (S9B)	Linear Algebra for Large-Scale Optimization (S9C)	Numerical Algorithms II (S9D)
14:15 - 15:30	Robust Optimization (S10A)	Combinatorial Optimization III (S10B)	Machine Learning (S10C)	Humanitarian Logistics I (S10D)
16:00 - 17:15		Financial Asset Allocation (S11B)	Humanitarian Logistics II (S11C)	
Friday, April 11, 2014				
09:30 - 10:45	Optimization Under Uncertainty I (S13A)	Finance I (S13B)	Multi-Criteria Optimization (S13C)	Decision Making Applications (S13D)
11:00 - 12:15	Optimization Under Uncertainty II (S14A)	Finance II (S14B)	Algebraic Modeling Languages (S14C)	

Timetable

Wednesday, April 09, 2014
08:30 – 08:40
Opening (S1)
08:40 – 09:40
Plenary Session (S2) Robust optimization and its guarantees
09:45 – 11:00
Track A– Handling Uncertain Data in Decision Support (S3A) • Robust optimization in Xpress Mosel • Applying oracles of on-demand accuracy in two-stage stochastic programming - a computational study • Computational aspects of risk-averse optimization in two-stage stochastic models
Track B – Search Games (S3B) • Submodular search games • Spatial dispersion of simple agents over a network • Optimal search for a small (or well hidden) object
Track C – Combinatorial Optimization I (S3C) • Workforce allocation for IT services using stable matching • Mixed-integer programming for the workforce scheduling and routing problem
Track D – Supporting Advanced Modeling Constructs in Algebraic Modeling Languages (S3D) • Analyzing structured optimization models with automatic transformations • Toward supporting bi-level programming in an algebraic modeling language • Specification and automatic discretization of ODE and DAE systems in an AML

Wednesday, April 09, 2014
11:00 – 11:30
Tea Break
11:30 – 12:45
Track A – Uncertainty in Logistics and Transportation (S4A) • Joint revenue management and vehicle routing in home-delivery operations • New models and methods for the multi-path Travelling Salesman Problem with stochastic travel costs • Bounds for stochastic multistage transportation problems
Track B – Portfolio Management (S4B) • Inverse portfolio problem with mean-deviation model • On the efficient hedging in incomplete markets • Risk management of electricity portfolios using hedging strategies
Track C – Game Theory (S4C) • Generalized minimum spanning tree game • Bounding the price of anarchy for congestion games with stochastic demand
Track D – Numerical Algorithms I (S4D) • Hybrid adaptive blind equalization algorithm with new cost function • Convergence of truncated stochastic algorithms with an extra control • Solving nonlinear second order conic optimization problems
13:00 – 14:00
Lunch Break

Wednesday, April 09, 2014
14:15 – 15:30
Track A – Optimization in Industry (S5A) • A branch-and-price approach for energy-efficient deployment of multi-tier services in cloud data centres • Which information is important in decision making under uncertainty? A case study from maritime transportation • Optimisation models for salmon farming
Track B – Combinatorial Optimization II (S5B) • Order acceptance and scheduling with and without due dates: A review and new results • Multidimensional tropical optimization problems with applications to job scheduling • Combining levels of crew aggregation in network flow based airline crew scheduling models
Track C – Student Best Paper Competition (S5C) • Stochastic local search versus genetic algorithm for feature selection • Adjustable robust optimization with decision rules based on inexact revealed data • Local search methods for the minimum interference frequency assignment problem
Track D – Developments in Modeling Languages and Platforms (S5D) • Modelling and solving generalized graph-based transport problems • Developments in the AMPL ecosystem • Fair division as an applied optimization problem
15:30 – 16:00
Tea Break

Wednesday, April 09, 2014
16:00 – 17:15
Track A – Stochastic Programming & Applications (S6A) • A stochastic optimisation model for offshore wind turbine micro-siting • Scenario reduction methods for stochastic optimization: an experimental comparison • The stochastic capacitated branch restructuring problem
Track B – Algorithms for Integer Programming (S6B) • BFC-SDC, an algorithm for solving multistage stochastic mixed 0-1 problems with a risk averse strategy • An algorithm for solving multistage stochastic nonlinear mixed 0-1 problems • Heuristic for a bilevel railroad-infrastructure access-pricing problem
Track C – Applications in Healthcare (S6C) • Whom to serve next: scheduling patients belonging to different categories at a multi-facility healthcare diagnostic centre • Optimum surgery time for rectal cancer patients receiving chemo-radio therapy • Simulation based evaluation of interdisciplinary ward clustering in a large university medical centre
Track D – Metaheuristics (S6D) • Development of a partially synchronized multithreaded metaheuristic to solve the supply chain network planning problem • Optimizing a linear fractional function over an integer efficient set • Hybrid metaheuristic using reactive GRASP and reinforcement learning
18:00 – 20:00
Welcome Reception

Thursday, April 10, 2014
08:40 – 09:40
Plenary Session (S7) Clearing the jungle of stochastic optimization
09:45 – 11:00
Track A – Applied Dynamic Stochastic Optimization (S8A) • Alternative portfolio optimization approaches in the fixed income market including 0-1 variables • Development environment for decision support in finance • Dynamic stochastic programming applied to insurance portfolios stress testing
Track B – Optimization in the Energy Sector (S8B) • Transmission switching in electricity networks via nonlinear stochastic programming • Optimal operation of medium-voltage AC networks with distributed generation and storage devices • A leader-followers model of power transmission capacity expansion in a market driven environment
Track C – Social Networks (S8C) • Sentiment analysis in social networks: a Markov-based prediction model • Community detection in social networks • Sales force allocation in pharmaceutical industry in presence of social contagion
Track D – Heuristics (S8D) • Diversity-driven hybrid genetic algorithm for a course timetabling problem • The broadening future of hyper-heuristic interfaces • The second cross-domain heuristic search challenge (CHeSC 2014)
11:00 – 11:30
Tea Break

Thursday, April 10, 2014
11:30 – 12:45
Track A – Stochastic Programming & Energy (S9A) • A multi-period stochastic equilibrium model for global energy markets • Optimal scheduling of demand side flexible units under uncertainty in SmartGrids • Integrating energy system models in a complementarity setting
Track B – Financial Optimization (S9B) • No-Arbitrage ROM simulation • Financial optimization modeling using R • Recent computational trends and opportunities in equity portfolio optimization
Track C – Linear Algebra for Large-Scale Optimization Problems (S9C) • Preconditioning IPMs for block-angular problems with "almost linearly dependent" constraints • Adaptive discontinuous Galerkin approximation of optimal control problems governed by transient convection-diffusion equations • Preconditioning techniques for large scale optimization problems
Track D – Numerical Algorithms II (S9D) • PSMG: A parallel problem generator for a structure conveying modelling language for mathematical programming • Nonlinear semidefinite optimization at NAG • Fast solvers for PDE-constrained optimization problems
13:00 – 14:00
Lunch Break

Thursday, April 10, 2014
14:15 – 15:30
Track A – Robust Optimization (S10A) • Robust network design with uncertain outsourcing cost • Multistage facility location and inventory problem • Robustness criteria and robust topology optimization with uncertain loads
Track B – Combinatorial Optimization III (S10B) • A column generation approach for bus driver rostering problems • Solving large-sized quadratic assignment problems by neural networks • Two exact algorithms for the Hamiltonian p-Median Problem
Track C – Machine Learning (S10C) • Spectral analysis and machine learning in water distribution networks • Enhancing teamwork by optimizing collaboration • A heuristic for tuning the kernel in dynamic clustering
Track D – Humanitarian Logistics I (S10D) • A review of management tools for humanitarian logistics • Mathematical methods in humanitarian logistics – the case of route planning under application of the heuristic “savings” after the typhoon Haiyan on the Philippines • Coordinating static and dynamic flow models for a multi-criteria humanitarian aid distribution problem
15:30 – 16:00
Tea Break

Thursday, April 10, 2014
16:00 – 17:15
Track A
Track B – Financial Asset Allocation (S11B) • Portfolio optimization using feature selection • Dynamic portfolio optimization with transaction costs and state-dependent drift • Time under the Water
Track C – Humanitarian Logistics II (S11C) • A Wardrop equilibrium model for the bi-objective location of distribution centres in disaster relief • Optimizing covering tours for the distribution of disaster relief items using competitive location models • A multi-objective integral approach for the humanitarian logistics problem. Application to a case study in Mexico
Track D
18:30
Coach Departure for Conference Dinner
19:00 – 23:00
Conference Dinner

Friday, April 11, 2014

08:30 – 09:30

Plenary Session (S12)

Structured stochastic integer programs: Understanding the effects of uncertainty

09:30 – 10:45

Track A – Optimization under Uncertainty I (S13A)

- Robust growth-optimal portfolios
- Entropic approximation for mathematical programs with robust equilibrium constraints
- Two-stage robust integer programming

Track B – Finance I (S13B)

- On the performance of the risk-adjusted on-line portfolio selection algorithm
- On Fenchel-duality and its application to non-life insurance
- Reduced order models for the implied variance under local volatility

Track C – Multi-Criteria Optimization (S13C)

- Multi-objective criteria for the aircraft conflict detection and resolution problem by using horizontal and vertical manoeuvres
- FRCA, a metaheuristic algorithm for solving large-scale multistage stochastic mixed 0-1 problems with risk averse stochastic dominance constraint 0-1 linear recourse
- An exact method for finding all integer efficient stochastic solutions

Track D – Decision Making Applications (S13D)

- Meaningful suitability indices as a basis for supplier selection
- Decision support system based on genetic algorithms and MUlti-criteria Satisfaction Analysis (MUSA) method for measuring university teachers' job satisfaction
- About the measurement of success of participants in decision-making

Friday, April 11, 2014
10:45 – 11:00
Tea Break
11:00 – 12:15
Track A – Optimization under Uncertainty II (S14A) • Interdiction games on Markovian PERT networks • Robust stable payoff distribution in stochastic cooperative games • Robust vehicle routing
Track B – Finance II (S14B) • Market neutral portfolios • A continuous piecewise linear programming approach to minimising portfolio E-VaR • Enhanced indexation based on second-order stochastic dominance
Track C – Algebraic Modeling Languages (S14C) • APMonitor: A modeling platform for dynamic optimization • JuMP: open-source algebraic modeling in Julia • Alternatives for programming in conjunction with an algebraic modeling language for optimization
Track D
12:15 – 12:45
Closing (S15) The future directions of analytics
13:00 – 13:45
Lunch Break
14:00
Coach Departure for Warwick Castle
14:30 – 16:30
Warwick Castle Visit

Abstracts

09:45 – 11:00, Wednesday, April 09, 2014

Handling Uncertain Data in Decision Support (S3A)

Chair: Achim Koberstein

Robust optimization in Xpress Mosel

(Pietro Belotti, **Zsolt Csizmadia**, Susanne Heipcke and Sebastien Lannez)

We present the new robust optimization modelling module for FICO Xpress Mosel. While focusing on the design and decisions behind the language syntax using example models, the current reformulation capabilities to the robust counterparts and some algorithmic details are also explained.

Applying oracles of on-demand accuracy in two-stage stochastic programming - a computational study

(**Achim Koberstein**, Christian Wolf, Csaba Fabian and Leena Suhl)

Traditionally, two variants of the L-shaped method based on Benders' decomposition principle are used to solve two-stage stochastic programming problems: the single-cut and the multi-cut version. The concept of an oracle with on-demand accuracy was originally proposed in the context of bundle methods for unconstrained convex optimization to provide approximate function data and subgradients. In this paper, we show how a special form of this concept can be used to devise a variant of the L-shaped method that integrates the advantages of the traditional variants while avoiding their disadvantages. On a set of 104 test problems, we compare and analyze parallel implementations of regularized and unregularized versions of the algorithms. The results indicate that significant speed-ups in computation time can be achieved by applying the concept of on-demand accuracy.

Computational aspects of risk-averse optimization in two-stage stochastic models

(**Csaba Fabian**, Christian Wolf, Achim Koberstein and Leena Suhl)

We generalize the on-demand accuracy approach of Oliveira and Sagastizabal to constrained convex problems, adapting the constrained level method of Lemarechal, Nemirovski and Nesterov to this framework. The new method is then applied to two-stage risk-averse problems. In this talk, we consider the CVaR-constrained model of Ahmed, and the stochastic ordering-constrained model of Dentcheva and Martinez. (The latter model is re-formulated using an appropriate constraint function.) We present a computational study on two-stage stochastic programming problems with a CVaR constraint for the recourse.

09:45 – 11:00, Wednesday, April 09, 2014

Search Games (S3B)

Chair: Thomas Lidbetter

Submodular search games

(Robbert Fokkink)

Search games are usually defined on graphs or metric spaces. They have a geometric flavour. In this talk I will consider search games from an operational point of view, by considering the cost of the search. This leads to a type of convex game, which generalizes the expanding search games that have recently been introduced by Alpern and Lidbetter. This is joint work with David Ramsey and Ken Kikuta.

Spatial dispersion of simple agents over a network

(**Martin Simanjuntak** and Steve Alpern)

For various possible reasons (including animal foraging, guarding a museum or search for an object) a team of agents may wish to disperse themselves over the nodes of a network. Alpern and Reyniers (2002) considered how n non-communicating agents can most quickly locate themselves evenly over a set of n locations. The current work, joint with Steve Alpern, adds a network structure to the locations (nodes), in that agents can only stay still or move to an adjacent location in each period. We assume they stay still with a given probability (which may depend on the population of their current node) and otherwise move randomly. We also consider the use of territoriality, where an agent who has been at his current node the longest comes to 'own' it and stays on it forever. The aim in all the problems we consider is to minimize the expected time to achieve full dispersal.

Optimal search for a small (or well hidden) object

(**Thomas Lidbetter** and Steve Alpern)

In traditional models of search games, an immobile Hider picks a point in some search space and a Searcher picks a constant speed trajectory in the space with the aim of minimising the expected time to reach the Hider. However, in practice a Searcher's ability to detect a Hider may depend on the speed at which he is travelling. For example, when searching for a contact lens there are two possible modes of travel: a fast walking speed and a slow searching speed. Equally, an explosives expert searching for an IED may be able to move from place to place quickly in a vehicle, but in order to detect the IEDs he must get out of his vehicle and move at a slower pace. Hence we adapt the traditional model to allow the Searcher to move at either a slow speed at which he is able to detect the Hider, or a fast speed at which he cannot. We view this as a zero sum game and show that the solution of the game is complicated even if it is played on a single arc. We give the solution to this, and to the game played on trees and other networks. We also consider what happens if the Searcher is able to detect the Hider with a small probability when he is travelling at the fast speed.

Combinatorial Optimization I (S3C)

Chair: Wasakorn Laesanklang

Workforce allocation for IT services using stable matching

(**Mangesh Gharote**, Rahul Patil and Sachin Lodha)

Workforce allocation to project requirements in an IT service is an important task. Improper allocation results in poor on-job performance, increase in attrition rate, and financial loss to the projects. The general methodology followed by managers for workforce allocation is either a round-robin fashion assignment (greedy heuristics) or using cost optimization assignment model. In both these approaches, one could find out unstable pairs. Pairs which are unhappy with their current allocation and overall solution could be improved by meagre increase in cost of allocation. We propose a technique based on the theory of stable matching to improve this allocation process.

In this paper, we address a specific trainee allocation problem faced by an IT service organization. The problem is as follows: We have n trainees and m projects. Each trainee few parameters, namely, skill, training score, three location choices are known. Each project specifications such as location, skill requirements, type of project, and the number of people required are known. The problem is to allocate each trainee to a single project requirement as per his/her preference, such that we obtain a good allocation.

We design utility function to measure matching satisfaction and to generate preference list of employees and projects. The utility function uses the empirical data distribution and managerial insights for generating preferences. We compare solution generated by different allocation methods using this preference list. Our findings are based on the experimentation done on different test cases by comparing the average satisfaction (in terms of preference matching) and allocation cost. The findings are as follows: allocation strategies such as greedy heuristics and assignment cost optimization produces unstable pairs, stable matching performs better with average trainee and project satisfaction, percent increase in average satisfaction achieved by stable matching is at a lower percent increase in cost of allocation.

Mixed-integer programming for the workforce scheduling and routing problem

(**Wasakorn Laesanklang** and Dario Landa-Silva)

We propose a mixed integer programming (MIP) approach to tackle a workforce scheduling and routing problem. This problem arises in scenarios where workforce has to travel to different locations in order to perform the assigned tasks (e.g. home care, technicians, cleaners, security patrols). Hence, this problem integrates elements from both workforce scheduling and also from vehicle routing. In this work we focus on a home care scenario with real-world data provided by our industrial partner. For this specific scenario, the solutions developed by human planners often result in a considerable number of unassigned tasks. This means additional costs if those unassigned tasks are to be covered by hiring additional workforce. Hence, our focus is to minimise the number of unassigned tasks in addition to minimise the total travelling distance by the whole workforce. The MIP model is tackled using IBM's CPLEX solver and as expected, finding a solution is a challenge in terms of computational time, particularly considering the problem size of our real-world scenarios. Therefore, we split a problem instance into multiple sub-problems by clustering tasks and then solving the sub-problems individually. The solutions obtained for the full-size scenarios are of course guaranteed to meet all the established constraints (e.g. workforce qualifications and geographical working restrictions), which is hardly the case in solutions produced by the human planners. We present a computational study that helps to better understand the difficulty of this integrated scheduling and routing problem and assess the suitability of tackling the problem with a contemporary MIP solver such as CPLEX. This work is helping us to determine an effective way to integrate clustering algorithms and heuristics with the MIP solver in order to solve real-world size problems in practical time and robustly, producing solutions that can be implemented in reality by our industrial partner.

Supporting Advanced Modeling Constructs in Algebraic Modeling Languages (S3D)

Chair: John Siirola

Analyzing structured optimization models with automatic transformations

(John Siirola and William Hart)

Computational tools for modeling mathematical programs are widely used within both academia and industry. Available commercial and open-source modeling packages support generic modeling by separating modeling constructs from instance data through concepts like sets, parameters, and parameterized constraints. However, their model representations are limited to constructs that directly correspond to established solver inputs. In general, this implies that mathematical programs must be expressed as either linear or nonlinear algebraic models; that is, a list of variables, an algebraic objective expression, and a list of algebraic constraints. Modelers must then explicitly convert non-algebraic constructs like switching decisions in disjunctive programs into algebraic relaxations (e.g., relaxing constraints implied by the decision with Big-M terms). This approach can obfuscate or eliminate the original model structure and it forces the modeler to sacrifice abstraction by injecting decisions related to how to solve a model into the model representation. In this presentation, we demonstrate how high-level non-algebraic modeling constructs can be coupled with automated model transformations to improve model clarity and abstraction. This coupling provides a more flexible workflow where the modeler can explicitly apply transformations that link the structured model to a particular solver. Additionally, this modeling approach simplifies the model specification by eliminating explicit modeling of reformulation decisions. We will highlight two key non-algebraic constructs: disjunctive programming and complementarity constraints. We present transformations that rely on both direct transcription to the Big-M or convex hull relaxation, as well as heuristic procedures leverage

both relaxations. Similarly, we show how to reformulate complementarity constraints as smooth nonlinear expressions or as a disjunctive expression that subsequently applies disjunctive transformations. These constructs and transformations are available in the open source Coopr optimization project, which includes the Pyomo modeling library.

Toward supporting bi-level programming in an algebraic modeling language

(Richard Chen, **William Hart** and John Siirola)

A bilevel program is a mathematical program in which a subset of decision variables is constrained to take values associated with an optimal solution of a distinct, "lower" level mathematical program. Bilevel programs are widespread in practice, and they arise in applications ranging from graph analysis to sensor and facility location. However, no algebraic modeling language (AML) natively supports bilevel programming, which forces users to directly implement intricate model transformations by hand.

In this presentation, we describe recent developments to support bilevel programming in an AML, specifically in the context of the Pyomo AML and the Coopr open-source optimization project. We focus on the class of bilevel programs that features two sequential decision makers (upper-level and lower-level) and information transparency. The upper-level program is a mixed-integer linear program and the lower-level program is a linear program parameterized by a subset of the upper-level program's binary variables. We describe modeling extensions that support the expression of bilevel programs in Pyomo, and transformations that automatically construct an equivalent single-level mixed-integer linear program. These transformations can be applied automatically to allow for direct solution by general solvers. The transformations are derived using duality and linearization/reformulation via disjunctive constraints. We demonstrate the use of these new constructs and tools using specific motivating problems from real-world application domains: shortest-path network interdiction and water sensor placement.

Specification and automatic discretization of ODE and DAE systems in an AML

(**Jean-Paul Watson**, John Siirola, Victor Zavala and Bethany Nicholson)

Dynamic optimization problems that include differential equations as constraints are typically solved by first discretizing the model and then solving the resulting nonlinear optimization problem. Several strategies exist for discretizing such dynamic systems, including multiple shooting and collocation over finite elements. However, implementing these discretization strategies is usually done by hand, which is both a time consuming and error prone process.

We begin this talk by introducing new modeling constructs to support the specification of ODE and DAE systems within the Pyomo algebraic modeling language. While simple, these constructs significantly expand the scope of optimization problem that can be addressed by typical AMLs, e.g., GAMS and AMPL. We then discuss mechanisms to perform automatic discretization of the resulting models, using flexible and configurable discretization transformations.

Given these new capabilities, we examine two illustrative dynamic optimization problems. The first problem involves parameter estimation for an infectious disease propagation model. We use this example to demonstrate the relative cost of automatic versus manual discretization, and to demonstrate validity of the proposed approach. The second problem involves operation of a natural gas transportation network. We use this example to illustrate more advanced discretization schemes and challenges, and show how the availability of ODE/DAE constructs in an AML enables expression and solution of stochastic dynamic optimization problems, using the PySP library for stochastic programming.

Uncertainty in Logistics and Transportation (S4A)

Chair: Francesca Maggioni

Joint revenue management and vehicle routing in home-delivery operations

(**Arne Strauss**, Xinan Yang, Christine Currie and Richard Eglese)

Attended home delivery services face the challenge of providing narrow delivery time slots to ensure customer satisfaction, whilst keeping the significant delivery cost under control. To that end, the firm can try to influence customers when they are booking their delivery time slot so as to steer them towards choosing slots that are expected to result in cost-effective schedules. We estimate a multinomial logit customer choice model from historic booking data and demonstrate that this can be calibrated well on a genuine e-grocer data set. We propose dynamic pricing policies based on this choice model to determine which and how much incentive (discount or charge) to offer for which time slot at the time a customer intends to make a booking. A crucial role in these dynamic pricing problems is played by the delivery cost, which is also estimated dynamically. We show in a simulation study based on real data that anticipating the likely future delivery cost of an additional order in a given location can lead to significantly increased profit as compared to current industry practice.

New models and methods for the multi-path Travelling Salesman Problem with stochastic travel costs

(**Luca Gobbato**, Francesca Maggioni and Guido Perboli)

City Logistics and the concept of Smart City are bringing researchers towards the definition of new transportation and supply-chain applications, integrated in the urban context, which, in particular, incorporate information about the uncertainty related to the transportation system. A recently introduced problem, specifically designed for this context, is the multi-path Travelling Salesman Problem with stochastic travel costs (mpTSPs). Given any pair of nodes, mpTSPs considers a set of paths between the two nodes. Each path is characterized by a random travel time, which represents the travel time oscillation due to the path congestion or the presence of different power trains for hybrid vehicles. In this paper we propose a two stage stochastic programming formulation where tour design makes up the first stage, while a series of recourse decisions are made in the second stage to select the best paths to use, according to observed travel time costs, with the objective to minimize the total cost due to paths congestion. To solve this formulation we propose a parallel heuristic method inspired by the progressive Hedging algorithm [R.T. Rockafellar, R.J.-B. Wets, Scenarios and policy aggregation in optimization under uncertainty, Mathematics of Operations Research, 1991, pp.119-147]. It applies a scenario decomposition technique to separate the stochastic problem following the possible scenarios of random events. Our methodology takes also advantage of strategies aimed at penalizing non-consensus amongst scenario sub-problems and at accelerating its convergence. New instances representing a medium-sized city derived from the speed sensor network of the city of Turin and a flow-based representation of the problem are introduced in order to numerically qualify the solution method and to examine the impact of the stochastic travel time costs on the problem solution, showing the benefits of the proposed methodology in both solution quality and computational effort when compared to commercial solver based methods.

Bounds for stochastic multistage transportation problems

(Francesca Maggioni)

In this talk we evaluate approximation methods based on different level of information gained from deterministic, sub-problems solutions and rolling-horizon approaches for stochastic transportation problems. The idea behind is that in case the solution of a large multistage stochastic program is quite demanding, one may try to solve simpler problems for finding lower and upper bounds and proceed to find tighter and tighter bounds, if the difference between the first two is quite large. Structural similarities and differences between the stochastic solution and its deterministic counterpart are also analyzed. It turns out that a large VSS does not necessarily imply that the deterministic solution is useless for the stochastic setting. Measures of the structure of the deterministic solution which generalize the loss using the skeleton solution by taking into account the information on reduced costs associated to the variables at zero in the expected value solution, will be introduced and basic inequalities in relation to the standard VSS are presented. The described relationships are illustrated on real cases supply transportation problems provided by Italcementi. The stochastic parameters are the demand of the customers and the production capacity of the production plants. Shipments are performed by capacitated vehicles, which have to be booked in advance, before the realization of the uncertainty. Once the production capacity and the demand are revealed, there is an option to cancel some of the booked vehicles against a cancellation fee; if the quantity shipped from the suppliers using the booked vehicles is not enough to satisfy the demand, the residual quantity is purchased from an external company. The problem is to determine the number of vehicles to book in order to minimize the total cost. Bounds are then tested on multistage stochastic mixed integer linear programming models formulated to solve the problems considered.

11:30 – 12:45, Wednesday, April 09, 2014

Portfolio Management (S4B)

Chair: Ethem Çanakoğlu

Inverse portfolio problem with mean-deviation model

(**Bogdan Grechuk** and Michael Zabarankin)

A Markowitz-type portfolio selection problem is to minimize a deviation measure of portfolio rate of return subject to constraints on portfolio budget and on desired expected return. In this context, the inverse portfolio problem is finding a deviation measure by observing the optimal mean-deviation portfolio that an investor holds. Necessary and sufficient conditions for the existence of such a deviation measure are established. It is shown that if the deviation measure exists, it can be chosen in the form of a mixed CVaR-deviation, and in the case of n risky assets available for investment (to form a portfolio), it is determined by a combination of n+1 CVaR-deviations. In the latter case, an algorithm for constructing the deviation measure is presented, and if the number of CVaR-deviations is constrained, an approximate mixed CVaR-deviation is offered as well. The solution of the inverse portfolio problem may not be unique, and the investor can opt for the most conservative one, which has a simple closed-form representation.

On the efficient hedging in incomplete markets

(**Hirbod Assa** and Keivan Mallahi)

In this note, we will make a quantitative study of the risk-price trade-off and find a necessary and sufficient condition for a market in which super-hedging strategy cannot be improved on by a more efficient strategy for some contingent claims. Remarkably, we find that in a market without Good Deals such contingent claims always exist. We will also show that even in a complete market, the advantages of using the efficient strategy are marginal.

Risk management of electricity portfolios using hedging strategies

(Ethem Çanakoğlu)

After deregulations in electricity markets contract planning has become one of the major risk management tools for either electricity generation or distribution companies. Participants of the electricity market are exposed to market risk due to the special characteristic of the electricity prices. Since electricity cannot be stored efficiently, spikes are common in the prices resulting as extremely high or negative levels in the price which results as highly volatile structure compared to other commodities or assets in financial markets. High levels of volatility encourage companies to use derivative contracts for risk management. In this paper we analyze the dynamics of spot prices for electricity market in UK and compare the forecasting power of different models such as econometric time series models and stochastic models with regime switching characteristics. Using different models we price the derivative contracts. Then we suggest and solve alternative portfolio optimization problems with different risk metrics. As a result we compare the expected payoff and risk structure of different strategies for an electricity company with a predefined demand structure.

11:30 – 12:45, Wednesday, April 09, 2014

Game Theory (S4C)

Chair: Chenlan Wang

Generalized minimum spanning tree game

(**Phuoc Le**, Tri-Dung Nguyen and Tolga Bektas)

The minimum spanning tree game is a special class of cooperative games defined on a graph with a set of vertices and a set of edges, where each player owns a vertex. Solutions of the game represent ways to distribute the total cost of the minimum spanning tree among all the players. When the graph is partitioned into clusters, the generalized minimum spanning tree problem is to determine a minimum-cost tree including exactly one vertex from each cluster. This paper introduces a new class of cooperative games called the generalized minimum spanning tree game and proposes a constraint generation algorithm to calculate a stable payoff distribution. The paper also presents some properties of this game and computational results with the proposed algorithm.

Bounding the price of anarchy for congestion games with stochastic demand

(**Chenlan Wang**, Xuan Vinh Doan and Bo Chen)

Congestion games are non-cooperative games in which players compete for finite resources, and the utility of a player depends only on the number of players sharing the same resource. Price of anarchy is a measure of system degradation due to travellers' selfish behaviours, comparing two classic assignments, i.e., user equilibrium and system optimum. For user equilibrium, each traveller aims to maximize the individual utility selfishly at a cost of whole system efficiency. For system optimum, all the network resources are well organized and assigned in the most efficient way by an ideal central controller. The study of the price of anarchy deems whether the user equilibrium is approximated to the system optimum, and how much can be improved by coordination from a system perspective. We extend the notions by considering day to day variation of demands and study the price of anarchy in our stochastic models. Without any restriction of cost functions, the price of anarchy is unbounded. We prove upper bounds the price of anarchy with affine cost functions and more general polynomial cost functions. The tightness of all upper bounds will also be presented in our study.

Numerical Algorithms I (S4D)

Chair: Alain Zemkoho

Hybrid adaptive blind equalization algorithm with new cost function

(Abdenour Labed)

Constant modulus algorithm (CMA) and its extensions like the multi-modulus algorithm (MMA) and the extended constant modulus algorithm (ECMA) have been proposed to combat inter-symbol interference (ISI) in digital communications systems transmitting signals with constant modulus such as phase shift keying (PSK) modulated signals. However, for quadrature amplitude modulated (QAM) signals suited for high date-rate communications these algorithms have shown their limits. Hybrid blind (unsupervised) equalization algorithms consist of adding a penalty term to a standard criterion which results in enhanced performance for communications systems transmitting QAM signals. The penalty term is introduced to take account of the non-constant nature of modulus and hence forces the equalizer output to match the constellation points and is referred to as constellation matching error (CME). We have recently proposed a new CME for which we analyse the convergence in this paper. Through this analysis, we show that it confers to the resulting penalized criteria substantial improvements and makes it outperform standard and other hybrid algorithms.

Convergence of truncated stochastic algorithms with an extra control

(Ramin Okhrati)

Many finance and risk management problems are modeled through solutions of optimization problems. While these problems are theoretically well developed, their numerical solutions are not much studied. Stochastic algorithms can be useful tools in developing numerical solutions for these problems. We design a stochastic approximation algorithm based on Robbins-Monro algorithm. At every step we have both a random truncation and a control on the approximating sequence. We prove almost sure convergence under improved local hypotheses which are easily verifiable.

Solving nonlinear second order conic optimization problems

(Alain Zemkoho)

We consider a second order conic optimization problem with twice continuously differentiable functions. Various solution approaches are discussed with special attention on augmented Lagrangian-type methods. In particular, a Lowner-Log-Sigmoid transformation is used to deal with the conic constraint. This allows the preservation of some important properties of the initial problem including the order of differentiability. Newton and quasi-newton methods are then applied to solve the resulting unconstrained optimization problem. In this talk, we discuss the features of each method and present some preliminary experiments.

Optimization in Industry (S5A)

Chair: Asgeir Tomasgard

A branch-and-price approach for energy-efficient deployment of multi-tier services in cloud data centres

(Bjørn Nygreen and Anders N. Gullhav)

Providers of cloud software services are concerned about being cost- and energy-efficient in their service delivery, while providing a quality of service in accordance with the end-users' requirements. We present a branch-and-price approach for a multi-tier service deployment problem where various types of virtual machines, with different functionality, are mapped to physical nodes while considering performance requirements and the energy costs of the service provider. In order to satisfy the performance requirements the provider might need to deploy several, identical virtual machines of a given type.

The columns in the master problem represent physical nodes packed with virtual machines, and the columns are generated in a pricing problem which is at the moment solved as an MIP. The structure of the master problem complicates the branching since the column variables are general integer variables and not restricted to be binary. Preliminary results show that a branch-and-price approach provides better solutions more quickly than a direct formulation.

Which information is important in decision making under uncertainty? A case study from maritime transportation

(Giovanni Pantuso, **Kjetil Fagerholt** and Stein W. Wallace)

Using stochastic programming comes in pair with modeling the uncertainty affecting the problem. We present an analysis which can help understanding which properties of uncertainty are more important to capture in a given model for decisions under uncertainty. The analysis is suitable for general stochastic programs, and especially for inherently multistage ones, where using incorrect models of uncertainty can lead to repeating poor decisions. Such analysis, performed before data collection, can illustrate which information should be primarily sought, and which is not critical for the final decision. We apply the analysis to a real instance of the maritime fleet renewal problem. Results show that, in our case study, some properties of the stochastic phenomena have very little relevance from a decision making point of view.

Optimisation models for salmon farming

(Asgeir Tomasgard)

In the last decade the salmon farming industry has expanded rapidly and gone towards consolidation, thus the complexity of planning has increased. Therefore, the need for better planning tools has arisen. We present a stochastic optimization model for integrated planning of deployment of smolt and harvesting of salmon This is a tactical planning problem in an environment where several parameters regarding production are uncertain. The most important sources of uncertainty in seawater production are growth, price and mortality. In addition we present a stochastic linear programming model for optimizing the smolt production.

Combinatorial Optimization II (S5B)

Chair: Michael Römer

Order acceptance and scheduling with and without due dates: A review and new results

(**Venkata Prasad Palakiti**, Usha Mohan and Viswanath Kumar Ganesan)

We provide a review of existing order acceptance and scheduling literature considering due-date and non-due-date related dimensions. We introduce a unified three field representation scheme for classifying the existing problems into different classes and for each class of the problems, we give an overview of computational tractability with solution algorithms for various problems studied in the literature. We provide details on the tractability of some open problems unaddressed in the literature. We extend our research into problems arising in systems having parallel machine configurations especially in client server systems, where the server has to process different client requests under limited capacity conditions with an objective of maximizing the profit by considering weighted completion time. Weighted completion time represents the significance associated with the service delivered to the clients by the provider. We present a Mixed Integer Linear Programming formulation for this problem and show that the complexity of this problem is NP-hard. A Branch and Bound algorithm is presented to solve the problem and its effectiveness is tested against the computational time required using CPLEX Solver through computational study. We find that CPLEX Optimizer solves the parallel machine problem with sizes no more than 5 machines and 20 customer orders, whereas the Branch and Bound scales up to 5 machines with 60 customer orders. We also identify several problem areas and issues for future research.

Multidimensional tropical optimization problems with applications to job scheduling

(Nikolai Krivulin)

Optimization problems are considered which are formulated and solved in the tropical mathematics setting. The problems are to minimize or maximize functions defined on vectors of finite-dimensional semimodules over idempotent semifields, subject to linear inequality and equality constraints. The objective functions can be linear or take the form of non-linear functions calculated by using a conjugate transposition of vectors. We give an overview of known problems and briefly discuss available solution methods. Furthermore, recent results on the solution of certain new problems are presented which give the problems direct explicit solutions in a compact vector form.

We apply the obtained results to solve scheduling problems for a set of jobs operating under various precedence relations in the form of start-start, start-finish, early-start, late-finish and other temporal constraints. The problems are formulated to find optimal schedules according to certain optimality criteria, which involve the minimization of the maximum deviation of job completion times from given due dates, the minimization and maximization of the maximum deviation time between job completion times, and the minimization of the maximum job flow (processing) time.

Combining levels of crew aggregation in network flow based airline crew scheduling models

(**Michael Römer** and Taieb Mellouli)

Due to its complexity, the airline crew scheduling problem is typically solved in two steps: In crew pairing optimization, flights are combined into pairings (legal sequences of daily flight duties) starting and ending at the same crew domicile. In the subsequent crew rostering step, these anonymous pairings are assigned to concrete crew members along with rest periods and standby duties. A major advantage of this decomposition is the fact that the highly combinatorial problem of identifying an optimal set of crew pairings is performed at the home base level of crew aggregation which avoids the replication of multiple similar (and thus symmetric) model layers for each crew member. However, a possible drawback of this approach is that important aspects such as crew members with multiple qualifications, time-dependent availability of crew members due to pre-assignments as well as weekly and monthly rest requirements are typically not accounted for in the pairing optimization step. In this paper, we discuss modelling techniques to efficiently combine different levels of crew aggregation in an integrated network flow based model for the crew pairing chain problem proposed by Mellouli. These techniques are used to deal with crew groups with hierarchically related qualifications and to anticipate crew rostering on the level of individual crew members within the crew pairing chain optimization. An important feature of the modelling techniques is the delegation of problem aspects exhibiting a high combinatorial complexity in model layers with a high level of crew aggregation while keeping track of crew-related aspects and rules in model layers with more detailed crew information. Computational experiments with real world data sets from a medium-sized German airline show that the resulting models are efficiently solvable using standard solvers enhanced by a problem-specific fixing technique and yield improvements with regard to the results of the overall planning process.

14:15 – 15:30, Wednesday, April 09, 2014

Student Best Paper Competition (S5C)

Chair: Nalan Gulpinar

Stochastic local search versus genetic algorithm for feature selection

(**Messaouda Nekkaa** and Dalila Boughaci)

Feature selection is an important process in data classification. It permits to eliminate the redundant attributes and enhance the classification accuracy by keeping only the relevant attributes. In this paper, we study and compare two meta-heuristics for feature selection in data classification. The first one is a stochastic local search and the second one is a genetic algorithm. The two methods are used for selecting an optimal set of attributes that are sent to the Support vector machine based classifier. The latter is used to find the good classification for the considered data. The two methods are tested on some benchmark datasets of various sizes available in UCI Machine Learning Repository in order to measure their performance. The results are encouraging and demonstrate the benefits of the proposed approaches in data classification.

Adjustable robust optimization with decision rules based on inexact revealed data

(**Frans de Ruiter**, Aharaon Ben-Tal, Ruud Brekelmans and Dick den Hertog)

Adjustable robust optimization (ARO) is a technique to solve dynamic (multistage) optimization problems. In ARO, the decision in each stage is a function of the information accumulated from the previous periods on the values of the uncertain parameters. This information, however, is often inaccurate; there is much evidence in the information management literature that even in our Big Data era the data quality is often poor. Reliance on the data "as is" may then lead to poor performance of ARO, or in fact to any "data-driven" method. In this paper, we remedy this weakness of ARO by introducing a methodology that treats past data itself as an uncertain parameter. We show that algorithmic tractability of the robust counterparts associated with this extension of ARO is still maintained. The benefit of the new approach is demonstrated by a production-inventory application.

Local search methods for the minimum interference frequency assignment problem

(**Yasmine Lahsinat** and Dalila Boughaci)

This paper studied three local search meta-heuristics for the Minimum Interference Frequency Assignment Problem (MI-FAP) in GSM network (Global System for Mobile communication). The MI-FAP is the problem of finding an assignment of small number of frequencies to a large number of transceivers that minimizes the interferences level. The MI-FAP is known to be NP-Hard and plays an important role in the GSM network planning. We first studied two local search based methods for MI-FAP. The first one is a Variable Neighbourhood Search (VNS) and the second one is a Stochastic Local Search (SLS). Then, we proposed to combine these two methods in a new method so-called VNS-SLS technique. The SLS method is incorporated into the VNS process as a local search step where the objective is to enhance the solution quality and the performance of the VNS process. The three methods for MI-FAP which are: SLS, VNS and VNS-SLS are implemented and tested on Benchmarks to measure their performance. The experimental study shows that VNS-SLS succeeds in finding good results for MI-FAP compared to both VNS and SLS which demonstrate the effectiveness of SLS as a local search routine into the VNS process.

Developments in Modeling Languages and Platforms (S5D)

Chair: David Curran

Modelling and solving generalized graph-based transport problems

(J. Fabian Meier and Uwe Clausen)

When you want to solve realistic transport problems, you are confronted with several different constraints and cost types. Nevertheless, many transport problems boil down to a set of many shipments (or commodities) which have to be transported from a node A to a node B in a graph. Therefore it would be nice to have a meta-heuristic that works on this level of generality while not ignoring a priori information about the graph and the constraints.
We have defined a graph-based modelling language that was first defined for hub location and open vehicle routing problems but can also model mixed problems including some sort of pre-haul or scheduling. It takes a shipment-driven view, i.e. all costs are derived from the routes of the shipments, and forbidden interactions between shipment routes are modelled by penalty costs so that all shipments can be routed individually. From a mathematical description we derived an XML structure and programmed a framework. Upon this framework, we defined a Simulated Annealing heuristic and tuned it. The numerical results show that we can handle complicated cost functions much better than commercial MIP solvers.

Developments in the AMPL ecosystem

(Gautam Mitra and Christian Valente)

We report new developments in the ecosystem of the AMPL modelling language; these include language constructs and operational methodologies. AMPLDev SP edition is a fully featured Integrated Development Environment (IDE) for AMPL, with workspace management, editors with syntax highlighting, solution viewers and console support. It also includes Stochastic AMPL (SAMPL), an extended version of AMPL designed to support

Stochastic Programming (SP) and Robust Optimisation (RO). Formulation of RO models is greatly simplified by a subset of the extended syntax that SAMPL supports. SP models expressed in SAMPL are generated, at instance level, in the SMPS format, which are then solved using another component of the software suite: FortSP. FortSP is a solver designed for Stochastic Programming, based on Bender's decomposition. The performance of the solver is enhanced through regularisation by the level method. FortSP has Stochastic Integer Programming capability and uses CPLEX, Gurobi or FortMP as embedded solver. We give use case examples and discuss the benefits of the extended syntax and of the integrated environment. We are making the AMPLDev modelling system and the solvers CPLEX and FortSP more readily available to the industrial users and the academic community through a cloud-based service. We illustrate the usage and the benefits of this approach.

Fair division as an applied optimization problem

(David Curran)

We present a method to fairly divide a collection of goods amongst a group of people. The method handles allocating mixtures of divisible and indivisible goods for two or more people. Our solution has been mainly applied to the creation of wills (the division of estates). It can also be applied to divorces, mergers and bankruptcies.
The process of turning this optimization method into an internet startup is then described. This includes competing for a place in and attending a startup incubator program, exploring market verticals, user interface and user experience refinements based on consumer trials and patent issues.
We also give a solution and our experience with the related 'dirty work' problem of dividing tasks or 'bads'. From customer interviews we found the practical requirements of this problem are drastically different to how it is described in the literature on fair division.
The literature dealing with fair division uses theoretical valuations of goods and mathematical definitions of fairness. We describe how real people's valuations of goods and metrics of fairness differ from these in practice.

A stochastic optimisation model for offshore wind turbine micro-siting

(Arne Klein)

The positioning of wind turbines within an offshore wind farm, also called turbine micro-siting, has a significant influence on the power production of the farm. The reason for this is the so-called wake effect, which is a decrease of the wind velocity and increase of turbulence behind a wind turbine. It causes a lower power production for turbines within the wake of another turbine and creates an optimisation problem for the placement of the wind turbines. This location problem can be approached by maximising the total power production, calculating the wind field within the farm with a wake model, and taking long-term wind estimates into account. In the current work we introduce an improved version of the frequently cited Jensen wake model, which is, in contrast to the original model, differentiable on the whole two-dimensional turbine location space. The optimisation problem can be formulated as a non-linear program with continuous turbine position variables for a fixed number of turbines, and be solved by a sequential quadratic programming method with multiple random starting positions.

Estimates of the expected wind over the lifetime of a wind farm are difficult to calculate, and usually include significant uncertainty. We thus set up a corresponding stochastic model to investigate the influence of uncertainty in the wind estimates on the resulting turbine layout and power production. Experimental results for a sample wind farm with different wind estimates and numbers of turbines are given. We compare the results of the deterministic model to those of the stochastic model with different levels of uncertainty in the wind estimates.

Scenario reduction methods for stochastic optimization: an experimental comparison

(Nils Loehndorf)

To solve stochastic optimization problems using sample average approximation, choosing the right set of scenarios is key, since approximation quality highly depends on the quality of the selected scenarios. To apply sample average approximation, we have to draw a sample of realizations of those random variables that define the stochastic part of our optimization problem. Since computational complexity scales with the number of scenarios, we normally want to reduce the set of scenarios while retaining its approximation quality. While methods for drawing a reduced sample from a univariate distribution are well established, empirical evidence on the performance of scenarios reduction methods for multivariate distributions is still scarce. The most widely used methods in this domain are quasi Monte Carlo, moment matching, as well as methods based on minimizing probability metrics. This work presents results of a large-scale experimental study on the efficiency of different scenario reduction methods, which is meant to serve as guidance for practitioners of computational stochastic optimization. Most notably, the study provides empirical evidence for the ineffectiveness of methods based on minimizing probability metrics in higher dimensions.

The stochastic capacitated branch restructuring problem

(**Diego Ruiz-Hernandez** and David Delgado-Gómez)

In the aftermath of the Great Recession of the first decade of this century, we have witnessed an important increase in the number of bank mergers and acquisitions. One of the most important problems faced after a merger is the reduction of the branch network, eliminating redundant branches and adapting the capacity of the resulting network in order to accommodate the demand. This problem becomes even more complex when the uncertainty in the way that the market will react to the restructuring is considered. In this work, we present a stochastic capacitated branch restructuring problem, formulated as a two-stage recourse stochastic programming model. It takes into account the size of the shuttered branches, the existence of competitors, and the uncertainty in the demand's response. We propose three alternative versions of our formulation that model different ways in which the different stages of the restructuring may be carried out. The model's performance is tested on 25 alternative settings designed on an extension of Swain's network. The results show that the banks may obtain important savings, if the necessary changes in the service capacity are carried out after the information about the market's reaction is available.

Algorithms for Integer Programming (S6B)

Chair: Michal Kaut

BFC-SDC, an algorithm for solving multistage stochastic mixed 0-1 problems with a risk averse strategy

(**María Araceli Garín**, Laureano Escudero, María Merino and Gloria Pérez)

We extend to the multistage case the recent two-stage risk averse measures introduced in Gollmer et al., (2008) and (2011), such that in the formulation of the whole multistage stochastic mixed 0-1 optimization problem an objective function is maximized in the domain of a feasible region subject to first- and second-order Stochastic Dominance Constraints integer-recourse (SDC). In this work we present the multistage time consistent mixture of those two SDC measures. So, an objective function is maximized in the domain of a feasible region subject also to first- and second-order SDC. Its advantage and the computing price to pay for it in case of plain use of MIP solvers are discussed. The SDC measure that we propose is included by user-driven set of profiles, each one consists of a threshold on the value of a function, a bound target for the shortfall probability and a bound target for the expected shortfall of the scenario to occur as soft constraints whose violations are appropriately penalized in the objective function, and a hard bound on the maximum shortfall. Given the dimensions of these large-scale problems augmented by the new set of variables and constraints required by these two risk measures, it is unrealistic to solve the problem up to optimality by plain use of MIP solvers. Instead of it, decomposition algorithms of some type should be used. We present an extension of our Branch-and-Fix Coordination algorithm, the so named BFC-SDC, where (besides some important refinements for cutting branches purposes) a special treatment is given to cross scenario cluster constraints that appear in SDC risk measures. A computational experience is presented by comparing the risk neutral approach and the tested risk averse strategies by using a randomly generated set of instances. The performance of the new version of the BFC-MS algorithm versus the plain use of a state-of-the-art MIP solver is also reported.

An algorithm for solving multistage stochastic nonlinear mixed 0-1 problems

(**Eugenio Mijangos**)

An algorithm for solving nonlinear, multistage mixed 0-1 problems under uncertainty is presented. This approach uses the twin node family concept within the algorithm framework of the Branch and Fix Coordination (BFC) method. Important features of this approach (BFC-MSMIP) with respect to other stochastic integer approaches are that it addresses multistage environments with both continuous and binary variables in each stage and that the objective function is nonlinear, the constraints being linear. It is very important to determine the stage where the non-anticipativity constraints are explicitly considered in the model. This information is used when the full model is divided into a scenario cluster partition with smaller problems. In this work an algorithm to solve these multistage stochastic nonlinear problems is designed, it is implemented in C++, and each nonlinear sub-problem generated in the nodes of the trees associated with this method is solved by solving sequences of quadratic sub-problems with the help of the Cplex library. Numerical results are reported.

Heuristic for a bilevel railroad-infrastructure access-pricing problem

(**Michal Kaut**, Truls Flatberg and Adrian Werner)

The Norwegian railroad network is used to its full capacity in the peak time, but is underutilized in other parts of the day. This is partly due to the fact that there are no incentives for the operators to move to the off-peak times. In co-operation with the Norwegian National Rail Administration (Jernbaneverket) and two train operators (Flytoget and Cargolink), we have developed a model that studies whether the infrastructure utilization can be improved by introducing scarcity costs and subsidies.

Since the model has to include the operators' response to the costs, we get a bilevel problem with integer variables in both levels. To solve this model, we have developed a heuristic consisting of several different MIP models, solved in sequence.

In this talk, we will present the heuristic together with preliminary results.

Applications in Healthcare (S6C)

Chair: Karsten Helbig

Whom to serve next: scheduling patients belonging to different categories at a multi-facility healthcare diagnostic centre

(**Varun Jain** and Usha Mohan)

One of the key operational decisions faced by any health care diagnostic provider is: whom to serve next, that is, which category of patient (for example: Emergency (EP), outpatient (OP), inpatient or health check-up (HC)) should be served next at a particular facility. This is important as the revenues generated by the different categories are different as is the priority by which they need service. The answer to this problem is complex owing to the limitations forced by their medical status which we describe as category; and limitations on essential resources, example: availability of equipment, nurse, supporting staff and physician. The current practice of expert based scheduling often lead to long waiting time for patients, and thus affecting the revenue generated. Current research in this area is witnessing a trade-off between operational and economic objectives for serving the demand in cost effective manner. However, we find research is limited to single facility.

In this work, we model random arrival of patients belonging to different categories and priorities with some patients having pre-defined sequence and service time, at multiple diagnostic centres with dedicated resources over a finite planning horizon, thus extending the scope of research to include diagnostic centres with multiple facilities. We develop a mathematical model for sequential decision making under uncertainty using Markov Decision Process (MDP) with the objective of maximising the profit, incurring penalty cost for waiting patient, rejecting patient due to limitation posed by capacity and unmet demand at the end of day. We solve the problem using Dynamic Programming (DP) and improve the result obtained by neighbourhood search technique. We further perform computational experiments to compare these results with the results obtained for six different heuristic decision rules for serving patients.

Optimum surgery time for rectal cancer patients receiving chemoradio therapy

(**Elvan Gokalp** and Nalan Gulpinar)

In the treatment of rectal cancer, neo-adjuvant chemoradio therapy (CRT) is a standard practice in many centres. The therapy is generally followed by a resection surgery in which the tumour is excreted from the rectum. The optimal surgery time is crucial in the treatment process and the effect of CRT (tumour regression). In this paper, we introduce a Markov decision process to determine the optimum time of surgery in the management of rectal cancer. We derive some structural properties of the model including the sufficiency conditions for optimal control-limit policies.

Simulation based evaluation of interdisciplinary ward clustering in a large university medical centre

(**Karsten Helbig**, Thomas Stoeck, Markus Gragert and Taieb Mellouli)

The current "Krankenhaus Rating Report 2013" documents that 51% of all hospitals in Germany incur a loss. Hospitals should improve efficiency and lower costs because of the cost pressure induce by the establishment of diagnosis related groups (DRGs) for hospital payment in Germany since 2003. Studies about resource management in hospitals show that improving flexibility could lead to more efficiency. As shown in our previous study in the university medical centre Halle (Saale), flexible bed management scenarios, like borrowing rooms to other wards nearby, are able to improve bed utilization and reduce waiting times for patient relocations considerably. Based on these findings, the hospital defined three realisable interdisciplinary scenarios mapping the 48 wards into seven or eight subject-specific allocation clusters (e.g. head, bone, internal medicine). These clusters contain similar wards and enable patient allocation in a cluster if the proper ward has no available beds. Based on analysis of patient data from 2012, we developed a discrete-event simulation model to study how ward-clustering effects bed utilisation, how to configure clusters, and whether clustering could deal with bed capacity reduction of about 1/3. The model is able to simulate patient flows (emergency and elective) under constraints like gender or isolation states. To evaluate the scenarios, we measured the excess of available bed capacity of wards or clusters and compared with current situation. Results show that configuration of clusters is more important than size. The scenario with eight clusters and one for internal medicine reduced capacity exceeding about 200 times which is twice as much as the scenario with seven clusters but without internal medicine. After bed capacity reduction, the scenario with seven clusters and internal medicine reduced the excess by 1.5 times compared to the actual inflexible ward-oriented system.

Metaheuristics (S6D)

Chair: Francisco Chagas De Lima Júnior

Development of a partially synchronized multithreaded metaheuristic to solve the supply chain network planning problem

(**Dennis Horstkemper**, Marcelo Lacerda, Luis Filipe Araújo Pessoa, Diego Siqueira, Bernd Hellingrath and Fernando B. De Lima Neto)

Supply Chain Network Planning (SCNP) is a planning problem from the logistics domain used to determine an optimal allocation of demands and capacities in storage, transportation and production facilities, aiming to fulfil customer demands at minimal costs. Consequently, the SCNP contains an integrated lot-sizing for production and distribution, and therefore entails a considerable complexity. It has been shown in previous work that the population-based metaheuristic Fish School Search (FSS) is applicable to this problem and is able to find (near-) optimal solutions. However, it still performs slower than exact optimization approaches regarding common size SCNP problems. One possible reason is the lack of parallelization within the FSS. Thus, this work proposes a multithreaded version of the FSS, which nevertheless only requires a partial synchronization of the used threads, which perform calculations for each individual, due to certain characteristics of the algorithm: unlike the most famous population-based metaheuristic, the Particle Swarm Optimization, the FSS does not use a defined neighbourhood of individuals. Instead, a combined movement of individuals is instead performed by gathering information about the positions of all existing individuals. The FSS uses three distinct movement operators, an individual one and two collective ones. The individual movement doesn't require any synchronization. However, the collective movements require some information gathered from all individuals. Strong delays among the individual calculations may in turn cause undesirable behaviours. Therefore, a synchronization point is needed before the execution of these operators, in which an extra thread performs calculations in order to

provide these collective information. Since these collective movements are independent of one another, they can be executed in parallel. This work concludes with an evaluation of the performance of this newly developed and, as explained beforehand, only partially synchronized multithreaded metaheuristic when used to solve the SCNP and offers comparisons to other state-of-the-art techniques.

Optimizing a linear fractional function over an integer efficient set

(**Chaabane Djamal** and Mahdi Sara)

In this paper we present a class of problems that deals with optimization over the efficient set of multiple objective integer linear programming problems. We propose an exact method to solve the case where a linear objective function (the principal objective) is to be optimized over such integer non convex feasible domain. The technique is mainly based on two approaches, one improves the principal objective from iteration to another and the second reduces the admissible region by the adjunction of a single constraint that successively eliminates all dominated points by the current efficient solution. We might explore some edges when a non-efficient solution is encountered. Our algorithm is implemented in MATLAB code and some randomly generated examples are tested.

Hybrid metaheuristic using reactive GRASP and reinforcement learning

(Ismael Izídio De Almeida, **Francisco Chagas De Lima Júnior** and Carlos Heitor Pereira Liberalino)

Metaheuristics represent an important class of approximative algorithms for solving NP-hard problems. A trend in combinatorial optimization research has been the exploration of hybrid metaheuristics. This paper presents a hybrid version of Reactive GRASP (RG) metaheuristic that incorporates a Reinforcement Learning (RL) agent. In traditional RG, is considered a set of α parameter values previously determined. The choice of α to be used in the construction phase is taken from this set with an associated probability distribution. In the hybrid algorithm proposal, a learner agent based on Q-learning algorithm is used to replace this process

by learning and providing the best α parameter. This strategy give the method an adaptive memory which is updated with the experience gained over the iterations, allowing a best utilization of the search process information in previous iterations. Preliminary tests were performed with the Traveling Salesman Problem confirming the applicability of the method. Hybrid RG-Learning was successfully applied to the p-centre location problem. The proposed method was utilized here to determine the best location of police bases in Mossoró city, Brazil, aiming to reduce the response time to police requests, and prohibit criminality. The test instances were prepared based on the location history of serious crimes in this city. Six instances were used to realization of the computational experiments. The results obtained with the hybrid version were compared with those obtained by the traditional RG, showing a better performing in solution quality and in runtime by this new approach. A statistical analysis of the results was made to validate the method. This work also contributes to present a new metaheuristic that uses RL for combinatorial optimization problems without the need to model them as Markov decision processes, and also a prototype that can be applied to public safety to aid decision making.

Applied Dynamic Stochastic Optimization (S8A)

Chair: Giorgio Consigli

Alternative portfolio optimization approaches in the fixed income market including 0-1 variables

(**Larraitz Aranburu** and Giorgio Consigli)

The 2008 credit crisis has deeply affected the price of corporate liabilities in both equity and fixed income secondary markets leading to unprecedented portfolio losses by financial investors. A coordinated intervention by monetary institutions limited the systemic consequences of the crisis, without, however, avoiding a significant fall of corporate bond prices across international markets. In this article, we analyse alternative portfolio optimization approaches in the fixed income market over the 2008–2009 period, a time in which credit derivative markets became very illiquid. All policies are analysed relying on a unique set of market and credit scenarios generated by common and idiosyncratic risk factors on an extended investment universe. This article, also includes some approaches that need mixed-integer programming techniques, such as the stop-loss constrains in dynamic optimization (very demanded by financial institutions), or the well-known stochastic dominance constrains (first-, second-, or interval second-order). The different approaches are compared in terms of required computational time and desirable risk treatment, in a realistic market. Those that imply 0-1 variables, become quite non-treatable when considering a considerable number of scenarios, so we are planning to solve them using the BFC approach.

Development environment for decision support in finance

(**Vittorio Moriggia** and Giorgio Consigli)

A large-scale stochastic programming model is adopted to support worldwide insurance company to manage exogenous constraints and capital allocation. Many requirements stem from input data sources, computation and output results. The proper development environment must provide a sufficient capability to adapt software to sudden changes. This work presents a group of well-known software combined together that creates a very powerful development environment. Various project already benefited by this solution.

Dynamic stochastic programming applied to insurance portfolios stress testing

(**Giorgio Consigli** and Vittorio Moriggia)

The introduction of the Solvency II regulatory framework in 2011 and unprecedented property and casualty claims experienced in recent years by large insurance firms have motivated the adoption of risk-based capital allocation policies in the insurance sector. In this paper we present the key features of a dynamic stochastic program leading to an optimal asset-liability management and capital allocation strategy by a large P/C insurance company and describe how from such formulation a specific, industry-relevant, stress-testing analysis can be derived. Throughout the article the investment manager of the insurance portfolio is regarded as the relevant decision maker: he faces exogenous constraints determined by the core insurance division and he is subject to the capital allocation policy decided by the management, consistently with the company's risk exposure. A novel approach to stress-testing analysis by the insurance management, based on a recursive solution of a large-scale dynamic stochastic program is presented.

Optimization in the Energy Sector (S8B)

Chair: Maria Teresa Vespucci

Transmission switching in electricity networks via nonlinear stochastic programming

(Alois Pichler, **Francesco Piu**, Asgeir Tomasgard and Maria Teresa Vespucci)

Switching off selected transmission lines of an electricity network can lead to savings in the total production costs. This—perhaps surprising—fact has gained increasing interest in the recent past, as the overall profitability of a given network can be increased. Energy is often produced in different places than in the past, for example in off-shore wind parks as in Germany, Denmark and many other countries. This situation offers the opportunity of re-designing the existing power flow network and to incorporate switching possibilities in the network. The central problem consists in finding and identifying those transmission lines, which provide the highest savings potential, while the power supply has to be secure at the same time in the whole area. This paper employs stochastic programming to elaborate the difficulties of the whole problem. In particular possibilities of how to reduce the problem to a tractable size are elaborated.

Optimal operation of medium-voltage AC networks with distributed generation and storage devices

(**Maria Teresa Vespucci**, Paolo Pisciella and Francesco Piu)

A medium-voltage AC network with distributed generation and storage devices is considered for which set points are assigned in each time period of a given time horizon. A set point in a time period is defined by modules and phases of voltages in all nodes, active and reactive powers, on load tap changer and variable loads. When some parameters vary, in order to restore feasibility new set points need to be determined so as to minimize the variations with respect to the initial ones. This can be done by minimizing distributor's redispatching costs, which are modeled by means of binary variables, while satisfying service security requirements and ensuring service quality, which are represented by nonlinear constraints, such as the nodal balance of active and reactive power and the current transits on lines and transformers for security. Storage devices are modeled by means of constraints that relate adjacent time periods. A two-step solution procedure is proposed, which is based on decoupling active and reactive variables: in the first step a MILP model determines the active power production and the use of storage devices that minimize redispatching costs over all time periods in the time horizon; in the second step, given the optimal active power production computed in the first step, reactive variables in each time period are computed by solving a nonlinear programming model.

A leader-followers model of power transmission capacity expansion in a market driven environment

(**Paolo Pisciella**, Marida Bertocchi, and Maria Teresa Vespucci)

We introduce a model intended for the analysis of the upgrade of the national transmission grid which explicitly accounts for responses given by the power generating companies in terms of generating unit expansion.
The problem is modeled as a bilevel program with mixed integer structure in both, upper and lower level. Upper level is de ned by the transmission company problem which has to de ne how to upgrade the network so to avoid congestions. Lower level models the reactions of generating companies, which take a decision on new facilities and power output, and market operator which strikes a new balance between demand and supply providing new Locational Marginal Prices. We illustrate our methodology by means of an example based on the Garver's 6-bus Network.

Social Networks (S8C)

Chair: Enza Messina

Sentiment analysis in social networks: a Markov-based prediction model

(Elisabetta Fersini, **Daniele Maccagnola** and Federico Alberto Pozzi)

According to the definition reported in [1], sentiment "suggests a settled opinion reflective of one's feelings". The extraction of this subjective information from texts in natural language is crucial to create structured and actionable knowledge to be used by a decision maker [2]. The analysis of sentiment is particularly challenging when dealing with online social networks, where decisions (e.g. in business and government intelligence) should take into account sentiment behind thousands of text messages posted by interconnected users. This work address the problem of classifying users sentiment in a social network environment by proposing a probabilistic model that obeys to the Markov assumption: the sentiment of a user is influenced by the sentiment of his text messages and the sentiment of the directly connected neighbours. The latent variables of the model, which weight the importance of text messages and neighbours, are estimated using a gradient-based approach [3] that maximizes the likelihood of the user sentiment labels. The experiments reveal that, thanks to the Markov property, the prediction of user sentiment affects all the other users by a "propagation" effect. We compare the results of the proposed model with traditional approaches that only consider text messages, disregarding connections among users. This investigation proves that the inclusion of relationships in the probabilistic model leads to accurate and robust sentiment prediction when dealing with networked environments.

[1] Pang, B., Lee, L.: Opinion mining and sentiment analysis. Foundations and Trends in Information Retrieval 2 (2008) 1–135. [2] Pozzi, F.A., Fersini, E., Messina, E.: Bayesian model averaging and model selection for polarity classification. In: Proc. of the 18th International Conference on Application of Natural Language to Information Systems. (2013) 189–200 [3] Wick, M., Rohanimanesh, K., Culotta, A., McCallum, A.: Samplerank: Learning preferences from atomic gradients. In: NIPS Workshop on Advances in Ranking. (2009)

Community detection in social networks

(**Elisabetta Fersini**, Daniele Maccagnola and Enza Messina)

One of the most important tasks in social network analysis is concerned with the discovery of homogeneous groups of users, or communities of users sharing some common interests. This task can be viewed as an uncapacitated location problem, where users (nodes) have to be associated to communities (clusters). For solving this problem, two alternative mathematical programming formulations are traditionally provided: the first one aims at maximizing the similarity between nodes belonging to the same community, where the similarity is computed based on the text messages posted by the users [1]. The second formulation aims at maximizing the number of connections (friendship, approval) among users belonging to the same cluster [2, 3] regardless the user generated contents. Detecting communities according to one of these formulations could lead to biased communities. Indeed, similarities between users' text messages can help to group users with few connections in the network, while the connections can complement when textual information is missing. Therefore, both paradigms should be taken into account and by considering social network communities as sets of nodes that are densely connected, but which also share some common message contents. In this work we propose a p-median formulation of this problem able to take into account both the contents of the messages posted by the user messages and the underlying social network structure. The proposed approach is validated on real data and compared against traditional baseline community detection methods.

[1] J. Liu. Comparative analysis for k-means algorithms in network community detection. In Advances in Computation and Intelligence (pp. 158-169). Springer Berlin Heidelberg, 2010. [2] S. Fortunato. Community detection in graphs. Physics Reports, 2010. [3] J. Xie, S. Kelley, and B. K. Szymanski. Overlapping community detection in networks: the state of the art and comparative study. ACM Computing Surveys, 2013.

Sales force allocation in pharmaceutical industry in presence of social contagion

(Alessandro Agnetis, **Enza Messina**, Gianluca Murgia and Marco Pranzo)

In this paper we deal with the influence of social contagion on the sales representative allocation problem for a pharmaceutical company. First of all, we present a heuristic algorithm that defines the number of calls for each drug to each physician, taking into account a call budget, a set of specific response functions, and the network of possible relationships among physicians. Because social contagion is a phenomenon inherently affected by uncertainty, we develop a methodology for the evaluation of the sales force allocation strategy taking into account the uncertainty and partial knowledge that may characterize the structure of the physician social network that regulates the information flow. We also analyze the impact of this partial knowledge on revenues generated by a call plan thus enabling the measurement of the information value.

Heuristics (S8D)

Chair: Ender Ozcan

Diversity-driven hybrid genetic algorithm for a course timetabling problem

(**Ayla Gulcu** and Serol Bulkan)

A diversity-driven Genetic Algorithm (GA) for the course timetabling problem at Marmara University Faculty of Engineering is developed. The performance of the algorithm is tested by the International Timetabling Competition 2 curriculum track dataset. Initial population is generated by a backtracking-based constraint programming (BBCP) technique which guarantees feasibility. Two diversity measures are developed in order to measure the distance between two individuals. The crossover operator is selected empirically among a number of CX operators according to both the diversity and the quality. The variable neighbourhood search is applied to improve the solution quality. The BBCP is able to find a feasible solution very quickly. For example, it finds a solution to instance 5, which is among the hardest instances, in 3 seconds with a Linux laptop with i7 processor and 16 GB of ram. At each step, the BBCP extends the partial solution by selecting an unassigned event and the best time and room value from the domain of that event. With the help of node consistency and filtering techniques, it is ensured that the domain of each event includes only consistent values. During the selection of the event to be assigned, one of the low-level ordering heuristics is used. A filtering technique is applied to remove the current time from the domain of other events whose assignment would cause inconsistency. When a dead-end is reached, which means that the selected event has no value consistent with the existing assignments, a backtracking is applied. Starting from the most recent assignment, each assignment and related filtering are undone until a consistent value is found. After assigning the current event, all the undone assignments that did not cause the dead-end are re-done if they are still consistent. The cycling is avoided by keeping a tabu list for each undone event.

The broadening future of hyper-heuristic interfaces

(**Andrew J. Parkes** and Ender Ozcan)

Hyper-heuristics provide a general-purpose software component to help reduce the implementation time needed for effective search methods. However, hyper-heuristics studies have generally used a framework with an overly limited communication between the high-level search control and the low-level domains. In particular, the hyper-heuristic received no other information than the current value of the objective function. We discuss various ideas for enriching the interface to allow a greater information flow from the low-level domain so as to allow better search control. The key challenge is to enable increased information but with the hyper-heuristic still able to work without needing knowledge of the specific domain knowledge. These can include approaches to the hyper-heuristic having information about features of the instances being solved, including, as a simple example, an indicator of the problem size. We give progress on converting it into a set of implemented APIs and benchmark problems. The dual aim is to support both future research in hyper-heuristics, and also usage in specific problem domains.

The second cross-domain heuristic search challenge (CHeSC 2014)

(Shahriar Asta, Tim Curtois, John Drake, Warren Jackson, Ahmad Muklason, José Carlos Ortiz-Bayliss, **Ender Ozcan** and Andrew J. Parkes)

The Second Cross-domain Heuristic Search Challenge (CHeSC 2014) seeks to bring together researchers and practitioners from operational research, computer science and artificial intelligence who are interested in developing more general and reusable methods for automated search control. Designing a single high level search strategy (e.g. hyper-heuristic) that can operate across different domains and control a set of low level heuristics provided for each domain is a challenging task. This competition encourages extension of high-level search strategies so as to treat different instances from different domains collectively as a batch. We expect a good hyper-heuristic in this competition will exhibit two new capabilities. Firstly, "effort balancing", that is, the better division of computational effort between the instances. Secondly, "inter-instance learning", that is, learning from the earlier instances in order to perform better on the latter ones. These aspects were not tested in the previous competition, CHeSC 2011. We will report the organisation and outcomes of the challenge and lessons learned for the future of hyper-heuristics. We expect that the competition will form the basis of a future benchmark for performance comparison of hyper-heuristics.

Stochastic Programming & Energy (S9A)

Chair: Asgeir Tomasgard

A multi-period stochastic equilibrium model for global energy markets

(**Zhonghua Su**, Ruud Egging and Asgeir Tomasgard)

We present a multi-period stochastic equilibrium model for global energy markets that capture everyday economic operations, infrastructure investments, fuel substitution, CO2 tax, market power in a unified framework. It includes players in the supply chains of various fuels, including production, trade, storage, transformation, transmission, consumption, emission permit auction.
We take advantage of multi-horizon scenario trees, by which we need fewer scenarios to represent the uncertainties compared to traditional scenario trees. Specifically, multi-horizon scenario trees classify the uncertainties into long-term and short-term uncertainties, both of which affect strategic investment decisions (e.g., production capacity expansion) and operational decisions (e.g., natural gas exports). In this paper, we suppose that the long-term uncertainties are deterministic. Further, we suppose that all players have symmetric information of scenarios and that upstream producers are Cournot players. By solving this one-level game model, equilibriums are reached, which are contingent on scenarios.
We use GAMS to model the problem and PATH to solve it. Finally, a case study of Chinese CO2 cap policy is discussed.

Optimal scheduling of demand side flexible units under uncertainty in SmartGrids

(**Stig Oedegaard Ottesen** and Asgeir Tomasgard)

In this paper we propose a general stochastic mixed integer program to support decisions for the short-term scheduling problem for end-users with flexible energy resources. We have defined a concept of internal energy systems with converter, storage and load units. We propose a set of standard classes for load units reflecting their flexibility properties including both technic and economic constraints. Since in real life all information is not known at the time of decision we propose a stochastic programming approach where uncertain parameters are modeled in scenarios and clustered into a scenario tree representing the information revelation process. The model is demonstrated in a case study for a Norwegian university college building. Load forecasts are modelled based on multiple linear regressions with exogenous explanatory variables. The scheduling decision process is presented by two approaches: 1) A deterministic approach (the expected value solution) where load is assumed to be known with certainty and 2) A stochastic approach (the 2-stage recourse problem) where the day is divided into 2 stages and load is known with certainty for the first 12 hours. Load for the last 12 hours are represented in 7 scenarios generated based on the load forecasts and the residuals. The results show a cost saving potential even in the existing Norwegian electricity market. There are three sources for the cost savings: 1) Electricity price variations during the day, 2) Price differences between electricity and oil and 3) Reduction in peak electricity. The case study also shows a value of the stochastic solution, due to a minimum running time constraint for the converter units generating hot water from electricity or oil respectively.

Integrating energy system models in a complementarity setting

(**Per Ivar Helgesen** and Asgeir Tomasgard)

Bottom up energy system models are often solved using linear programming techniques in order to minimize the costs of producing the projected energy demand. It is desirable to complement such models with top-down Computable General Equilibrium models. These are usually formulated and solved as Mixed Complementarity problems.

The complementarity format has advantages over the linear programming: 1) It provides both primal and dual variables in one model, and allows relationships to be formulated. 2) It allows us to include multiple agents that individually optimize their behaviour towards their own goals.

One example illustrating the first advantage is the PIES model, where the dual price variables affect the primal demand. The PIES model was previously solved using iterations, but can now be solved directly by Mixed Complementarity solvers like PATH or MILES.

The second advantage is central in CGE models, which includes different agents like households, firms and government.

The complementarity format also has disadvantages: 1) Although an equilibrium solution is known to exist, there is not a proven solution method that always will find such a solution. 2) Uniqueness of an equilibrium solution can in general not be guaranteed.

CGE models are exposed to these disadvantages already. By reformulating a linear programming energy system model like the TIMES model as a complementarity model, it could be integrated into a CGE model and solved directly. This is done through the associated Karush-Kuhn-Tucker conditions. Developing such an integrated model would be very important, providing equilibrium solutions towards which solutions from other heuristic approaches could be measured. Empirical models may still be intractable to solve in an integrated manner, but different linked approaches could be evaluated against an integrated approach.

Financial Optimization (S9B)

Chair: Dessislava Pachamanova

No-Arbitrage ROM simulation

(Alois Geyer, Michael Hanke and Alex Weissensteiner)

Ledermann et al. (2011) propose random orthogonal matrix (ROM) simulation for generating multivariate samples matching means and covariances exactly. Its computational efficiency compared to standard Monte Carlo methods makes it an interesting alternative. In this paper we enhance this method's attractiveness by focusing on applications in finance. Many financial applications require simulated asset returns to be free of arbitrage opportunities. We analytically derive no-arbitrage bounds for expected excess returns to be used in the context of ROM simulation, and we establish the theoretical relation between the number of states (i.e., the sample size) and the size of (no-)arbitrage regions. Based on these results, we present a No-Arbitrage ROM simulation algorithm, which generates arbitrage-free random samples by purposefully rotating a simplex. Hence, the proposed algorithm completely avoids any need for checking samples for arbitrage. Compared to the alternative of (potentially frequent) re-sampling followed by arbitrage checks, it is considerably more efficient. As a by-product, we provide interesting geometrical insights into affine transformations associated with the No-Arbitrage ROM simulation algorithm.

Financial optimization modeling using R

(Ronald Hochreiter)

Simplifying the task of modeling optimization problems is important. Many commercial products have been created to support the optimization modeling process, but none of these products has been adopted by a significantly large number of users. As soon as real-world decision problems under uncertainty have to be modeled, flexible and quick changes to the underlying model are necessary. Simplifications are crucial to implement such optimization models into business processes successfully. Examples from portfolio optimization will be shown to substantiate the proposed modeling environment.

Recent computational trends and opportunities in equity portfolio optimization

(Dessislava Pachamanova)

Portfolio managers have traditionally attempted to maximize alpha, the portfolio outperformance relative to a benchmark. The financial crisis of 2007-2008, however, has increased interest in smart beta, risk-based and risk parity allocation strategies. This talk discusses computational challenges and opportunities associated with the implementation of such strategies.

Linear Algebra for Large-Scale Optimization Problems (S9C)

Chair: Tyrone Rees

Preconditioning IPMs for block-angular problems with "almost linearly dependent" constraints

(**Stefano Nasini** and Jordi Castro)

One of the most efficient interior-point methods for some classes of primal-block angular problems solves the normal equations by a combination of Cholesky factorizations and preconditioned conjugate gradient for, respectively, the block and linking constraints. We show that the principal angles between the subspaces generated by the diagonal blocks and the linking constraints play an important role in the proper choice of the preconditioner. Under these considerations we propose an easily computable preconditioner which results to be particularly effective when the principal angles between the subspaces generated by the diagonal blocks and the linking constraints are small, that is to say, when the linking constraints are almost linearly dependent with the block constraints. This preconditioner resulted to be complementary to the currently available power series preconditioner for block angular problems: the smaller the principal angles are, the more the power series preconditioner is outperformed by the new preconditioner. Computational results will be presented.

Adaptive discontinuous Galerkin approximation of optimal control problems governed by transient convection-diffusion equations

(**Hamdullah Yücel**, Martin Stoll and Peter Benner)

This talk will focus on the numerical solution of unsteady optimal control problems governed by convection diffusion partial differential equations (PDEs). The solutions of these PDEs can exhibit layers on small regions where the solution has large gradients, when convection dominates diffusion. To avoid spurious oscillations emerging from the layers, we use adaptive mesh refinement. The symmetric interior penalty Galerkin (SIPG) method

with upwinding for the convection term is used for space discretization, whereas backward Euler is used for time discretization. We derive some a posteriori error estimates for the state, the adjoint and the control variables. The arising saddle point system is solved using a suitable preconditioner. Numerical examples are presented for convection dominated problems to illustrate the effectiveness of the adaptivity.

Preconditioning techniques for large scale optimization problems

(Tyrone Rees)

The interior point method has emerged as one of the most popular methods for solving quadratic programming problems. At each iteration of this method, one has to solve a large linear system, and this step is the computational bottleneck in modern interior point solvers. For large-scale optimization problems it is not feasible to factorize this matrix, and so we must turn to iterative methods.
Krylov subspace methods are, in general, the most efficient iterative methods known, but they have to be applied with a preconditioner in order to be effective. The optimization community has favoured constraint preconditioners to date for solving the augmented system, as it can be shown that the approximate solutions obtained satisfy the constraints exactly, and hence convergence of an interior point method can be proved. In this talk I will describe a method which allows us to use other preconditioners to solve this problem while maintaining convergence of the outer iterative method. I will demonstrate my findings with numerical results from the CUTEst test collection.

Numerical Algorithms II (S9D)

Chair: John Pearson

PSMG: A parallel problem generator for a structure conveying modelling language for mathematical programming

(Feng Qiang and Andreas Grothey)

SML is a structured conveying modelling language that enables the modeller to express a problem structure. SML allow modeller to construct models from sub-models and also facilitate the formulation of stochastic programming problems with recourse. In this talk, we briefly introduce the syntax SML and then present PSMG - Parallel Structured Model Generator - a parallel implementation for the SML. PSMG analyses the structure of an optimization problem given as an SML model file and uses this information to parallelise the model generation process itself. As far as we are aware PSMG is the only algebraic modelling language that can perform parallel problem generation. PSMG offers an interface that can be linked in parallel with many different categories of structure exploiting optimization solvers such as interior point or decomposition based solvers. One of the features of this interface is that the decision on how to distribute problem parts to processors can be delegated to the solver thus enabling better data locality and load balancing. We also demonstrate the use of PSMG by modelling and solving a non-linear optimization problem, known as Security Constrained Optimal Power Flow Problem. We have chosen OOPS- a parallel interior point optimization solver to link with PSMG. The results show that PSMG achieves good parallel efficiency. They also show that exploitation of parallelism enables the generation of problems that cannot be processed on a single node due to memory restrictions.

Nonlinear semidefinite optimization at NAG

(Jan Fiala)

Problem formulations which lead to nonlinear semidefinite optimization are not yet very common. They were, until recently, considered numerically unsolvable and a lack of available software meant that researches tended to avoid them. This talk introduces a new solver provided by NAG which can handle nonlinear optimization, linear and nonlinear semidefinite optimization and any combination of these. A variant of the solver written in Matlab is also available as an open source software package to support further development in this field.

The first part of the talk will be devoted to the description of the algorithm which is based on a generalized augmented Lagrangian method and on a suitable choice of nonlinear rescaling functions. Some of the applications, such as a nearest correlation matrix problem, will be presented in the second part.

Fast solvers for PDE-constrained optimization problems

(John Pearson)

An active area of research within the fields of numerical linear algebra and continuous optimization is that of developing effective solution strategies for PDE-constrained optimization problems. In this talk we present a framework for constructing preconditioned iterative methods for the matrix systems arising from such problems. We do this by exploiting the saddle point structure of the matrices involved, and using this to derive good approximations of the (1,1)-block and Schur complement. We consider PDE-constrained optimization problems of both time-independent and time-dependent form, as well as nonlinear examples. For each problem that we examine, we motivate and derive our suggested preconditioners, and present numerical results to demonstrate the performance of our methods.

Robust Optimization (S10A)

Chair: Michal Kocvara

Robust network design with uncertain outsourcing cost

(**Michael Poss** and Artur Pessoa)

The expansion of a telecommunications network faces two sources of uncertainty, which are the total amount of traffic that shall transit through the expanded network and the outsourcing cost that the network operator will have to pay for unmet demands. The latter is specified by the future service level agreements, whose exact terms are unknown at the time the expansion is planned. Unlike previous robust optimization works on the subject, we consider in this paper both sources of uncertainty. The resulting linear program exhibits a constraint with quadratic dependency on the uncertainties. We propose a decomposition approach that avoids considering the constraint for all scenarios. Instead, we use a cutting plane algorithm that generates required scenarios on the fly by solving linear multiplicative programs. Computational experiments realized on the networks from SNDlib show that our approach is orders of magnitude faster than the classical semi-definite programming reformulation for such problems.

Multistage facility location and inventory problem

(**Mahdi Noorizadegan** and Nalan Gulpinar)

This paper considers the integrated facility location and inventory problem with uncertain customer's demand. The total expected cost consisting of transportation and inventory costs as well as the fixed location cost is minimized. We study robust approximations to the problem in order to incorporate information about the random demand distribution in the best possible, computationally tractable way. Finally, we present numerical experiments that illustrate the performance of the different robust formulations.

Robustness criteria and robust topology optimization with uncertain loads

(Michal Kocvara)

We propose a new algorithm for the solution of the robust multiple-load topology optimization problem. The algorithm can be applied to any type of problem, e.g., truss topology, variable thickness sheet or free material optimization. We assume that the given loads are uncertain and can be subject to small random perturbations. Furthermore, we define a rigorous measure of robustness of the given design with respect to these perturbations. To implement the algorithm, the users only need software to solve their standard multiple-load problem. Additionally, they have to solve a few small-dimensional eigenvalue problems. Numerical examples demonstrate the efficiency of our approach.

Combinatorial Optimization III (S10B)

Chair: Gunes Erdogan

A column generation approach for bus driver rostering problems

(Lin Xie and **Leena Suhl**)

The crew rostering problem arises in public transport bus companies, and addresses the task of assigning a given set of anonymous duties and some other activities, such as standbys and days off, to drivers or groups of drivers, without violating any complex labour union rules. Additionally, the preferences of drivers are considered during the assignment. The plan generated for each driver/group of drivers is called a roster. Optimal rosters are characterized by maximum satisfaction of drivers and minimal operational costs. In order to generate a personalized roster for each driver/group of drivers, the problem is formulated in this paper as a multi-commodity network flow problem. In each network layer, a roster is generated for each driver or driver group. The network model is very flexible and can accommodate a variety of constraints. Additionally, with a minor modification, the network can formulate the cyclic and non-cyclic crew rostering problems. Column Generation approach is applied in this work to solve both crew rostering problems for diversified real-world instances. Moreover, the obtained results are compared to those solved with MIP-models.

Solving large-sized quadratic assignment problems by neural networks

(**Enrique Dominguez**)

Assignment problems are well studied topic in combinatorial optimization. These kinds of problems find numerous applications in production planning, telecommunication, VLSI design, economics, etc. The Quadratic Assignment Problem (QAP) was introduced by Koopmans and Beckmann in 1957 as a mathematical model for the location of a set of indivisible economical activities. This problem consists of allocating a set of facilities to a set of

locations, taking into account the costs of the distance and flow between facilities, and the cost of the facility's installation in a certain location. Therefore, the problem is to assign all the facilities to the locations with the objective of minimizing the total cost. The QAP is NP-hard and one of the fundamental combinatorial optimization problems in the area of facility location. This problem has been solved by many different techniques; but no exact algorithm is known for solving large-sized instances of the QAP in reasonable computational time. In this work, neural networks are proposed for solving large-sized instances of the QAP. Preliminary results show that neural networks are capable to provide good solutions in a low computational time.

Two exact algorithms for the Hamiltonian p-Median Problem

(**Gunes Erdogan**, Maria Battarra, Antonio M. Rodriguez Chia and Gilbert Laporte)

This study provides two new exact solution algorithms for the Hamiltonian p-Median Problem (HpMP). The HpMP is the problem of finding p cycles on a given graph that cover every vertex with minimum total cost. The first solution method is a branch-and-cut algorithm based on an enhanced p-median formulation with reduced symmetry. For the second method, a polynomial time column generation scheme based on fractional programming is presented. The resulting branch-and-price-and-cut algorithm is described in detail. Computational results show that the branch-and-cut algorithm outperform the existing exact solution methods. Preliminary results for the branch-and-cut-and-price algorithm are discussed.

Machine Learning (S10C)

Chair: Belen Martin-Barragan

Spectral analysis and machine learning in water distribution networks

(Antonio Candelieri, Davide Soldi and Francesco Archetti)

Leaks in urban water distribution networks (WDN) are leading to large amounts of Non-Revenue Water (NRW) as well as higher energy and rehabilitation costs. To obtain a smarter network management a strategy based on the combination of hydraulic simulation and machine learning is proposed in this paper. Hydraulic simulation is used to run different leakage scenarios by introducing a leak on each pipe, in turn, and varying its severity. For each scenario, pressure and flow variations in correspondence of the actual monitoring points into the WDN, and with respect to the faultless model, are stored. These scenarios are the nodes of a graph, whose edges are weighted by a similarity measure between each pair of nodes, and which is then analysed in the eigen-subspace spanned by the most relevant eigenvectors of its Normalized Laplacian matrix. This transformation from the physical space, associated to the WDN, to the eigenvectors space, allows for a computationally efficient application of the Spectral Clustering procedure. In this way leaks generating similar effects, in terms of observable pressure and flow variations are grouped together; each scenario is then labelled with the corresponding cluster to obtaining a dataset on which a Support Vector Machine is trained. In this way we encode the non-linear transformation, from Input Space (i.e., pressure and flow variations) to Feature Space (i.e., most relevant eigen-vectors) and therefore to the correspondent scenarios cluster. When an actual leak is detected, the variations in measured pressure and flow with respect to the faultless hydraulic model are given as input to the SVM which provides the most probable cluster label. Leaky pipes belonging to that cluster are provided as the list of components to investigate for leakage. The approach has been validated on two WDNs: a Pressure Management Zone in Milan (Italy) and a District Metered Area in Timisoara (Romania).

Enhancing teamwork by optimizing collaboration

(**Victor Cavalcante**, Ana Paula Appel, Marcos Vieira, Vagner Santana, Rogerio Paula and Nelson Nauata)

Assembling an effective team to perform a particular set of collaborative tasks requires an approach that goes beyond the analysis of individual skills and capabilities. Team members' ability to work together and communicate with each other is paramount in collaborative tasks. Thus, social relationships play an important role when teaming up people and are essential elements to add to decision making processes. In order to investigate this, we started off by exploring collaboration aspects that can be extracted from the network (an undirected weighted graph) built from a particularly popular but unexpected dataset: we use the social relationship and historical data of Marvel comic books to examine the problem of team formation. In this context, the aspect we would like to assess is how important is the ability of working together for super heroes, considering their power grids amended by relationships extracted from comic books records The approaches we implemented automatically assemble a group of villains and a group of heroes, both considering the social links among every team member personal attributes. In our experimentation we examine the performance of three heuristic strategies and report computational results on them: a genetic algorithm, a GRASP and an optimization heuristic tailored specifically to tackle the problem. Our experimental results show that our algorithms produce meaningful and useful results, matching groups that occur in the Marvel world as well as interesting possibilities of new teams. We consider metrics related to the connectivity and collaboration of teams and discuss on variations for the initial team formation problem. As a result, experiments with this first dataset reinforce the relevance of considering social aspects when dealing with optimization decisions. Hence, our results corroborate the increasing necessity of enhancing optimization problems by introducing social network information, whenever their descriptions are susceptible to people's interactions.

A heuristic for tuning the kernel in dynamic clustering

(Emilio Carrizosa, **Belen Martin-Barragan** and Dolores Romero Morales)

Kernel methods are a class of methods for data analysis that generalize existing techniques by implicitly mapping the data into a high dimensional feature space. In this talk we focus on kernel clustering in a dynamic context where the groups in the cluster and the features evolve over time. As in any kernel method, in kernel clustering, the choice of the kernel is crucial for the results. We explore different definitions of the performance of a kernel in the context of dynamic clustering and develop a heuristic to tune the kernel in order to maximize such performance. Kernel models that are very flexible allow us to capture important information in the data, at the expense of a need to tune many parameters. When the number of parameters is large, it is difficult for traditional metaheuristics to find good solutions. Our algorithm takes advantage of the fact that complex kernel models can be seen as generalization of simpler ones, yielding a nested sequence of models of increasing complexity.

Humanitarian Logistics I (S10D)

Chair: M.Teresa Ortuño

A review of management tools for humanitarian logistics

(**Priyanka Roy**, Pavel Albores and Christopher Brewster)

Purpose: In recent years, there are large number of humanitarian disasters happen, e.g., the 2010 floods in Pakistan, the 2011 Earthquake in Japan and the 2013 earthquake in Philippines. These events have captured international attention both in the media and disaster management research community. Aid is available to the beneficiaries, by relief organisations, after a disaster strikes. This supply chain process has to be very rapid and efficient to minimize the human casualty. An effective logistics system (such as demand forecasting, inventory management, material handling, warehousing, order processing, and distribution management) is very important to continue a well organised supply chain process. This paper identifies the rapidly expanding body of literature which contribute to understand the approach towards design and operation of humanitarian logistics for the disaster response operation.

Design/Methodology: Structured literature review of academic journals, conference papers which are appeared in the international journals from 1990 to 2012 are gathered and analysed so that the following two questions can be answered. (1) Which methods are the most popular? (2) Which problem attracts the most attention? The time frame is chosen because the technology, communication, GPS system evolved more rapidly during this period and usage of these facilities could make huge difference in relief logistic operations. Another reason of choosing this time frame is the availability of more literature during this period.

Findings: The review finds that optimisation method is the most popular in humanitarian logistical operation followed by qualitative method. Surprisingly 35 articles are about nonspecific disaster but 17 articles explain about earthquake problem. Future work should engage clearly with current developments of disaster management to identify the relevant practical logistical problems during the implement and design phase of decision support system.

Originality/Value: The humanitarian logistic operation needs more attention of academics for future research of logistical drivers.

Mathematical methods in humanitarian logistics – the case of route planning under application of the heuristic "savings" after the typhoon Haiyan on the Philippines

(Dorit Prof. Dr. Boelsche)

The presentation and publication deal with the opportunities of mathematical methods in humanitarian logistics. Unexpected hard but not totally unforeseen made the typhoon Haiyan landfall in the Philippines in November 2013. Humanitarian aid began short time after the landfall and even the day before when the weather forecast had anticipated a typhoon. First aid deliveries such as food, medicines and non-food relief items arrived few days later at accessible seaports and airports on the Philippines – if possible near to the main crisis region around Tacloban. How can mathematical heuristics and optimization methods help to distribute the relief items to the people in need? How can humanitarian logistics be organized in the same time efficient and effective? Effective means in the sense of humanitarian logistics to act fast, flexible and reliable and therewith to realize a high logistics service. The term efficient focuses on costs; lowering logistics costs enables to spend more money for relief items or other measures of humanitarian aid. Is it possible to integrate destroyed streets, bridges or other parts of the infrastructure into solutions and mathematical methods? This contribution to the session deals with the mentioned questions and tries to find answers. Using the example of the typhoon Haiyan the author demonstrates the application of the mathematical method "Savings". Starting from a first but poor solution for the route planning problem the solution is modified iterative to a solution which can be characterized as effective and efficient. The people in need on the Philippines receive aid faster and by considerable lower costs than in the first solution. The method can be adjusted flexible to new conditions such as new intersections for the delivery, different amounts of relief items, available modes of transport, destroyed or re-established infrastructure, new information about people in need. Over that it is comprehensible for the personnel in humanitarian aid and programmable for IT-solutions.

Coordinating static and dynamic flow models for a multi-criteria humanitarian aid distribution problem

(**M.Teresa Ortuño**, F.Javier Martin-Campo, Gregorio Tirado and Begoña Vitoriano)

Natural and human-made disasters cause humanitarian crises all around the world. Recent disasters, such as Haiti earthquake (2010), Japan earthquake and subsequent tsunami (2011) or Philippines earthquake (2013), among others, have highlighted the importance of Disaster and Emergency Management, in order to alleviate the suffering of vulnerable people and save lives. This is a highly relevant area of interest nowadays, which is undergoing widespread development. In this context, Humanitarian Logistics play a major role and a wide range of optimization models, among others, are being developed.

The problem addressed in this work concerns last-mile distribution in disaster relief operations. In particular, the problem consists of designing routes for vehicles among nodes that have an available quantity of goods or have a demand of those goods, choosing the types of vehicles more adequate and determining the flow of the aid. In order to do so, a lexicographical dynamic flow model that takes into account the decision maker's preferences is presented, extending a previously introduced static flow model. The new model is validated in a realistic case study and a computational study is performed to compare both models, showing how they can be coordinated. The computational experiments suggest that the coordination of both models improves significantly their overall performance.

16:00 – 17:15, Thursday, April 10, 2014

Financial Asset Allocation (S11B)

Chair: Alex Weissensteiner

Portfolio optimization using feature selection

(**Thomas Trier Bjerring**, Omri Ross and Alex Weissensteiner)

It's well-known that mean-variance portfolios perform poorly out-of-sample due to estimation problems, especially when the number of assets to be considered is very large. We propose hierarchical clustering to reduce the investment universe and apply classical asset allocation techniques to the selected assets. In addition to an in-depth analysis of the performance, we analyze the impact of the key parameters for the algorithm.

Dynamic portfolio optimization with transaction costs and state-dependent drift

(**Rolf Poulsen**)

We present an efficient numerical method to determine optimal portfolio strategies under time- and state-dependent drift and proportional transaction costs. This scenario arises when investors have behavioural biases or the actual drift is unknown and needs to be estimated. The numerical method solves dynamic optimal portfolio problems for time-horizons of up to 40 years. It is applied to measure the value of information and the loss from transaction costs using the indifference principle.

Time under the water

(**Omri Ross**)

We explore the construction of a risk measure that focus on the time a firm has been below its highest water mark. We show that such a risk measure can be used for portfolio optimization and suggest an empirical evidence for its usefulness in portfolio optimization.

Humanitarian Logistics II (S11C)

Chair: Begoña Vitoriano Villanueva

A Wardrop equilibrium model for the bi-objective location of distribution centres in disaster relief

(**Walter Gutjahr** and Nada Dzubur)

In a post-disaster situation, the choice of locations for distribution centres (DCs) is an important decision faced by an NGO providing humanitarian aid. Usually, people from the affected population have to walk from their homes to a DC to obtain relief goods. The throughput of a DC is limited, not only by storage considerations, but also by staff requirements. In the case of congestion at a DC, only part of the overall demand can possibly be satisfied, which may motivate part of the people to go to more remote DCs that are not congested. This shows that the assumption of some facility location models that clients will always choose the nearest facility may not be realistic in a disaster relief situation.

We try to overcome this limitation by means of the theory of Wardrop equilibria. In our case, a Wardrop equilibrium is defined by the property that the gain a client can expect to receive in a chosen DC (which depends how many other clients go there), reduced by the cost of traveling to this DC, is not worse than for alternative DCs. The Wardrop equilibrium can be computed as the solution of a convex mathematical program. We do this by means of the Frank-Wolfe algorithm.
On the upper decision level representing the viewpoint of the NGO, a bi-objective combinatorial optimization problem is solved, the objectives of which are cost and uncovered demand.
We illustrate the approach at real-world test instances from Senegal. The efficient solutions of our approach are compared to those obtained from a “nearest facility” model. It is shown that our more realistic client behaviour prediction allows for relevant improvements in the solution quality.

Optimizing covering tours for the distribution of disaster relief items using competitive location models

(**Pamela Nolz**, Walter Gutjahr and Christian Burkart)

We consider the problem of designing the logistic system to assure adequate distribution of relief aid after a natural disaster. We face the situation, where the population members stay in the affected regions and need to be supplied with food and drinking water. These relief items are to be transported from a central depot to distribution centres, where they are handed out to the population in need. The problem is formulated as a multi-objective optimization problem, encompassing two objective functions of central interest in such problems. The underlying competitive Covering Tour Problem (CTP) aims at minimizing (i) total uncovered demand and (ii) total distribution costs.

We include modeling approaches for customer behaviour as they have been developed in the field of competitive location models. In disaster relief, the provision of help by different organizations should not be competitive, such that we face a different situation, but as the mentioned approaches possibly allow us to predict the behaviour of the individuals affected by a disaster in more detail, they may enable a more efficient organization of the relief logistics. Depending on the distribution centres made available to the population members, they will make decisions where to go to (if at all), which is an important information for health providing organizations, such that supplies can be delivered to the right places in the right quantities.

We solve the multi-objective competitive CTP with the Non-dominated Sorting Genetic Algorithm II (Deb et al., 2002) and compare the proposed solutions to the Pareto-optimal solutions generated with a Brute Force Complete Enumeration procedure. The suggested metaheuristic solution approach is tested on real-world data from the southern part of Mozambique near the river Limpopo, which is regularly affected by drought. The sets of solutions are evaluated using the hyper-volume indicator as proposed by Zitzler and Thiele (1998).

Deb K., Pratap A., Agarwal S., Meyarivan T. (2002) A fast and elitist multiobjective genetic algorithm: NSGA-II. IEEE Transactions on Evolutionary Computation 6 (2), pp. 182-197.

Zitzler E., Thiele L. (1998) Multiobjective optimization using evolutionary algorithms: a comparative case study. In: Eiben A.E., Bäck T., Schoenauer M., Schwefel H.-P. (editors) PPSN 1998, LNCS

A multiobjective integral approach for the humanitarian logistics problem. Application to a case study in Mexico

(Christopher Mejía-Argueta, Juan Gaytán-Iniestra, Rafael Caballero, Julian Molina and **Begoña Vitoriano**)

Disasters are phenomena which strike countries around the world. The work introduces an integral proposal to consider distribution, evacuation, location of facilities and a preposition stock policy during floods with multi-criteria (equity: minimizing the maximum evacuation and distribution flow-times, as well as total cost). The efficient frontier for the preparedness phase is built through the weighting with the epsilon-constraint methods and for the response phase through a metaheuristic based on tabu and scatter search. The usefulness of the model is validated through a Mexican case study and the analysis of different scenarios created from three key factors in humanitarian logistics.

9:30 – 10:45, Friday, April 11, 2014

Optimization under Uncertainty I (S13A)

Chair: Daniel Kuhn

Robust growth-optimal portfolios

(**Napat Rujeerapaiboon**, Daniel Kuhn and Wolfram Wiesemann)

The log-optimal portfolio is known to outperform any other portfolio in the long run if stock returns are i.i.d. and follow a known distribution. In this talk, we establish similar guarantees for finite investment horizons where the distribution of stock returns is ambiguous. By focusing on fixed-mix portfolios, we exploit temporal symmetries to formulate the emerging distributionally robust optimization problems as tractable conic programs whose sizes are independent of the investment horizon.

Entropic approximation for mathematical programs with robust equilibrium constraints

(Yongchao Liu and **Huifu Xu**)

We consider a class of mathematical programs with robust equilibrium constraints represented by a system of semi-infinite complementarity constraints (SICC). We propose a numerical scheme for tackling SICC. Specifically, by relaxing the complementarity constraints and then randomizing the index set of SICC, we employ the well-known entropic risk measure to approximate the semi-infinite constraints with a finite number of stochastic inequality constraints. Under some moderate conditions, we quantify the approximation in terms of the feasible set and the optimal value. The approximation scheme is then applied to a class of two stage stochastic mathematical programs with complementarity constraints in combination with the polynomial decision rules. Finally, we extend the discussion to a mathematical program with distributionally robust equilibrium constraints which is essentially a one stage stochastic program with semi-infinite stochastic constraints indexed by some probability measures from an ambiguity set defined through the KL-divergence.

Two-stage robust integer programming

(**Grani Adiwena Hanasusanto**, Daniel Kuhn and Wolfram Wiesemann)

Over the last two decades, robust optimization has emerged as a computationally viable approach to formulate and solve single-stage decision problems affected by uncertainty. More recently, robust optimization has been successfully applied to multi-stage problems with continuous recourse. This research takes a step towards extending the robust optimization methodology to problems with integer recourse, which have largely resisted solution so far. To this end, we approximate two-stage robust integer programs by their corresponding K-adaptibility problems, in which the decision maker pre-commits to K second-stage policies here-and-now and implements the best policy once the uncertain parameters are observed. We study the approximation quality and the computational complexity of the K-adapatibility problem, and we propose two mixed-integer linear programming reformulations that can be solved with off-the-shelf software. We demonstrate the effectiveness of our reformulations in numerical experiments.

Finance I (S13B)

Chair: Marina Schneider

On the performance of the risk-adjusted on-line portfolio selection algorithm

(**Esther Mohr** and Robert Dochow)

The optimality of Cover's universal portfolio (UP) is one of the main reasons behind the popularity of this algorithm in the on-line portfolio selection literature [Cov91]. The ability of successfully utilizing a portfolio selection algorithm in practice requires the possibility to include risk management. This has been neglected in previous theoretical works, ignoring the necessity of risk-adjustment in real applications. In [DMS14] a risk-adjusted online portfolio selection algorithm (RAPS) is derived, that performs provably as well as UP in the worst-case. Contrary to UP, RAPS takes into account the trading risk by the maximum possible return fluctuation of the constant-rebalanced portfolio. Based on the growth rate of the assets within the portfolio UP reallocates the capital invested, while RAPS reallocates based on the assets' volatility. We give an experimental investigation of RAPS and UP assuming a finite investment horizon. A stochastic market model with two assets is applied, and results are compared to the theoretical analysis of [DMS14] and [Cov91]. By means of a Monte-Carlo simulation we investigate the impact of an assets' (i) growth rate, (ii) volatility, and (iii) correlation on the performance of UP and RAPS. Not surprisingly, besides (iii), the main success drivers of UP and RAPS are (i) and (ii), respectively. The higher the volatility the higher is the probability to beat the best asset in the market. In general, RAPS outperforms UP if we aim to the best stock [BYG04].

[BYG04] Borodin, A.; El-Yaniv, R., and Gogan, V.: Can we Learn to Beat the Best Stock. Journal of Artificial Intelligence Research (21) (2004) 579-594 [Cov91] Cover, T.: Universal portfolios. Mathematical Finance 1(1) (1991) 1–29 [DMS14] Dochow, R., Mohr, E., and Schmidt, G.: Risk-adjusted On-line Portfolio Selection. Selected Papers of the Annual International Conference of the German and the Dutch Operations Research Society, University of Rotterdam, September 3-6 (2013), in press.

On Fenchel-duality and its application to non-life insurance

(**Lin Yang**, Hirbod Assa and Athanasios Pantelous)

In this paper, a model for the accumulated reserve and the pricing process of a portfolio of different Non-Life insurance products is considered. The decision for today's reserve depends on the level of reserve for the last t periods, and the price of the premium is the control parameter of the model. We show how in general we can setup the problem in a finite dimensional space and then we find a necessary and sufficient condition for the existence of a viable reserve control path by using Fenchel-duality.

Reduced order models for the implied variance under local volatility

(Ekkehard Sachs and **Marina Schneider**)

Implied volatility is a key value in financial mathematics. We demonstrate the shortcomings of the standard ways to compute this quantity, i.e. numerical inversion of the well-known Black-Scholes formula or asymptotic expansion approximations, and propose a new way to directly calculate the implied variance in a local volatility framework as the solution of a quasi-linear degenerate parabolic partial differential equation. Since the numerical solution of this equation may result in large nonlinear systems and thus high computation times compared to the classical approaches, we apply model reduction techniques to achieve computational efficiency. A popular method for the derivation of reduced-order models is Proper Orthogonal Decomposition (POD). This strategy is additionally combined with the Discrete Empirical Interpolation Method (DEIM) to deal with the nonlinear terms. Numerical results prove the quality of our approach compared to other methods.

Multi-Criteria Optimization (S13C)

Chair: Chaabane Djamal

Multi-objective criteria for the aircraft conflict detection and resolution problem by using horizontal and vertical manoeuvres

(F. **Javier Martin-Campo**, Antonio Alonso-Ayuso and Laureano Escudero)

The aircraft conflict detection and resolution problem takes an important role within the air traffic management. Given a set of aircraft configuration, the aim of the problem is to provide a new configuration in such a way that every conflict situation is detected as well as solved. A conflict situation is such an event in which two or more aircraft violate the safety distances that the must keep during their flights. In order to deal with this problem, a mixed integer non-convex nonlinear optimization model is presented where velocity, heading angle and altitude changes are allowed to be performed by each aircraft. Three different multi-objective criteria are also studied: lexicographical, compromise and a mixture of two phases in which firstly the maximum deviation from the initial configuration is minimized and secondly the compromise criterion is used. The lexicographical criterion takes into account the comfort of the passengers, compared with the other two criteria based on economic costs. Comfort and economic costs are facing each other since in terms of comfort, the preferences on the manoeuvres are: velocity, heading angle and altitude, whereas in terms of economy, the preferences are: altitude, heading angle and velocity. Due to the difficulty of the model solving, a metaheuristic approach based on sequentially solving a set of mixed integer linear optimization models is presented. The angle range is discretized and the nonlinear constraints of the model are linearized by using a set of binary variables. The total computing time for solving the set of linear models is smaller than the time required for solving the nonlinear one for large scale problems, where Cplex (been iteratively used) and Minotaur are the estate-of-the-art solvers of choice, respectively. A broad computational experience is presented.

FRCA, a metaheuristic algorithm for solving large-scale multistage stochastic mixed 0-1 problems with risk averse stochastic dominance constraint 0-1 linear recourse

(**Celeste Pizarro Romero**, Laureano F. Escudero, María Araceli Garín and Aitziber Unzueta)

A metaheuristic, so named Fix-and-Relax Coordination algorithm (FRCA), is presented for solving large-scale multiperiod stochastic mixed 0-1 optimization problems. The large-scale character can be motivated by the intrinsic dimensions of the problem as well as due to the large number of additional 0-1 and continuous variables and constraints required by the risk averse strategy to use, in our case the time consistent stochastic dominance constraints based recourse-integer (T- SDC) strategy. The inexact approach that is proposed in this work handles the uncertainty of the parameters by a set of scenarios structured in a tree. One of its main characteristics consists of considering macro-periods along the time horizon dynamically included by sets of consecutive periods. For each scenario group that belongs to the first period of any macro-period a mixture of multistage and two-stage stochastic mixed 0-1 subproblems is solved, by relaxing the integrality and non-anticipativity constraints in successor groups of the scenario groups that belong to the last period in the macro-period. A backward procedure is introduced such that the macro-periods are dynamically adjusted. The T-SDC strategy considers a set of profiles at each selected time period. Each profile is included by a threshold to satisfy, its failure probability and expected shortfall bounds as soft constraints, and a maximum shortfall allowed as a hard constraint.

An exact method for finding all integer efficient stochastic solutions

(**Mebrek Fatma** and Chaabane Djamal)

In this paper we propose a new exact method to solve Multiple Objective Integer Stochastic Linear Programming problem. Once the problem is converted into a deterministic one by adapting the 2-levels recourse approach, an aggregation of the expected objective functions is optimized on the admissible region taking into account an additional penalty cost due to violation of some stochastic constraints.
A list of all non-dominated solutions is formed progressively and the domain is being reduced until it becomes empty. A detailed didactic example is given to illustrate different steps of our developed algorithm.

Decision Making Applications (S13D)

Chair: Josep Freixas

Meaningful suitability indices as a basis for supplier selection

(**Sourour Aouadni** and Abdelwaheb Rebai)

The Supplier Selection Problem consists of the definition of models and methods to analyze and measure the performance of a set of suppliers in order to improve customer competitiveness. It is an intrinsically multi-attribute problem, since many qualitative and quantitative factors, very often conflicting with each other, should be taken into account. This decision is considered more complex because the diversity of quantitative and qualitative criteria considered in the decision-making process. In this research, we propose a new methodology for supplier selection based on meaningful suitability indices. This index is computed for ranking and selecting the right suppliers for all cardinal and ordinal criteria. Moreover, this index is meaningful whatever the representation of the measurement scale considering the point of view of decision-maker to other. Also, we based on the measurement theory and the multi-criteria decision analysis to determine the meaningful suitability indices. In other hand, on the basis of the meaningful suitability indices, the buyer can determined the order lot-sizing and distributed proportionally the total demand among suppliers.

Decision support system based on genetic algorithms and MUlti-criteria Satisfaction Analysis (MUSA) method for measuring university teachers' job satisfaction

(**Ismahene Aouadni** and Abdelwaheb Rebai)

In this study we are interested in measuring job satisfaction by developing a Decision Support System (DSS) based on the Multi-criteria Satisfaction Analysis (MUSA) method and the genetic algorithm. The objective is to help the organization evaluate and measure the employees' satisfaction. Our study is decomposed on two parts. Firstly, we propose a genetic algorithm to solve the MUSA method in order to obtain a robust solution of good performance.

The aim of the development of this algorithm is to verify its efficiency regarding the algorithm proposed by Grigoroudis and Siskos in 2002. In the second part we present our Decision Support Systems called "GMUSA System". Our approach was applied at Sfax University to measure teachers' job satisfaction.

About the measurement of success of participants in decision-making

(**Josep Freixas** and Montserrat Pons)

Two measures of power excel to evaluate the importance of individual decision-making in a democratic institution under uncertainty. These measures are known as success and decisiveness and are widely applied in management.

It is known that if the probability of voting yes is equal to the probability of voting no for all players, the notions of success and decisiveness are related in an affine relationship and therefore there are no essential differences between them.

In this work we consider any arbitrary probability distribution for players and establish conditions under which these two notions are ordinally equivalent. The main result obtained, by means of optimization, helps to clarify the similarities and distinctions between the two concepts. The binary approach is then extended to situations with multiple alternatives for input and output highlighting similarities and differences with the binary model.

Optimization under Uncertainty II (S14A)

Chair: Wolfram Wiesemann

Interdiction games on Markovian PERT networks

(Eli Gutin, **Daniel Kuhn** and Wolfram Wiesemann)

In a stochastic interdiction game a proliferator aims to minimize the expected duration of a nuclear weapons development project, while an interdictor endeavours to maximize the project duration by delaying some of the project tasks. We formulate static and dynamic versions of the interdictor's decision problem where the interdiction plan is either pre-committed or adapts to new information revealed over time, respectively. The static model gives rise to a stochastic program, while the dynamic model is formalized as a multiple optimal stopping problem in continuous time and with decision-dependent information. Under a memoryless probabilistic model for the task durations, we prove that the static model reduces to a mixed-integer linear program, while the dynamic model reduces to a finite Markov decision process in discrete time that can be solved via efficient value iteration. We then generalize the dynamic model to account for uncertainty in the outcomes of the interdiction actions. We also discuss a crashing game where the proliferator can use limited resources to expedite tasks so as to counterbalance the interdictor's efforts. The resulting problem can be formulated as a robust Markov decision process.

Robust Stable Payoff Distribution in Stochastic Cooperative Games

(**Tri-Dung Nguyen** and Vinh Doan)

Cooperative games with transferable utilities belong to a branch of game theory where groups of players can form coalitions in order to jointly achieve the groups' objectives. Under a cooperative setting, having a payoff distribution among the players in such a way that ensures the stability of the game becomes one of the most important questions to be answered. Classical solutions concepts such as the core and the least core are defined only in games with deterministic

characteristic functions. However, the payoff function might be stochastic, e.g. through estimation or approximation of the reality, and classical solutions concepts are no longer applicable. We redefine the concept of stability in a stochastic setting and introduce new concepts for robust payoff distribution. We demonstrate these to a number of games including the stochastic newsvendor games. Properties and numerical schemes for finding the robust solutions are presented.

Robust vehicle routing

(**Wolfram Wiesemann**, Chrysanthos E. Gounaris and Christodoulos A. Floudas)

We study the robust capacitated vehicle routing problem (robust CVRP), which asks for the minimum cost delivery of a product to geographically dispersed customers using capacity-constrained vehicles. Contrary to the deterministic CVRP, which postulates that the customer demands for the product are deterministic and known, the robust CVRP models the customer demands as random variables, and it determines a minimum cost delivery plan that is feasible for all anticipated demand realizations. We show that the robust CVRP can be modelled as a two-stage robust optimization problem that has an equivalent reformulation as a mixed-integer linear program (MILP). We generalize the classical rounded capacity inequalities to the robust setting and illustrate how they expedite the solution of the MILP in a branch-and-cut framework. We also discuss how the robust CVRP relates to the chance-constrained CVRP, which allows a controlled degree of supply shortfall to decrease delivery costs.

Finance II (S14B)

Chair: Gautam Mitra

Market neutral portfolios

(**Cristiano Arbex Valle**, John Beasley and Nigel Meade)

In this work we consider the problem of constructing a market neutral portfolio. This is a portfolio of financial assets that (ideally) exhibits performance independent from that of an underlying market as represented by a benchmark index. We formulate this problem as a mixed-integer nonlinear program, minimising the absolute value of the correlation between portfolio return and index return. Our model is a flexible one that incorporates decisions as to both long and short positions in assets. Computational results, obtained using the software package Minotaur, are given for constructing market neutral portfolios for eleven different problem instances derived from universes defined by S\&P international equity indices. We also compare our approach against an alternative approach based on minimising the absolute value of regression slope (the zero-beta approach).

A continuous piecewise linear programming approach to minimising portfolio E-VaR

(**Giuliano De Rossi**, Katharina Schwaiger and Cristiano Arbex Valle)

We discuss a risk measure recently advocated in the academic literature, E-VaR, which hinges on the statistical concept of expectile. The paper derives an asset allocation procedure that minimises E-VaR by using piecewise linear programming. Moreover, we show that a straightforward generalization of our framework can be used to incorporate a dynamic model of E-VaR. As a result, the information available from time series of asset returns is used to learn about the evolution of downside risk at portfolio level. Risk is then minimised by targeting the predicted E-VaR. The numerical efficiency and stability of our approach are illustrated through a number of asset allocation examples.

Enhanced indexation based on second-order stochastic dominance

(**Gautam Mitra**, Diana Roman, Victor Zverovich and Cristiano Arbex Valle)

Second order Stochastic Dominance (SSD) has a well-recognised importance in portfolio selection, since it provides a natural interpretation of the theory of risk-averse investor behaviour. Recently, SSD-based models of portfolio choice have been proposed; these assume that a reference distribution is available and a portfolio is constructed, whose return distribution dominates the reference distribution with respect to SSD. We present an empirical study which analyses the effectiveness of such strategies in the context of enhanced indexation. Several datasets, drawn from FTSE 100, SP 500 and Nikkei 225 are investigated through portfolio rebalancing and back-testing. Three main conclusions are drawn. First, the portfolios chosen by the SSD based models consistently outperformed the indices and the traditional index trackers. Secondly, the SSD based models do not require imposition of cardinality constraints since naturally a small number of stocks are selected. Thus, they do not present the computational difficulty normally associated with index tracking models. In this paper we present a unified framework which incorporates (a) SSD, (b) downside risk (Conditional Value-at-Risk) minimisation and (c) enhanced indexation.

Algebraic Modeling Languages (S14C)

Chair: Robert Fourer

APMonitor: A modeling platform for dynamic optimization

(Jose Mojica and John Hedengren)

A significantly condensed modeling approach to planning and scheduling optimization is to pose the problem as differential and algebraic equations (DAEs) with either continuous or discrete variables. The APMonitor modeling language solves large-scale and complex systems of DAEs not only for dynamic optimization but also for model reconciliation to data. Some of the recent applications in APMonitor include computational biology, unmanned aerial systems, chemical process control, solid oxide fuel cells, grid-scale energy storage, and oil & gas upstream systems. Highlighted in this presentation is a capacity expansion of a district heating network. This study evaluates the investment decision timing and type of capacity expansion. An optimal investment schedule is determined over a 30 year horizon with stochastic inputs (e.g. fuel prices, carbon tax costs, electricity prices) as well as daily dynamics across seasonal variations. This is formulated as a dynamic optimization problem in which an initial system configuration is modified by decisions to drive from an initial state to an optimal state. In this case, the underlying DAE model is discretized into an equivalent set of nonlinear equations with mixed-integer variables. The APMonitor Optimization Suite facilitates this transformation so that problems can be solved with capable mixed-integer (MINLP) solvers. In addition to forward predictions, there is also value in "looking backward" in time to align these same models to available measurements through state and parameter estimation. Once the system is aligned with dynamic data, the model with updated parameters is projected forward in time and solved as an MINLP problem to solve capacity planning scenarios. The solution of this MINLP problem drives the system along a desired trajectory or best meets multiple objectives. Recent progress with parallelization, web services architecture, and remaining challenges with large-scale and complex dynamic systems are reviewed.

JuMP: open-source algebraic modeling in Julia

(**Miles Lubin**, Iain Dunning and Joey Huchette)

We present JuMP, an open-source algebraic modeling language embedded in Julia, a new high-level language for scientific computing. JuMP uses Julia's modern language features such as just-in-time compilation and meta-programming to achieve performance competitive with hand-written matrix generators while providing a familiar algebraic syntax. Benchmarks with state-of-the-art modeling packages such as AMPL and Pyomo are provided. We discuss our most recent feature, a solver-independent interface for MIP callbacks supporting lazy constraints and user cuts, compatible with Gurobi, CPLEX, and GLPK.

Alternatives for programming in conjunction with an algebraic modeling language for optimization

(**Robert Fourer**)

Modeling languages for formulating and analyzing optimization problems are essentially declarative, in that they are founded on a symbolic description of a model's objective function and constraints rather than a procedural specification of how a problem instance is to be generated and solved. Yet successful optimization modeling languages have come to offer many of the same facilities as procedural, high-level programming languages, in two ways: by extension of their syntax to interpreted scripting languages, and by exposure of their functions through application programming interfaces (APIs). How can scripting and APIs benefit the user of a declarative language, and what do they offer in comparison to modeling exclusively in a general-purpose language? This presentation suggests a variety of answers, through examples in which the AMPL modeling language is applied to parametric analysis, solution generation (via cuts and via solver options), heuristic optimization, pattern generation, and decomposition. Concluding comments discuss the design of new AMPL scripting features and the new AMPL API for Java, MATLAB, and other platforms.

Conference Organizers

Nalan GULPINAR, Xuan Vinh DOAN, and Arne K. STRAUSS

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Guest Editors

Nalan GULPINAR, Xuan Vinh DOAN, and Arne K. STRAUSS

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